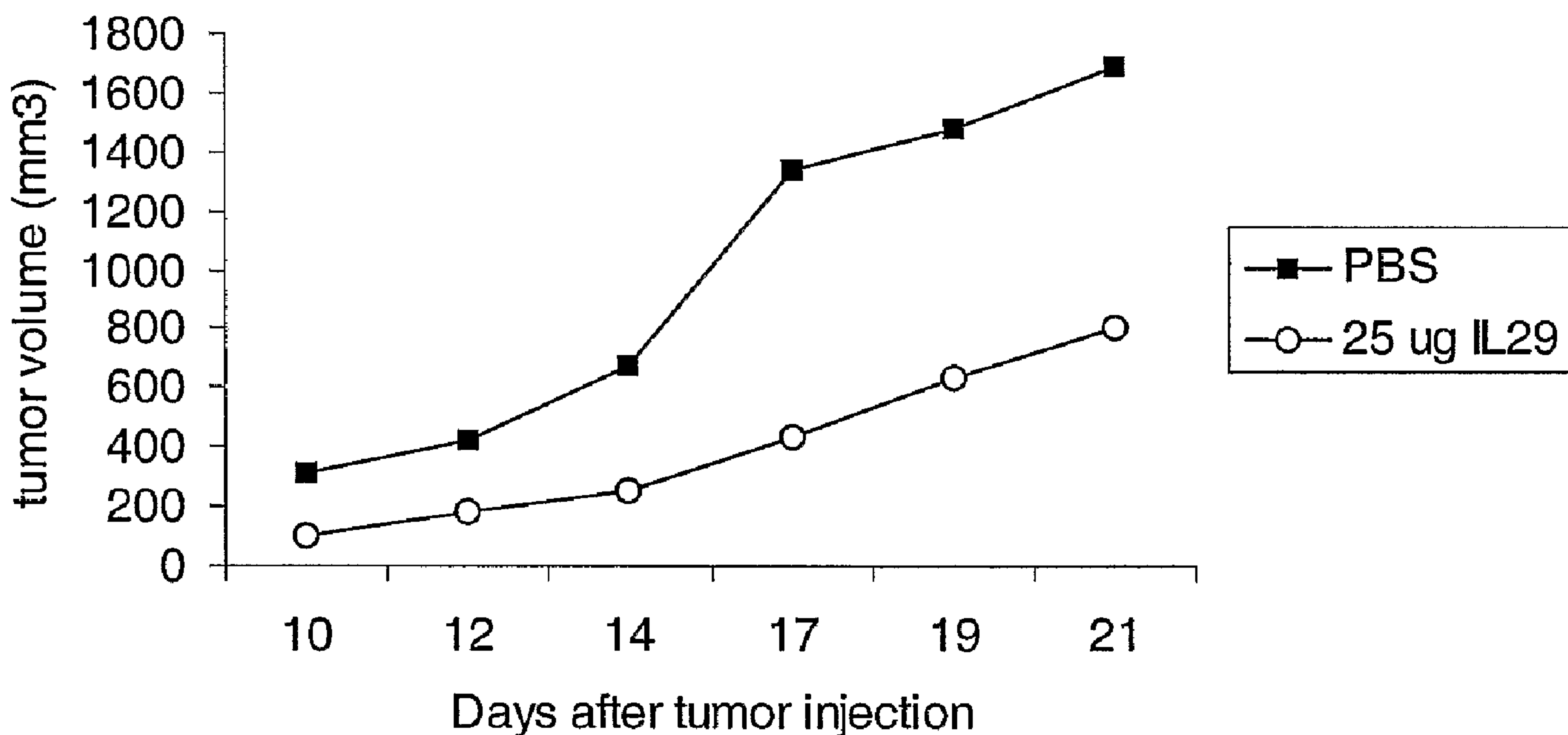




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(54) Title: USE OF TRUNCATED CYSTEINE IL28 AND IL29 MUTANTS TO TREAT CANCERS AND AUTOIMMUNE
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Methods for treating patients with cancer and autoimmune disorders using IL-28 and IL-29 molecules. The IL-28 and IL-29 molecules include polypeptides that have homology to the human IL-28 or IL-29 polypeptide sequence and proteins fused to a polypeptide with IL-28 and IL-29 functional activity. The molecules can be used as a monotherapy or in combination with other known cancer and/or autoimmune therapeutics.

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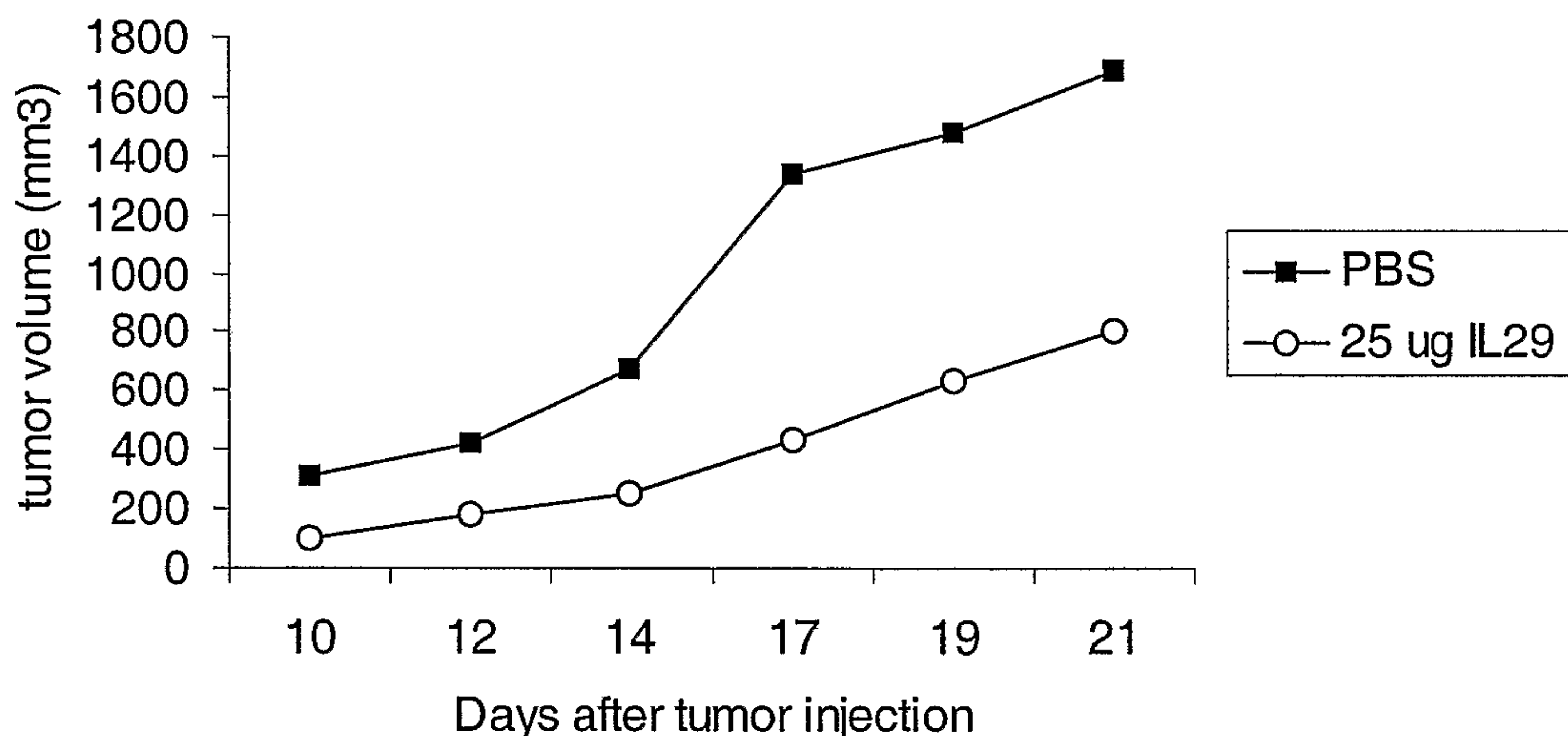
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USE OF TRUNCATED CYSTEINE IL28 AND IL29 MUTANTS TO TREAT CANCERS AND
AUTOIMMUNE DISORDERS

BACKGROUND OF THE INVENTION

[1] Cytokines generally stimulate proliferation or differentiation of cells of the hematopoietic lineage or participate in the immune and inflammatory response mechanisms of the body. Examples of cytokines which affect hematopoiesis are erythropoietin (EPO), which stimulates the development of red blood cells; thrombopoietin (TPO), which stimulates development of cells of the megakaryocyte lineage; and granulocyte-colony stimulating factor (G-CSF), which stimulates development of neutrophils. These cytokines are useful in restoring normal blood cell levels in patients suffering from anemia, thrombocytopenia, and neutropenia or receiving chemotherapy for cancer.

[2] The interleukins are a family of cytokines that mediate immunological responses. Central to an immune response is the T cell, which produce many cytokines and adaptive immunity to antigens. Cytokines produced by the T cell have been classified as type 1 and type 2 (Kelso, A. Immun. Cell Biol. 76:300-317, 1998). Type 1 cytokines include IL-2, IFN- γ , LT- α , and are involved in inflammatory responses, viral immunity, intracellular parasite immunity and allograft rejection. Type 2 cytokines include IL-4, IL-5, IL-6, IL-10 and IL-13, and are involved in humoral responses, helminth immunity and allergic response. Shared cytokines between Type 1 and 2 include IL-3, GM-CSF and TNF- α . There is some evidence to suggest that Type 1 and Type 2 producing T cell populations preferentially migrate into different types of inflamed tissue.

[3] The immune system is the body's primary defense against diseases caused by pathogens, namely bacteria, viruses, fungi etc, as well as against diseases caused by abnormal growth of the body's own cells and tissues (*i.e.* cancerous tumors). Normally, the immune system is able to distinguish between the body's normal cells or "self" and foreign pathogens or abnormal cells or "non-self". The processes by which the immune system refrains from reacting to one's own body is called tolerance. Sometimes, the immune system loses the ability to recognize "self" as normal and the subsequent response directed against the tissue or cells, results in loss of tolerance, a state of autoimmunity. The pathologies resulting from autoimmunity often have serious clinical consequences and are one of the major health problems in the world, especially in developed nations.

[4] One example of such an autoimmune disorder is multiple sclerosis (MS), a progressive disease of the central nervous system (CNS). In MS patients, the patient's own immune system destroys myelin, the protective layer that surrounds and insulates the nerve fibers in the brain and spinal cord. The destruction of the myelin sheath leads to disruption of neurotransmission and

scarring damage to the nerve fibers. The end result is the manifestation of numerous symptoms in the affected patient including tingling or numbness, slurred speech, impaired vision, vertigo etc. Over the course of the disease, there is loss of strength in the extremities, leading to problems with movement and in the most severe cases, leading to paralysis of the limbs. Based on clinical diagnosis, there are currently four types of MS classifications, based on which part of the brain or spinal cord are affected, severity, frequency of attacks etc.

[5] Current therapies for MS include corticosteroid drugs (to alleviate symptoms of acute episodes), as well as other drugs like IFN- β and Novantrone®. Novantrone® has been approved for late stage MS patients, specifically for whom other therapies have not worked. Novantrone® is cytotoxic to most cells and therefore as one would expect, has an array of side effects and is toxic at doses required for the maximal therapeutic effects. IFN- β is also toxic, limiting dosage of the drug in MS patients. Furthermore, continuous use of these drugs has been shown to desensitize patients to further use of the same drug, thereby limiting the ability to use these drugs as long term therapeutics.

[6] Of particular interest, from a therapeutic standpoint, are the interferons (reviews on interferons are provided by De Maeyer and De Maeyer-Guignard, "Interferons," in *The Cytokine Handbook*, 3rd Edition, Thompson (ed.), pages 491-516 (Academic Press Ltd. 1998), and by Walsh, *Biopharmaceuticals: Biochemistry and Biotechnology*, pages 158-188 (John Wiley & Sons 1998)). Interferons exhibit a variety of biological activities, and are useful for the treatment of certain autoimmune diseases, particular cancers, and the enhancement of the immune response against infectious agents, including viruses, bacteria, fungi, and protozoa. To date, six forms of interferon have been identified, which have been classified into two major groups. The so-called "type I" IFNs include IFN- α , IFN- β , IFN- ω , IFN- δ , and interferon- τ . Currently, IFN- γ and one subclass of IFN- α are the only type II IFNs.

[7] Type I IFNs, which are thought to be derived from the same ancestral gene, have retained sufficient similar structure to act by the same cell surface receptor. The α -chain of the human IFN- α/β receptor comprises an extracellular N-terminal domain, which has the characteristics of a class II cytokine receptor. IFN- γ does not share significant homology with the type I IFN or with the type II IFN- α subtype, but shares a number of biological activities with the type I IFN.

[8] Clinicians are taking advantage of the multiple activities of interferons by using the proteins to treat a wide range of conditions. For example, one form of IFN- α has been approved for use in more than 50 countries for the treatment of medical conditions such as hairy cell leukemia, renal cell carcinoma, basal cell carcinoma, malignant melanoma, AIDS-related Kaposi's sarcoma, multiple myeloma, chronic myelogenous leukemia, non-Hodgkin's lymphoma, laryngeal papillomatosis, mycosis fungoides, condyloma acuminata, chronic hepatitis B, hepatitis C, chronic hepatitis D, and chronic non-A, non-B/C hepatitis. The U.S. Food and Drug Administration has

approved the use of IFN- β to treat multiple sclerosis, a chronic disease of the nervous system. IFN- γ is used to treat chronic granulomatous diseases, in which the interferon enhances the patient's immune response to destroy infectious bacterial, fungal, and protozoal pathogens. Clinical studies also indicate that IFN- γ may be useful in the treatment of AIDS, leishmaniasis, and lepromatous leprosy.

[9] IL-28A, IL-28B, and IL-29 comprise a recently discovered new family of proteins that have sequence homology to type I interferons and genomic homology to IL-10. This new family is fully described in co-owned PCT application WO 02/086087 and Sheppard et al., Nature Immunol. 4:63-68, 2003; both incorporated by reference herein. Functionally, IL-28 and IL-29 resemble type I IFNs in their ability to induce an antiviral state in cells but, unlike type I IFNs, they do not display antiproliferative activity against certain B cell lines.

[10] Mature T cells can be activated, i.e., by an antigen or other stimulus, to produce, for example, cytokines, biochemical signaling molecules, or receptors that further influence the fate of the T cell population.

[11] B cells can be activated via receptors on their cell surface including B cell receptor and other accessory molecules to perform accessory cell functions, such as production of cytokines. B cell activation results in the production of antibodies that can bind to immunogenic cell-surface proteins on tumor cells and initiate complement-mediated cell lysis, bridge NK cells or macrophages to the tumor for antibody-dependent cell-mediated cytotoxicity (ADCC), interfere with tumor cell growth by blocking survival or inducing apoptotic signals, or increase immunogenicity by facilitating the uptake and presentation of tumor antigens by APCs. Thus, enhancing B cell responses *in vivo* has the potential to promote antitumor activity (Blattman et al., Science, 305:200-205 (July 9, 2004)).

[12] Therefore, agents which can augment natural host defenses against tumor induction or progression may increase remission rates and enhance survival of patients, without the cytotoxic side effects of prior methods.

[13] The present invention provides such methods for treating solid tumors, lymphomas, and autoimmune disorders by administering IL-28A, IL-28B, or IL-29 compositions that may be used as a monotherapy or in combination with chemotherapy, radiation therapy, small molecules or other biologics. These and other uses should be apparent to those skilled in the art from the teachings herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[14] Figure 1 shows mice injected with mouse IL-28 plasmid on Days 5 and 12 inhibit RENCA tumor growth *in vivo*.

[15] Figure 2 shows mice injected with mouse IL-28 plasmid, mouse IFN- α plasmid, and human IL-29 C172S polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol

propionaldehyde inhibit RENCA tumor growth *in vivo*. Plasmid injections are on Days 5 and 12. Protein was given every other day from day 5-21.

[16] Figure 3 shows mice injected with 1 μ g, 5 μ g and 25 μ g of human IL-29 C172S polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde and human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde inhibit RENCA tumor growth *in vivo*. All protein given every other day from days 5-23.

[17] Figure 4 shows mice injected with vehicle (■), 5 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde (▼), and 25 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde (◆) every-other-day for 20 days once tumor volume reached 100mm³, 5 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde everyday for 20 days once tumor volume reached 100mm³ (●), and 5 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde administered prophylactically every other day for 20 days starting on day 5 of tumor injection (▲).

[18] Figure 5A shows mice injected with 25 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde or vehicle beginning on Day 0 and ten subsequent i.p. injections every-other-day prolongs survival of the mice in the E.G7 thymoma model.

[19] Figure 5B shows mice injected with 25 μ g human IL-29 C172S d2-7 polypeptide N-terminally conjugated to a 20kD methoxy-polyethylene glycol propionaldehyde or vehicle beginning on Day 0 and ten subsequent i.p. injections every-other-day inhibits tumor growth in the E.G7 thymoma model.

[20] Figure 6 shows the prophylactic administration of PEG-mIL-28 inhibits disease severity and incidence in RR-EAE model.

[21] Figure 7 shows the prophylactic administration of PEG-mIL-28 significantly reduces incidence of clinical disease in mice with RR-EAE.

[22] Figure 8 shows the prophylactic administration of PEG-rIL-29 inhibits disease severity and incidence in the RR-EAE mouse model.

[23] Figure 9 shows the prophylactic administration of PEG-rIL-29 significantly reduces incidence of clinical disease in mice with RR-EAE.

[24] Figure 10 shows the therapeutic administration with PEG-mIL-28 significantly inhibits disease severity in RR-EAE model.

[25] Figure 11 shows the therapeutic administration of PEG-mIL-28 reduces clinical severity in the RR-EAE model. Average total clinical score for the study period are shown.

[26] Figure 12 shows the therapeutic administration of PEG-mIL-28 increase percent of mice with complete remission in the RR-EAE model.

DESCRIPTION OF THE INVENTION

[27] In the description that follows, a number of terms are used extensively. The following definitions are provided to facilitate understanding of the invention.

[28] Unless otherwise specified, "a," "an," "the," and "at least one" are used interchangeably and mean one or more than one.

[29] The term "affinity tag" is used herein to denote a polypeptide segment that can be attached to a second polypeptide to provide for purification or detection of the second polypeptide or provide sites for attachment of the second polypeptide to a substrate. In principal, any peptide or protein for which an antibody or other specific binding agent is available can be used as an affinity tag. Affinity tags include a poly-histidine tract, protein A (Nilsson et al., EMBO J. 4:1075, 1985; Nilsson et al., Methods Enzymol. 198:3, 1991), glutathione S transferase (Smith and Johnson, Gene 67:31, 1988), Glu-Glu affinity tag (Grussenmeyer et al., Proc. Natl. Acad. Sci. USA 82:7952-4, 1985), substance P, FlagTM peptide (Hopp et al., Biotechnology 6:1204-10, 1988), streptavidin binding peptide, or other antigenic epitope or binding domain. See, in general, Ford et al., Protein Expression and Purification 2: 95-107, 1991. DNAs encoding affinity tags are available from commercial suppliers (e.g., Pharmacia Biotech, Piscataway, NJ).

[30] The term "allelic variant" is used herein to denote any of two or more alternative forms of a gene occupying the same chromosomal locus. Allelic variation arises naturally through mutation, and may result in phenotypic polymorphism within populations. Gene mutations can be silent (no change in the encoded polypeptide) or may encode polypeptides having altered amino acid sequence. The term allelic variant is also used herein to denote a protein encoded by an allelic variant of a gene.

[31] The terms "amino-terminal" and "carboxyl-terminal" are used herein to denote positions within polypeptides. Where the context allows, these terms are used with reference to a particular sequence or portion of a polypeptide to denote proximity or relative position. For example, a certain sequence positioned carboxyl-terminal to a reference sequence within a polypeptide is located proximal to the carboxyl terminus of the reference sequence, but is not necessarily at the carboxyl terminus of the complete polypeptide.

[32] The term "cancer" or "cancer cell" is used herein to denote a tissue or cell found in a neoplasm which possesses characteristics which differentiate it from normal tissue or tissue cells. Among such characteristics include but are not limited to: degree of anaplasia, irregularity in shape, indistinctness of cell outline, nuclear size, changes in structure of nucleus or cytoplasm, other phenotypic changes, presence of cellular proteins indicative of a cancerous or pre-cancerous state,

increased number of mitoses, and ability to metastasize. Words pertaining to "cancer" include carcinoma, sarcoma, tumor, epithelioma, leukemia, lymphoma, polyp, and scirrus, transformation, neoplasm, and the like.

[33] The term "complement/anti-complement pair" denotes non-identical moieties that form a non-covalently associated, stable pair under appropriate conditions. For instance, biotin and avidin (or streptavidin) are prototypical members of a complement/anti-complement pair. Other exemplary complement/anti-complement pairs include receptor/ligand pairs, antibody/antigen (or hapten or epitope) pairs, sense/antisense polynucleotide pairs, and the like. Where subsequent dissociation of the complement/anti-complement pair is desirable, the complement/anti-complement pair preferably has a binding affinity of $<10^9 \text{ M}^{-1}$.

[34] The term "complements of a polynucleotide molecule" denotes a polynucleotide molecule having a complementary base sequence and reverse orientation as compared to a reference sequence.

[35] The term "degenerate nucleotide sequence" denotes a sequence of nucleotides that includes one or more degenerate codons (as compared to a reference polynucleotide molecule that encodes a polypeptide). Degenerate codons contain different triplets of nucleotides, but encode the same amino acid residue (i.e., GAU and GAC triplets each encode Asp).

[36] The term "expression vector" is used to denote a DNA molecule, linear or circular, that comprises a segment encoding a polypeptide of interest operably linked to additional segments that provide for its transcription. Such additional segments include promoter and terminator sequences, and may also include one or more origins of replication, one or more selectable markers, an enhancer, a polyadenylation signal, etc. Expression vectors are generally derived from plasmid or viral DNA, or may contain elements of both.

[37] The term "isolated", when applied to a polynucleotide, denotes that the polynucleotide has been removed from its natural genetic milieu and is thus free of other extraneous or unwanted coding sequences, and is in a form suitable for use within genetically engineered protein production systems. Such isolated molecules are those that are separated from their natural environment and include cDNA and genomic clones. Isolated DNA molecules of the present invention are free of other genes with which they are ordinarily associated, but may include naturally occurring 5' and 3' untranslated regions such as promoters and terminators. The identification of associated regions will be evident to one of ordinary skill in the art (see for example, Dynan and Tijan, *Nature* 316:774-78, 1985).

[38] An "isolated" polypeptide or protein is a polypeptide or protein that is found in a condition other than its native environment, such as apart from blood and animal tissue. In a preferred form, the isolated polypeptide is substantially free of other polypeptides, particularly other polypeptides of animal origin. It is preferred to provide the polypeptides in a highly purified form, i.e.

greater than 95% pure, more preferably greater than 99% pure. When used in this context, the term "isolated" does not exclude the presence of the same polypeptide in alternative physical forms, such as dimers or alternatively glycosylated or derivatized forms.

[39] The term "level" when referring to immune cells, such as NK cells, T cells, in particular cytotoxic T cells, B cells and the like, an increased level is either increased number of cells or enhanced activity of cell function.

[40] The term "neoplastic", when referring to cells, indicates cells undergoing new and abnormal proliferation, particularly in a tissue where the proliferation is uncontrolled and progressive, resulting in a neoplasm. The neoplastic cells can be either malignant, i.e. invasive and metastatic, or benign.

[41] The term "operably linked", when referring to DNA segments, indicates that the segments are arranged so that they function in concert for their intended purposes, e.g., transcription initiates in the promoter and proceeds through the coding segment to the terminator.

[42] A "polynucleotide" is a single- or double-stranded polymer of deoxyribonucleotide or ribonucleotide bases read from the 5' to the 3' end. Polynucleotides include RNA and DNA, and may be isolated from natural sources, synthesized *in vitro*, or prepared from a combination of natural and synthetic molecules. Sizes of polynucleotides are expressed as base pairs (abbreviated "bp"), nucleotides ("nt"), or kilobases ("kb"). Where the context allows, the latter two terms may describe polynucleotides that are single-stranded or double-stranded. When the term is applied to double-stranded molecules it is used to denote overall length and will be understood to be equivalent to the term "base pairs". It will be recognized by those skilled in the art that the two strands of a double-stranded polynucleotide may differ slightly in length and that the ends thereof may be staggered as a result of enzymatic cleavage; thus all nucleotides within a double-stranded polynucleotide molecule may not be paired.

[43] A "polypeptide" is a polymer of amino acid residues joined by peptide bonds, whether produced naturally or synthetically. Polypeptides of less than about 10 amino acid residues are commonly referred to as "peptides".

[44] The term "promoter" is used herein for its art-recognized meaning to denote a portion of a gene containing DNA sequences that provide for the binding of RNA polymerase and initiation of transcription. Promoter sequences are commonly, but not always, found in the 5' non-coding regions of genes.

[45] A "protein" is a macromolecule comprising one or more polypeptide chains. A protein may also comprise non-peptidic components, such as carbohydrate groups. Carbohydrates and other non-peptidic substituents may be added to a protein by the cell in which the protein is produced, and will vary with the type of cell. Proteins are defined herein in terms of their amino acid

backbone structures; substituents such as carbohydrate groups are generally not specified, but may be present nonetheless.

[46] The term "receptor" denotes a cell-associated protein that binds to a bioactive molecule (i.e., a ligand) and mediates the effect of the ligand on the cell. Membrane-bound receptors are characterized by a multi-peptide structure comprising an extracellular ligand-binding domain and an intracellular effector domain that is typically involved in signal transduction. Binding of ligand to receptor results in a conformational change in the receptor that causes an interaction between the effector domain and other molecule(s) in the cell. This interaction in turn leads to an alteration in the metabolism of the cell. Metabolic events that are linked to receptor-ligand interactions include gene transcription, phosphorylation, dephosphorylation, increases in cyclic AMP production, mobilization of cellular calcium, mobilization of membrane lipids, cell adhesion, hydrolysis of inositol lipids and hydrolysis of phospholipids. In general, receptors can be membrane bound, cytosolic or nuclear; monomeric (e.g., thyroid stimulating hormone receptor, beta-adrenergic receptor) or multimeric (e.g., PDGF receptor, growth hormone receptor, IL-3 receptor, GM-CSF receptor, G-CSF receptor, erythropoietin receptor and IL-6 receptor).

[47] The term "secretory signal sequence" denotes a DNA sequence that encodes a polypeptide (a "secretory peptide") that, as a component of a larger polypeptide, directs the larger polypeptide through a secretory pathway of a cell in which it is synthesized. The larger polypeptide is commonly cleaved to remove the secretory peptide during transit through the secretory pathway.

[48] Molecular weights and lengths of polymers determined by imprecise analytical methods (e.g., gel electrophoresis) will be understood to be approximate values. When such a value is expressed as "about" X or "approximately" X, the stated value of X will be understood to be accurate to $\pm 10\%$.

[49] "zcyto20", "zcyto21", "zcyto22" are the previous designations for human IL-28A, human IL-29, and human IL-28B, respectively, and are used interchangeably herein. The nucleotide and amino acid sequence for IL-28A are shown in SEQ ID NO:1 and SEQ ID NO:2, respectively. The nucleotide and amino acid sequences for IL-29 are shown in SEQ ID NO:3 and SEQ ID NO:4, respectively. The nucleotide and amino acid sequence for IL-28B are shown in SEQ ID NO:5 and SEQ ID NO:6, respectively. These sequences are fully described in PCT application WO 02/086087, U.S. Patent No. 6,927,040, PCT Application WO 04/037995, PCT Application WO 05/023862, PCT Application WO 05/097165, and PCT Application 06/012644 commonly assigned to ZymoGenetics, Inc., all of which are herein incorporated by reference.

[50] "zcyto24" and "zcyto25" are the previous designations for mouse IL-28, and are shown in SEQ ID NOs: 7, 8, 9, 10, respectively. The polynucleotide and polypeptides are fully described in PCT application WO 02/086087 commonly assigned to ZymoGenetics, Inc., incorporated herein by reference.

[51] "zcytor19" is the previous designation for IL-28 receptor α -subunit, and is shown in SEQ ID NO: 11. The polynucleotides and polypeptides are described in PCT application WO 02/20569 on behalf of Schering, Inc., and WO 02/44209 assigned to ZymoGenetics, Inc and incorporated herein by reference. "IL-28 receptor" denotes the IL-28 α -subunit and CRF2-4 subunit forming a heterodimeric receptor.

[52] All references cited herein are incorporated by reference in their entirety.

A. IL-28, IL-29 and its Receptor

[53] When referring to IL-28, the term shall mean both IL-28A and IL-28B. Previously IL-28A was designated zcyto20 (SEQ ID NOs: 1 and 2), IL-29 was designated zcyto21 (SEQ ID NOs: 3 and 4), and IL-28B was designated zcyto22 (SEQ ID NOs: 5 and 6). (See, PCT application WO 02/086087 and Sheppard et al., *supra*.) The mouse orthologs for IL-28 were previously designated as zcyto24 (SEQ ID NOs: 7 and 8), zcyto25 (SEQ ID NOs: 9 and 10).

[54] Wildtype IL-28A gene encodes a polypeptide of 200 amino acids, as shown in SEQ ID NO: 2. The signal sequence for IL-28A can be predicted as comprising amino acid residue -25 (Met) through amino acid residue -1 (Ala) of SEQ ID NO: 2. The mature peptide for IL-28A begins at amino acid residue 1 (Val). IL-28A helices are predicted as follow: helix A is defined by amino acid residues 24 (Leu) to 40 (Glu); helix B by amino acid residues 58 (Thr) to 65 (Gln); helix C by amino acid residues 69 (Arg) to 85 (Ala); helix D by amino acid residues 95 (Val) to 114 (Ala); helix E by amino acid residues 126 (Thr) to 142 (Lys); and helix F by amino acid residues 148 (Cys) to 169 (Ala); as shown in SEQ ID NO: 2.

[55] Wildtype IL-29 gene encodes a polypeptide of 200 amino acids, as shown in SEQ ID NO: 4. The signal sequence for IL-29 can be predicted as comprising amino acid residue -19 (Met) through amino acid residue -1 (Ala) of SEQ ID NO: 4, SEQ ID NO: 119, or SEQ ID NO: 121. The mature peptide for IL-29 begins at amino acid residue 1 (Gly). IL-29 has been described in PCT application WO 02/02627. IL-29 helices are predicted as follows: helix A is defined by amino acid residues 30 (Ser) to 44 (Leu); helix B by amino acid residues 57 (Asn) to 65 (Val); helix C by amino acid residues 70 (Val) to 85 (Ala); helix D by amino acid residues 92 (Glu) to 114 (Gln); helix E by amino acid residues 118 (Thr) to 139 (Lys); and helix F by amino acid residues 144 (Gly) to 170 (Leu); as shown in SEQ ID NO: 4.

[56] Wildtype IL-28B gene encodes a polypeptide of 200 amino acids, as shown in SEQ ID NO: 6. The signal sequence for IL-28B can be predicted as comprising amino acid residue -21 (Met) through amino acid residue -1 (Ala) of SEQ ID NO: 6. The mature peptide for IL-28B begins at amino acid residue 1 (Val). IL-28B helices are predicted as follow: helix A is defined by amino acid residues 8 (Leu) to 41 (Glu); helix B by amino acid residues 58 (Trp) to 65 (Gln); helix C by amino acid residues 69 (Arg) to 86 (Ala); helix D by amino acid residues 95 (Gly) to 114 (Ala); helix

E by amino acid residues 126 (Thr) to 142 (Lys); and helix F by amino acid residues 148 (Cys) to 169 (Ala); as shown in SEQ ID NO: 6.

[57] The present invention provides mutations in the IL-28 and IL-29 wildtype sequences as shown in, for example, SEQ ID NOs: 1, 2, 3, 4, 5, and 6, that result in expression of single forms of the IL-28 or IL-29 molecule. Because the heterogeneity of forms is believed to be a result of multiple intramolecular disulfide bonding patterns, specific embodiments of the present invention includes mutations to the cysteine residues within the wildtype IL-28 and IL-29 sequences. When IL-28 and IL-29 are expressed in *E. coli*, an N-terminal Methionine is present. SEQ ID NOs:12-17, for example, show the nucleotide and amino acid residue numbering for IL-28A, IL-29 and IL-28B when the N-terminal Met is present. Table 1 shows the possible combinations of intramolecular disulfide bonded cysteine pairs for wildtype IL-28A, IL-28B, and IL-29.

Table 1

IL-28A SEQ ID NO:2	C ₁₆ - C ₁₁₅	C ₄₈ - C ₁₄₈	C ₅₀ - C ₁₄₈	C ₁₆₇ - C ₁₇₄	C ₁₆ -C ₄₈	C ₁₆ -C ₅₀	C ₄₈ - C ₁₁₅	C ₅₀ - C ₁₁₅	C ₁₁₅ - C ₁₄₈
Met IL- 28A SEQ ID NO:13	C ₁₇ - C ₁₁₆	C ₄₉ - C ₁₄₉	C ₅₁ - C ₁₄₉₈	C ₁₆₈ - C ₁₇₅	C ₁₇ -C ₄₉	C ₁₇ -C ₅₁	C ₄₉ - C ₁₁₆	C ₅₁ - C ₁₁₆	C ₁₁₆ - C ₁₄₉
IL-29 SEQ ID NO:4	C ₁₅ - C ₁₁₂	C ₄₉ - C ₁₄₅	C ₁₁₂ - C ₁₇₁						
Met IL-29 SEQ ID NO:15	C ₁₆ - C ₁₁₃	C ₅₀ - C ₁₄₆	C ₁₁₃ - C ₁₇₂						
IL-28B SEQ ID NO:6	C ₁₆ - C ₁₁₅	C ₄₈ - C ₁₄₈	C ₅₀ - C ₁₄₈	C ₁₆₇ - C ₁₇₄	C ₁₆ -C ₄₈	C ₁₆ -C ₅₀	C ₄₈ - C ₁₁₅	C ₅₀ - C ₁₁₅	C ₁₁₅ - C ₁₄₈
Met IL- 28B SEQ ID NO:17	C ₁₇ - C ₁₁₆	C ₄₉ - C ₁₄₉	C ₅₁ - C ₁₄₉₈	C ₁₆₈ - C ₁₇₅	C ₁₇ -C ₄₉	C ₁₇ -C ₅₁	C ₄₉ - C ₁₁₆	C ₅₁ - C ₁₁₆	C ₁₁₆ - C ₁₄₉

[58] The polynucleotide and polypeptide molecules of the present invention may have a mutation at one or more of the Cysteines present in the wildtype IL-28A, IL-29 or IL-28B molecules, yet retain some biological activity as described herein. Table 2 illustrates exemplary Cysteine mutants, in particular point mutations of cysteine (C) to serine (S).

Table 2

IL-28A C48S	SEQ ID NO:19
Met IL-28A C49S	SEQ ID NO:21
IL-28A C50S	SEQ ID NO:23
Met IL-28A C51S	SEQ ID NO:25
IL-29 C171S	SEQ ID NO:27
Met IL-29 C172S	SEQ ID NO:29

[59] All the members of the family have been shown to bind to the same class II cytokine receptor, IL-28R. IL-28 α -subunit was previously designated zcytor19 receptor. While not wanting to be bound by theory, these molecules appear to all signal through IL-28R receptor via the same pathway. IL-28 receptor is described in a commonly assigned PCT patent application WO 02/44209, incorporated by reference herein; Sheppard et al., *supra*; Kotenko et al., *Nature Immunol.* 4:69-77, 2003; and PCT WO/03/040345. IL-28R is a member of the Class II cytokine receptors which is characterized by the presence of one or more cytokine receptor modules (CRM) in their extracellular domains. Other class II cytokine receptors include zcytor11 (commonly owned US Patent No. 5,965,704), CRF2-4 (Genbank Accession No. Z17227), IL-10R (Genbank Accession No.s U00672 and NM_001558), DIRS1, zcytor7 (commonly owned US Patent No. 5,945,511), and tissue factor. IL-28 receptor, like all known class II receptors except interferon-alpha/beta receptor alpha chain, has only a single class II CRM in its extracellular domain.

[60] Four-helical bundle cytokines are also grouped by the length of their component helices. "Long-helix" form cytokines generally consist of between 24-30 residue helices, and include IL-6, ciliary neurotrophic factor (CNTF), leukemia inhibitory factor (LIF) and human growth hormone (hGH). "Short-helix" form cytokines generally consist of between 18-21 residue helices and include IL-2, IL-4 and GM-CSF. Studies using CNTF and IL-6 demonstrated that a CNTF helix can be exchanged for the equivalent helix in IL-6, conferring CTNF-binding properties to the chimera. Thus, it appears that functional domains of four-helical cytokines are determined on the basis of structural homology, irrespective of sequence identity, and can maintain functional integrity in a chimera (Kallen et al., *J. Biol. Chem.* 274:11859-11867, 1999). Therefore, IL-28 and IL-29 polypeptides will be useful for preparing chimeric fusion molecules, particularly with other interferons to determine and modulate receptor binding specificity. Of particular interest are fusion

proteins that combine helical and loop domains from interferons and cytokines such as INF- α , IL-10, human growth hormone.

[61] The present invention provides polynucleotide molecules, including DNA and RNA molecules, which encode IL-28 or IL-29 polypeptides. For example, the present invention provides degenerate nucleotide sequences encoding IL-28A C48S, Met IL-28A C49S, IL-28A C50S, Met IL-28A C51S, IL-29 C171S and Met IL-29 C172S polypeptides disclosed herein. Those skilled in the art will readily recognize that, in view of the degeneracy of the genetic code, considerable sequence variation is possible among these polynucleotide molecules. SEQ ID NOs:30, 31, 32, 33, 34, and 35 are a degenerate DNA sequences that encompasses all DNAs that encode IL-28A C48S, Met IL-28A C49S, IL-28A C50S, Met IL-28A C51S, IL-29 C171S and Met IL-29 C172S, respectively. Those skilled in the art will recognize that the degenerate sequence of SEQ ID NOs: 30, 31, 32, 33, 34, and 35 also provides all RNA sequences encoding SEQ ID NOs: 30, 31, 32, 33, 34, and 35 by substituting U for T and are thus contemplated by the present invention.

[62] A zcyto20 or IL-28A gene encodes a polypeptide of 205 amino acids, as shown in SEQ ID NO:2. The signal sequence for IL-28A comprises amino acid residue -25 (Met) through amino acid residue -1 (Ala) of SEQ ID NO:2, or alternatively amino acid residues -21 (Met) through amino acid residue -1 (Ala) of SEQ ID NO:2. The mature peptide for IL-28A begins at amino acid residue 1 (Val) of SEQ ID NO:2. Zcyto20 helices are predicted as follow: helix A is defined by amino acid residues 52 (Ala) to 66 (Leu); helix B by amino acid residues 78 (Arg) to 87 (Val); helix C by amino acid residues 91 (Pro) to 108 (Thr); helix D by amino acid residues 116 (Val) to 138 (Ser); helix E by amino acid residues 151 (Thr) to 172 (Lys); and helix F by amino acid residues 177 (Gly) to 197 (Cys); as shown in SEQ ID NO:2. Further analysis of Zcyto20 based on multiple alignments predicts that cysteines at amino acid residues 37 and 136; 69 and 197; and 71 and 178 (as shown in SEQ ID NO:2) will form intramolecular disulfide bonds. The corresponding polynucleotides encoding the Zcyto20 polypeptide regions, domains, motifs, residues and sequences described herein are as shown in SEQ ID NO:1. When a polynucleotide sequence encoding the mature polypeptide is expressed in a prokaryotic system, such as *E. coli*, the a secretory signal sequence may not be required and the an N-terminal Met will be present, resulting in expression of a polypeptide such as is shown in SEQ ID NO:13.

[63] IL-28A polypeptides of the present invention also include a mutation at the second cysteine, C2, of the mature polypeptide. For example, C2 from the N-terminus of the polypeptide of SEQ ID NO:2 is the cysteine at amino acid position 48, or position 49 (additional N-terminal Met) if expressed in *E coli* (see, for example, SEQ ID NO:13). This second cysteine (of which there are seven, like IL-28B) or C2 of IL-28A can be mutated, for example, to a serine, alanine, threonine, valine, or asparagine. IL-28A C2 mutant molecules of the present invention include, for example, polynucleotide molecules as shown in SEQ ID NOs:18 and 20, including DNA and RNA molecules,

that encode IL-28A C2 mutant polypeptides as shown in SEQ ID NOs:19 and 21, respectively. Additional IL-28A C2 mutant molecules of the present invention include polypeptides as shown in SEQ ID NOs:36, 37 and 163.

[64] The present invention also includes biologically active mutants of IL-28A C2 cysteine mutants which provide, at least partially, anti-tumor activity and/or immune regulatory activity. The second cysteine or C2 from the N-terminus of IL-28A can be mutated to any amino acid that does not form a disulfide bond with another cysteine, e.g., serine, alanine, threonine, valine or asparagine. The biologically active mutants of IL-28A C2 cysteine mutants of the present invention include N-, C-, and N- and C-terminal deletions of IL-28A, e.g., the polypeptide of SEQ ID NO:163 encoded by the polynucleotide of SEQ ID NO:162.

[65] N-terminally modified biologically active mutants of IL-28A C2 mutants include, for example, amino acid residues 3-176 of SEQ ID NO:163 which is encoded by nucleotides 7-528 of SEQ ID NO:162; amino acid residues 4-176 of SEQ ID NO:163 which is encoded by nucleotides 10-528 of SEQ ID NO:162; amino acid residues 5-176 of SEQ ID NO:163 which is encoded by nucleotides 13-528 of SEQ ID NO:162; amino acid residues 6-176 of SEQ ID NO:163 which is encoded by nucleotides 16-528 of SEQ ID NO:162; amino acid residues 7-176 of SEQ ID NO:163 which is encoded by nucleotides 19-528 of SEQ ID NO:162; amino acid residues 8-176 of SEQ ID NO:163 which is encoded by nucleotides 22-528 of SEQ ID NO:162; amino acid residues 9-176 of SEQ ID NO:163 which is encoded by nucleotides 25-528 of SEQ ID NO:162; amino acid residues 10-176 of SEQ ID NO:163 which is encoded by nucleotides 28-528 of SEQ ID NO:162; amino acid residues 11-176 of SEQ ID NO:163 which is encoded by nucleotides 31-528 of SEQ ID NO:162; amino acid residues 12-176 of SEQ ID NO:163 which is encoded by nucleotides 34-528 of SEQ ID NO:162; amino acid residues 13-176 of SEQ ID NO:163 which is encoded by nucleotides 37-528 of SEQ ID NO:162; amino acid residues 14-176 of SEQ ID NO:163 which is encoded by nucleotides 40-528 of SEQ ID NO:162; amino acid residues 15-176 of SEQ ID NO:163 which is encoded by nucleotides 43-528 of SEQ ID NO:162; and amino acid residues 16-176 of SEQ ID NO:163 which is encoded by nucleotides 46-528 of SEQ ID NO:162. The N-terminally modified biologically active mutants of IL-28A C2 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[66] C-terminally modified biologically active mutants of IL-28A C2 mutants include, for example, amino acid residues 1-175 of SEQ ID NO:163 which is encoded by nucleotides 1-525 of SEQ ID NO:162.

[67] N-terminally and C-terminally modified biologically active mutants of IL-28A C2 mutants include, for example, amino acid residues 2-175 of SEQ ID NO:163 which is encoded by nucleotides 4-525 of SEQ ID NO:162; amino acid residues 3-175 of SEQ ID NO:163 which is encoded by nucleotides 7-525 of SEQ ID NO:162; amino acid residues 4-175 of SEQ ID NO:163

which is encoded by nucleotides 10-525 of SEQ ID NO:162; amino acid residues 5-175 of SEQ ID NO:163 which is encoded by nucleotides 13-525 of SEQ ID NO:162; amino acid residues 6-175 of SEQ ID NO:163 which is encoded by nucleotides 16-525 of SEQ ID NO:162; amino acid residues 7-175 of SEQ ID NO:163 which is encoded by nucleotides 19-525 of SEQ ID NO:162; amino acid residues 8-175 of SEQ ID NO:163 which is encoded by nucleotides 22-525 of SEQ ID NO:162; amino acid residues 9-175 of SEQ ID NO:163 which is encoded by nucleotides 25-525 of SEQ ID NO:162; amino acid residues 10-175 of SEQ ID NO:163 which is encoded by nucleotides 28-525 of SEQ ID NO:162; amino acid residues 11-175 of SEQ ID NO:163 which is encoded by nucleotides 31-525 of SEQ ID NO:162; amino acid residues 12-175 of SEQ ID NO:163 which is encoded by nucleotides 34-525 of SEQ ID NO:162; amino acid residues 13-175 of SEQ ID NO:163 which is encoded by nucleotides 37-525 of SEQ ID NO:162; amino acid residues 14-175 of SEQ ID NO:163 which is encoded by nucleotides 40-525 of SEQ ID NO:162; amino acid residues 15-175 of SEQ ID NO:163 which is encoded by nucleotides 43-525 of SEQ ID NO:162; amino acid residues 16-175 of SEQ ID NO:163 which is encoded by nucleotides 46-525 of SEQ ID NO:162; and amino acid residues 17-175 of SEQ ID NO:163 which is encoded by nucleotides 49-525 of SEQ ID NO:162. The N-terminally and C-terminally modified biologically active mutants of IL-28A C2 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[68] In addition to the IL-28A C2 mutants, the present invention also includes IL-28A polypeptides comprising a mutation at the third cysteine position, C3, of the mature polypeptide. For example, C3 from the N-terminus of the polypeptide of SEQ ID NO:2, is the cysteine at position 50, or position 51 (additional N-terminal Met) if expressed in *E. coli* (see, for example, SEQ ID NO:13). IL-28A C3 mutant molecules of the present invention include, for example, polynucleotide molecules as shown in SEQ ID NOs:22 and 24, including DNA and RNA molecules, that encode IL-28A C3 mutant polypeptides as shown in SEQ ID NOs:23 and 25, respectively. Additional IL-28A C3 mutant molecules of the present invention include polypeptides as shown in SEQ ID NOs:38, 39 and 165.

[69] The present invention also includes biologically active mutants of IL-28A C3 cysteine mutants which provide, at least partially, anti-tumor activity and/or immune regulatory activity. The third cysteine or C3 from the N-terminus of IL-28A can be mutated to any amino acid that does not form a disulfide bond with another cysteine, e.g., serine, alanine, threonine, valine or asparagine. The biologically active mutants of IL-28A C3 cysteine mutants of the present invention include N-, C-, and N- and C-terminal deletions of IL-28A, e.g., the polypeptide of SEQ ID NO:165 encoded by the polynucleotide of SEQ ID NO:164.

[70] N-terminally modified biologically active mutants of IL-28A C3 mutants include, for example, amino acid residues 2-176 of SEQ ID NO:165 which is encoded by nucleotides 4-528 of SEQ ID NO:164; amino acid residues 3-176 of SEQ ID NO:165 which is encoded by nucleotides 7-528 of SEQ ID NO:164; amino acid residues 4-176 of SEQ ID NO:165 which is encoded by

nucleotides 10-528 of SEQ ID NO:164; amino acid residues 5-176 of SEQ ID NO:165 which is encoded by nucleotides 13-528 of SEQ ID NO:164; amino acid residues 6-176 of SEQ ID NO:165 which is encoded by nucleotides 16-528 of SEQ ID NO:164; amino acid residues 7-176 of SEQ ID NO:165 which is encoded by nucleotides 19-528 of SEQ ID NO:164; amino acid residues 8-176 of SEQ ID NO:165 which is encoded by nucleotides 22-528 of SEQ ID NO:164; amino acid residues 9-176 of SEQ ID NO:165 which is encoded by nucleotides 25-528 of SEQ ID NO:164; amino acid residues 10-176 of SEQ ID NO:165 which is encoded by nucleotides 28-528 of SEQ ID NO:164; amino acid residues 11-176 of SEQ ID NO:165 which is encoded by nucleotides 31-528 of SEQ ID NO:164; amino acid residues 12-176 of SEQ ID NO:165 which is encoded by nucleotides 34-528 of SEQ ID NO:164; amino acid residues 13-176 of SEQ ID NO:165 which is encoded by nucleotides 37-528 of SEQ ID NO:164; amino acid residues 14-176 of SEQ ID NO:165 which is encoded by nucleotides 40-528 of SEQ ID NO:164; amino acid residues 15-176 of SEQ ID NO:165 which is encoded by nucleotides 43-528 of SEQ ID NO:164; and amino acid residues 16-176 of SEQ ID NO:165 which is encoded by nucleotides 46-528 of SEQ ID NO:164. The N-terminally modified biologically active mutants of IL-28A C3 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[71] C-terminally modified biologically active mutants of IL-28A C3 mutants include, for example, amino acid residues 1-175 of SEQ ID NO:165 which is encoded by nucleotides 1-525 of SEQ ID NO:164.

[72] N-terminally and C-terminally modified biologically active mutants of IL-28A C3 mutants include, for example, amino acid residues 2-175 of SEQ ID NO:165 which is encoded by nucleotides 4-525 of SEQ ID NO:164; amino acid residues 3-175 of SEQ ID NO:165 which is encoded by nucleotides 7-525 of SEQ ID NO:164; amino acid residues 4-175 which is encoded by nucleotides 10-525 of SEQ ID NO:164; amino acid residues 5-175 of SEQ ID NO:165 which is encoded by nucleotides 13-525 of SEQ ID NO:164; amino acid residues 6-175 of SEQ ID NO:165 which is encoded by nucleotides 16-525 of SEQ ID NO:164; amino acid residues 7-175 of SEQ ID NO:165 which is encoded by nucleotides 19-525 of SEQ ID NO:164; amino acid residues 8-175 of SEQ ID NO:165 which is encoded by nucleotides 22-525 of SEQ ID NO:164; amino acid residues 9-175 of SEQ ID NO:165 which is encoded by nucleotides 25-525 of SEQ ID NO:164; amino acid residues 10-175 of SEQ ID NO:165 which is encoded by nucleotides 28-525 of SEQ ID NO:164; amino acid residues 11-175 of SEQ ID NO:165 which is encoded by nucleotides 31-525 of SEQ ID NO:164; amino acid residues 12-175 of SEQ ID NO:165 which is encoded by nucleotides 34-525 of SEQ ID NO:164; amino acid residues 13-175 of SEQ ID NO:165 which is encoded by nucleotides 37-525 of SEQ ID NO:164; amino acid residues 14-175 of SEQ ID NO:165 which is encoded by nucleotides 40-525 of SEQ ID NO:164; amino acid residues 15-175 of SEQ ID NO:165 which is encoded by nucleotides 43-525 of SEQ ID NO:164; amino acid residues 16-175 of SEQ ID NO:165

which is encoded by nucleotides 46-525 of SEQ ID NO:164; and amino acid residues 17-175 of SEQ ID NO:165 which is encoded by nucleotides 49-525 of SEQ ID NO:164. The N-terminally and C-terminally modified biologically active mutants of IL-28A C3 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[73] The IL-28A polypeptides of the present invention include, for example, SEQ ID NOs:2, 13, 19, 21, 23, 25, 163 and 165 which are encoded by IL-28A polynucleotide molecules as shown in SEQ ID NOs:1, 12, 18, 20, 22, 24, 162 and 164, respectively. In addition, the present invention also provides for IL-28A polypeptides as shown in SEQ ID NOs:36, 37, 38, and 39, C2 mutants thereof, N-terminally modified C2 mutants thereof, C-terminally modified C2 mutants thereof, N-terminally and C-terminally C2 mutants thereof, C3 mutants thereof, N-terminally modified C3 mutants thereof, C-terminally modified C3 mutants thereof, N-terminally and C-terminally modified C3 mutants thereof, fragments thereof, and fusion proteins thereof.

[74] A Zcyto22 or IL-28B gene encodes a polypeptide of 205 amino acids, as shown in SEQ ID NO:6. The signal sequence for IL-28B comprises amino acid residue -25 (Met) through amino acid residue 0 (Ala) of SEQ ID NO:6, or alternatively amino acid residues -21 (Met) through amino acid residue 0 (Ala) of SEQ ID NO:6. The mature peptide for IL-28B begins at amino acid residue 1 (Val) of SEQ ID NO:6. IL-28B helices are predicted as follow: helix A is defined by amino acid residues 8 (Leu) to 41 (Glu); helix B by amino acid residues 58 (Trp) to 65 (Gln); helix C by amino acid residues 69 (Arg) to 86 (Ala); helix D by amino acid residues 95 (Gly) to 114 (Ala); helix E by amino acid residues 126 (Thr) to 142 (Lys); and helix F by amino acid residues 148 (Cys) to 169 (Ala); as shown in SEQ ID NO:6. When a polynucleotide sequence encoding the mature polypeptide is expressed in a prokaryotic system, such as *E. coli*, the a secretory signal sequence may not be required and the an N-terminal Met will be present, resulting in expression of a polypeptide such as is shown in SEQ ID NO:17.

[75] IL-28B polypeptides of the present invention also include a mutation at the second cysteine, C2, of the mature polypeptide. For example, C2 from the N-terminus of the polypeptide of SEQ ID NO:6 is the cysteine at amino acid position 48, or position 49 (additional N-terminal Met) if expressed in *E. coli* (see, for example, SEQ ID NO:17). This second cysteine (of which there are seven, like IL-28A) or C2 of IL-28B can be mutated, for example, to a serine, alanine, threonine, valine, or asparagine. IL-28B C2 mutant molecules of the present invention include, for example, polynucleotide molecules as shown in SEQ ID NOs:122 and 124, including DNA and RNA molecules, that encode IL-28B C2 mutant polypeptides as shown in SEQ ID NOs:123 and 125, respectively. Additional IL-28B C2 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:130 and 132 including DNA and RNA molecules, that encode IL-28B C2 mutant polypeptides as shown in SEQ ID NOs:131 and 133, respectively (PCT publication WO 03/066002 (Kotenko et al.)).

[76] The present invention also includes biologically active mutants of IL-28B C2 cysteine mutants which provide, at least partially, anti-tumor activity and/or immune regulatory activity. The second cysteine or C2 from the N-terminus of IL-28B can mutated to any amino acid that does not form a disulfide bond with another cysteine, e.g., serine, alanine, threonine, valine or asparagine. The biologically active mutants of IL-28B C2 cysteine mutants of the present invention include N-, C-, and N- and C-terminal deletions of IL-28B, e.g., the polypeptide of SEQ ID NO:167 encoded by the polynucleotide of SEQ ID NO:166.

[77] N-terminally modified biologically active mutants of IL-28B C2 mutants include, for example, amino acid residues 2-176 of SEQ ID NO:167 which is encoded by nucleotides 4-528 of SEQ ID NO:166; amino acid residues 3-176 of SEQ ID NO:167 which is encoded by nucleotides 7-528 of SEQ ID NO:166; amino acid residues 4-176 of SEQ ID NO:167 which is encoded by nucleotides 10-528 of SEQ ID NO:166; amino acid residues 5-176 of SEQ ID NO:167 which is encoded by nucleotides 13-528 of SEQ ID NO:166; amino acid residues 6-176 of SEQ ID NO:167 which is encoded by nucleotides 16-528 of SEQ ID NO:166; amino acid residues 7-176 of SEQ ID NO:167 which is encoded by nucleotides 19-528 of SEQ ID NO:166; amino acid residues 8-176 of SEQ ID NO:167 which is encoded by nucleotides 22-528 of SEQ ID NO:166; amino acid residues 9-176 of SEQ ID NO:167 which is encoded by nucleotides 25-528 of SEQ ID NO:166; amino acid residues 10-176 of SEQ ID NO:167 which is encoded by nucleotides 28-528 of SEQ ID NO:166; amino acid residues 11-176 of SEQ ID NO:167 which is encoded by nucleotides 31-528 of SEQ ID NO:166; amino acid residues 12-176 of SEQ ID NO:167 which is encoded by nucleotides 34-528 of SEQ ID NO:166; amino acid residues 13-176 of SEQ ID NO:167 which is encoded by nucleotides 37-528 of SEQ ID NO:166; amino acid residues 14-176 of SEQ ID NO:167 which is encoded by nucleotides 40-528 of SEQ ID NO:166; amino acid residues 15-176 of SEQ ID NO:167 which is encoded by nucleotides 43-528 of SEQ ID NO:166; amino acid residues 16-176 of SEQ ID NO:167 which is encoded by nucleotides 46-528 of SEQ ID NO:166; and amino acid residues 17-176 of SEQ ID NO:167 which is encoded by nucleotides 49-528 of SEQ ID NO:166. The N-terminally modified biologically active mutants of IL-28 C2 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[78] C-terminally modified biologically active mutants of IL-28B C2 mutants include, for example, amino acid residues 1-175 of SEQ ID NO:167 which is encoded by nucleotides 1-525 of SEQ ID NO:166.

[79] N-terminally and C-terminally biologically active mutants of IL-28B C2 mutants include, for example, amino acid residues 2-175 of SEQ ID NO:167 which is encoded by nucleotides 4-525 of SEQ ID NO:166; amino acid residues 3-175 of SEQ ID NO:167 which is encoded by nucleotides 7-525 of SEQ ID NO:166; amino acid residues 4-175 of SEQ ID NO:167 which is encoded by nucleotides 10-525 of SEQ ID NO:166; amino acid residues 5-175 of SEQ ID NO:167

which is encoded by nucleotides 13-525 of SEQ ID NO:166; amino acid residues 6-175 of SEQ ID NO:167 which is encoded by nucleotides 16-525 of SEQ ID NO:166; amino acid residues 7-175 of SEQ ID NO:167 which is encoded by nucleotides 19-525 of SEQ ID NO:166; amino acid residues 8-175 of SEQ ID NO:167 which is encoded by nucleotides 22-525 of SEQ ID NO:166; amino acid residues 9-175 of SEQ ID NO:167 which is encoded by nucleotides 25-525 of SEQ ID NO:166; amino acid residues 10-175 of SEQ ID NO:167 which is encoded by nucleotides 28-525 of SEQ ID NO:166; amino acid residues 11-175 of SEQ ID NO:167 which is encoded by nucleotides 31-525 of SEQ ID NO:166; amino acid residues 12-175 of SEQ ID NO:167 which is encoded by nucleotides 34-525 of SEQ ID NO:166; amino acid residues 13-175 of SEQ ID NO:167 which is encoded by nucleotides 37-525 of SEQ ID NO:166; amino acid residues 14-175 of SEQ ID NO:167 which is encoded by nucleotides 40-525 of SEQ ID NO:166; amino acid residues 15-175 of SEQ ID NO:167 which is encoded by nucleotides 43-525 of SEQ ID NO:166; amino acid residues 16-175 of SEQ ID NO:167 which is encoded by nucleotides 46-525 of SEQ ID NO:166; and amino acid residues 17-175 of SEQ ID NO:167 which is encoded by nucleotides 49-525 of SEQ ID NO:166. The N-terminally and C-terminally modified biologically active mutants of IL-28 C2 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[80] In addition to the IL-28B C2 mutants, the present invention also includes IL-28B polypeptides comprising a mutation at the third cysteine position, C3, of the mature polypeptide. For example, C3 from the N-terminus of the polypeptide of SEQ ID NO:6, is the cysteine at position 50, or position 51 (additional N-terminal Met) if expressed in *E. coli* (see, for example, SEQ ID NO:17). IL-28B C3 mutant molecules of the present invention include, for example, polynucleotide molecules as shown in SEQ ID NOs:126 and 128, including DNA and RNA molecules, that encode IL-28B C3 mutant polypeptides as shown in SEQ ID NOs:127 and 129, respectively (PCT publication WO 03/066002 (Kotenko et al.)). Additional IL-28B C3 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:134 and 136 including DNA and RNA molecules, that encode IL-28B C3 mutant polypeptides as shown in SEQ ID NOs:135 and 137, respectively (PCT publication WO 03/066002 (Kotenko et al.)).

[81] N-terminally biologically active mutants of IL-28B C3 mutants include, for example, amino acid residues 2-176 of SEQ ID NO:169 which is encoded by nucleotides 4-528 of SEQ ID NO:168; amino acid residues 3-176 of SEQ ID NO:169 which is encoded by nucleotides 7-528 of SEQ ID NO:168; amino acid residues 4-176 of SEQ ID NO:169 which is encoded by nucleotides 10-528 of SEQ ID NO:168; amino acid residues 5-176 of SEQ ID NO:169 which is encoded by nucleotides 13-528 of SEQ ID NO:168; amino acid residues 6-176 of SEQ ID NO:169 which is encoded by nucleotides 16-528 of SEQ ID NO:168; amino acid residues 7-176 of SEQ ID NO:169 which is encoded by nucleotides 19-528 of SEQ ID NO:168; amino acid residues 8-176 of SEQ ID NO:169 which is encoded by nucleotides 22-528 of SEQ ID NO:168; amino acid residues 9-176 of

SEQ ID NO:169 which is encoded by nucleotides 25-528 of SEQ ID NO:168; amino acid residues 10-176 of SEQ ID NO:169 which is encoded by nucleotides 28-528 of SEQ ID NO:168; amino acid residues 11-176 of SEQ ID NO:169 which is encoded by nucleotides 31-528 of SEQ ID NO:168; amino acid residues 12-176 of SEQ ID NO:169 which is encoded by nucleotides 34-528 of SEQ ID NO:168; amino acid residues 13-176 of SEQ ID NO:169 which is encoded by nucleotides 37-528 of SEQ ID NO:168; amino acid residues 14-176 of SEQ ID NO:169 which is encoded by nucleotides 40-528 of SEQ ID NO:168; amino acid residues 15-176 of SEQ ID NO:169 which is encoded by nucleotides 43-528 of SEQ ID NO:168; amino acid residues 16-176 of SEQ ID NO:169 which is encoded by nucleotides 46-528 of SEQ ID NO:168; and amino acid residues 17-176 of SEQ ID NO:169 which is encoded by nucleotides 49-528 of SEQ ID NO:168. The N-terminally modified biologically active mutants of IL-28 C3 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[82] C-terminally modified biologically active mutants of IL-28B C3 mutants include, for example, amino acid residues 1-175 of SEQ ID NO:169 which is encoded by nucleotides 1-525 of SEQ ID NO:168.

[83] N-terminally and C-terminally biologically active mutants of IL-28B C3 mutants include, for example, amino acid residues 2-175 of SEQ ID NO:169 which is encoded by nucleotides 4-525 of SEQ ID NO:168; amino acid residues 3-175 of SEQ ID NO:169 which is encoded by nucleotides 7-525 of SEQ ID NO:168; amino acid residues 4-175 of SEQ ID NO:169 which is encoded by nucleotides 10-525 of SEQ ID NO:168; amino acid residues 5-175 of SEQ ID NO:169 which is encoded by nucleotides 13-525 of SEQ ID NO:168; amino acid residues 6-175 of SEQ ID NO:169 which is encoded by nucleotides 16-525 of SEQ ID NO:168; amino acid residues 7-175 of SEQ ID NO:169 which is encoded by nucleotides 19-525 of SEQ ID NO:168; amino acid residues 8-175 of SEQ ID NO:169 which is encoded by nucleotides 22-525 of SEQ ID NO:168; amino acid residues 9-175 of SEQ ID NO:169 which is encoded by nucleotides 25-525 of SEQ ID NO:168; amino acid residues 10-175 of SEQ ID NO:169 which is encoded by nucleotides 28-525 of SEQ ID NO:168; amino acid residues 11-175 of SEQ ID NO:169 which is encoded by nucleotides 31-525 of SEQ ID NO:168; amino acid residues 12-175 of SEQ ID NO:169 which is encoded by nucleotides 34-525 of SEQ ID NO:168; amino acid residues 13-175 of SEQ ID NO:169 which is encoded by nucleotides 37-525 of SEQ ID NO:168; amino acid residues 14-175 of SEQ ID NO:169 which is encoded by nucleotides 40-525 of SEQ ID NO:168; amino acid residues 15-175 of SEQ ID NO:169 which is encoded by nucleotides 43-525 of SEQ ID NO:168; amino acid residues 16-175 of SEQ ID NO:169 which is encoded by nucleotides 46-525 of SEQ ID NO:168; and amino acid residues 17-175 of SEQ ID NO:169 which is encoded by nucleotides 49-525 of SEQ ID NO:168. The N-terminally and C-terminally modified biologically active mutants of IL-28 C3 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[84] The IL-28B polypeptides of the present invention include, for example, SEQ ID NOs:6, 17, 123, 125, 127, 129, 131, 133, 135, 137, 167 and 169, which are encoded by IL-28B polynucleotide molecules as shown in SEQ ID NOs:5, 16, 122, 124, 126, 128, 130, 132, 134, 136, 166 and 168, respectively, C2 mutants thereof, N-terminally modified C2 mutants thereof, C-terminally modified C2 mutants thereof, N-terminally and C-terminally C2 mutants thereof, C3 mutants thereof, N-terminally modified C3 mutants thereof, C-terminally modified C3 mutants thereof, N-terminally and C-terminally modified C3 mutants thereof, fragments thereof, and fusion proteins thereof.

[85] Zcyto21 or IL-29 polypeptides of the present invention also include a mutation at the fifth cysteine, C5, of the mature polypeptide. For example, C5 from the N-terminus of the polypeptide of SEQ ID NO:4, is the cysteine at position 171, or position 172 (additional N-terminal Met) if expressed in *E. coli*. (see, for example, SEQ ID NO:15). This fifth cysteine or C5 of IL-29 can be mutated, for example, to a serine, alanine, threonine, valine, or asparagine. These IL-29 C5 mutant polypeptides have a disulfide bond pattern of C1(Cys15 of SEQ ID NO:4)/C3(Cys112 of SEQ ID NO:4) and C2(Cys49 of SEQ ID NO:4)/C4(Cys145 of SEQ ID NO:4). Additional IL-29 C5 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:26, 28, 82, 84, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, and 160, including DNA and RNA molecules, that encode IL-29 C5 mutant polypeptides as shown in SEQ ID NOs:27, 29, 83, 85, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, and 161, respectively. Additional IL-29 C5 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:86, 88, 94, and 96, including DNA and RNA molecules, that encode IL-29 C5 mutant polypeptides as shown in SEQ ID NOs:87, 89, 95, and 97, respectively (PCT publication WO 03/066002 (Kotenko et al.)). Additional, IL-29 C5 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:102, 104, 110, and 112, including DNA and RNA molecules, that encode IL-29 C5 mutant polypeptides as shown in SEQ ID NOs:103, 105, 111, and 113, respectively (PCT publication WO 02/092762 (Baum et al.)).

[86] The present invention also includes biologically active mutants of IL-29 C5 cysteine mutants which provide, at least partially, anti-tumor activity and/or immune regulatory activity. The fifth cysteine or C5 from the N-terminus of IL-29 can be mutated to any amino acid that does not form a disulfide bond with another cysteine, e.g., serine, alanine, threonine, valine or asparagine. The biologically active mutants of IL-29 C5 cysteine mutants of the present invention include N-, C-, and N- and C-terminal deletions of IL-29, e.g., the polypeptides of SEQ ID NOs:173 and 175 encoded by the polynucleotides of SEQ ID NOs:172 and 174, respectively.

[87] N-terminally modified biologically active mutants of IL-29 C5 mutants include, for example, amino acid residues 2-182 of SEQ ID NO:173 which is encoded by nucleotides 4-546 of SEQ ID NO:172; amino acid residues 3-182 of SEQ ID NO:173 which is encoded by nucleotides 7-546 of SEQ ID NO:172; amino acid residues 4-182 of SEQ ID NO:173 which is encoded by

nucleotides 10-546 of SEQ ID NO:172; amino acid residues 5-182 of SEQ ID NO:173 which is encoded by nucleotides 13-546 of SEQ ID NO:172; amino acid residues 6-182 of SEQ ID NO:173 which is encoded by nucleotides 16-546 of SEQ ID NO:172; amino acid residues 7-182 of SEQ ID NO:173 which is encoded by nucleotides 19-546 of SEQ ID NO:172; amino acid residues 8-182 of SEQ ID NO:173 which is encoded by nucleotides 22-546 of SEQ ID NO:172; amino acid residues 9-182 of SEQ ID NO:173 which is encoded by nucleotides 25-546 of SEQ ID NO:172; amino acid residues 10-182 of SEQ ID NO:173 which is encoded by nucleotides 28-546 of SEQ ID NO:172; amino acid residues 11-182 of SEQ ID NO:173 which is encoded by nucleotides 31-546 of SEQ ID NO:172; amino acid residues 12-182 of SEQ ID NO:173 which is encoded by nucleotides 34-546 of SEQ ID NO:172; amino acid residues 13-182 of SEQ ID NO:173 which is encoded by nucleotides 37-546 of SEQ ID NO:172; amino acid residues 14-182 of SEQ ID NO:173 which is encoded by nucleotides 40-546 of SEQ ID NO:172; amino acid residues 15-182 of SEQ ID NO:173 which is encoded by nucleotides 43-546 of SEQ ID NO:172; amino acid residues 2-176 of SEQ ID NO:150 which is encoded by nucleotides 4-528 of SEQ ID NO:149; amino acid residues 3-176 of SEQ ID NO:150 which is encoded by nucleotides 7-528 of SEQ ID NO:149; amino acid residues 4-176 of SEQ ID NO:150 which is encoded by nucleotides 10-528 of SEQ ID NO:149; amino acid residues 5-176 of SEQ ID NO:150 which is encoded by nucleotides 13-528 of SEQ ID NO:149; amino acid residues 6-176 of SEQ ID NO:150 which is encoded by nucleotides 16-528 of SEQ ID NO:149; amino acid residues 7-176 of SEQ ID NO:150 which is encoded by nucleotides 19-528 of SEQ ID NO:149; amino acid residues 8-176 of SEQ ID NO:150 which is encoded by nucleotides 22-528 of SEQ ID NO:149; and amino acid residues 9-176 of SEQ ID NO:150 which is encoded by nucleotides 25-528 of SEQ ID NO:149. The N-terminally modified biologically active mutants of IL-29 C5 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[88] C-terminally modified biologically active mutants of IL-29 C5 mutants include, for example, amino acid residues 1-181 of SEQ ID NO:173 which is encoded by nucleotides 1-543 of SEQ ID NO:172; amino acid residues 1-180 of SEQ ID NO:173 which is encoded by nucleotides 1-540 of SEQ ID NO:172; amino acid residues 1-179 of SEQ ID NO:173 which is encoded by nucleotides 1-537 of SEQ ID NO:172; amino acid residues 1-178 of SEQ ID NO:173 which is encoded by nucleotides 1-534 of SEQ ID NO:172; amino acid residues 1-177 of SEQ ID NO:173 which is encoded by nucleotides 1-531 of SEQ ID NO:172; amino acid residues 1-176 of SEQ ID NO:173 which is encoded by nucleotides 1-528 of SEQ ID NO:172; amino acid residues 1-175 of SEQ ID NO:173 which is encoded by nucleotides 1-525 of SEQ ID NO:172; amino acid residues 1-174 of SEQ ID NO:173 which is encoded by nucleotides 1-522 of SEQ ID NO:172; amino acid residues 1-173 of SEQ ID NO:173 which is encoded by nucleotides 1-519 of SEQ ID NO:172; amino acid residues 1-172 of SEQ ID NO:173 which is encoded by nucleotides 1-516 of SEQ ID NO:172;

amino acid residues 1-175 of SEQ ID NO:150 which is encoded by nucleotides 1-525 of SEQ ID NO:149; amino acid residues 1-174 of SEQ ID NO:150 which is encoded by nucleotides 1-522 of SEQ ID NO:149; amino acid residues 1-173 of SEQ ID NO:150 which is encoded by nucleotides 1-519 of SEQ ID NO:149; amino acid residues 1-172 of SEQ ID NO:150 which is encoded by nucleotides 1-516 of SEQ ID NO:149; amino acid residues 1-171 of SEQ ID NO:150 which is encoded by nucleotides 1-513 of SEQ ID NO:149; amino acid residues 1-170 of SEQ ID NO:150 which is encoded by nucleotides 1-510 of SEQ ID NO:149; amino acid residues 1-169 of SEQ ID NO:150 which is encoded by nucleotides 1-507 of SEQ ID NO:149; amino acid residues 1-168 of SEQ ID NO:150 which is encoded by nucleotides 1-504 of SEQ ID NO:149; amino acid residues 1-167 of SEQ ID NO:150 which is encoded by nucleotides 1-501 of SEQ ID NO:149; and amino acid residues 1-166 of SEQ ID NO:150 which is encoded by nucleotides 1-498 of SEQ ID NO:149.

[89] N-terminally and C-terminally modified biologically active mutants of IL-29 C5 mutants include, for example, amino acid residues 2-182 of SEQ ID NO:173 which is encoded by nucleotides 4-546 of SEQ ID NO:172; amino acid residues 2-181 of SEQ ID NO:173 which is encoded by nucleotides 4-543 of SEQ ID NO:172; amino acid residues 2-180 of SEQ ID NO:173 which is encoded by nucleotides 4-540 of SEQ ID NO:172; amino acid residues 2-179 of SEQ ID NO:173 which is encoded by nucleotides 4-537 of SEQ ID NO:172; amino acid residues 2-178 of SEQ ID NO:173 which is encoded by nucleotides 4-534 of SEQ ID NO:172; amino acid residues 2-177 of SEQ ID NO:173 which is encoded by nucleotides 4-531 of SEQ ID NO:172; amino acid residues 2-176 of SEQ ID NO:173 which is encoded by nucleotides 4-528 of SEQ ID NO:172; amino acid residues 2-175 of SEQ ID NO:173 which is encoded by nucleotides 4-525 of SEQ ID NO:172; amino acid residues 2-174 of SEQ ID NO:173 which is encoded by nucleotides 4-522 of SEQ ID NO:172; amino acid residues 2-173 of SEQ ID NO:173 which is encoded by nucleotides 4-519 of SEQ ID NO:172; amino acid residues 2-172 of SEQ ID NO:173 which is encoded by nucleotides 4-516 of SEQ ID NO:172; amino acid residues 3-182 of SEQ ID NO:173 which is encoded by nucleotides 7-546 of SEQ ID NO:172; amino acid residues 3-181 of SEQ ID NO:173 which is encoded by nucleotides 7-543 of SEQ ID NO:172; amino acid residues 3-180 of SEQ ID NO:173 which is encoded by nucleotides 7-540 of SEQ ID NO:172; amino acid residues 3-179 of SEQ ID NO:173 which is encoded by nucleotides 7-537 of SEQ ID NO:172; amino acid residues 3-178 of SEQ ID NO:173 which is encoded by nucleotides 7-534 of SEQ ID NO:172; amino acid residues 3-177 of SEQ ID NO:173 which is encoded by nucleotides 7-531 of SEQ ID NO:172; amino acid residues 3-176 of SEQ ID NO:173 which is encoded by nucleotides 7-528 of SEQ ID NO:172; amino acid residues 3-175 of SEQ ID NO:173 which is encoded by nucleotides 7-525 of SEQ ID NO:172; amino acid residues 3-174 of SEQ ID NO:173 which is encoded by nucleotides 7-522 of SEQ ID NO:172; amino acid residues 3-173 of SEQ ID NO:173 which is encoded by nucleotides 7-519 of SEQ ID NO:172; amino acid residues 3-172 of SEQ ID NO:173 which is encoded by nucleotides 7-

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nucleotides 43-519 of SEQ ID NO:172; amino acid residues 15-172 of SEQ ID NO:173 which is encoded by nucleotides 43-516 of SEQ ID NO:172; amino acid residues 16-182 of SEQ ID NO:173 which is encoded by nucleotides 46-546 of SEQ ID NO:172; amino acid residues 16-181 of SEQ ID NO:173 which is encoded by nucleotides 46-543 of SEQ ID NO:172; amino acid residues 16-180 of SEQ ID NO:173 which is encoded by nucleotides 46-540 of SEQ ID NO:172; amino acid residues 16-179 of SEQ ID NO:173 which is encoded by nucleotides 46-537 of SEQ ID NO:172; amino acid residues 16-178 of SEQ ID NO:173 which is encoded by nucleotides 46-534 of SEQ ID NO:172; amino acid residues 16-177 of SEQ ID NO:173 which is encoded by nucleotides 46-531 of SEQ ID NO:172; amino acid residues 16-176 of SEQ ID NO:173 which is encoded by nucleotides 46-528 of SEQ ID NO:172; amino acid residues 16-175 of SEQ ID NO:173 which is encoded by nucleotides 46-525 of SEQ ID NO:172; amino acid residues 16-174 of SEQ ID NO:173 which is encoded by nucleotides 46-522 of SEQ ID NO:172; amino acid residues 16-173 of SEQ ID NO:173 which is encoded by nucleotides 46-519 of SEQ ID NO:172; and amino acid residues 16-172 of SEQ ID NO:173 which is encoded by nucleotides 46-516 of SEQ ID NO:172. The N-terminally and C-terminally modified biologically active mutants of IL-29 C5 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[90] Additional IL-29 C5 N-terminally and C-terminally biologically active mutants include, for example, amino acid residues 2-176 of SEQ ID NO:175 which is encoded by nucleotides 4-528 of SEQ ID NO:174; amino acid residues 2-175 of SEQ ID NO:175 which is encoded by nucleotides 4-525 of SEQ ID NO:174; amino acid residues 2-174 of SEQ ID NO:175 which is encoded by nucleotides 4-522 of SEQ ID NO:174; amino acid residues 2-173 of SEQ ID NO:175 which is encoded by nucleotides 4-519 of SEQ ID NO:174; amino acid residues 2-172 of SEQ ID NO:175 which is encoded by nucleotides 4-516 of SEQ ID NO:174; amino acid residues 2-171 of SEQ ID NO:175 which is encoded by nucleotides 4-513 of SEQ ID NO:174; amino acid residues 2-170 of SEQ ID NO:175 which is encoded by nucleotides 4-510 of SEQ ID NO:174; amino acid residues 2-169 of SEQ ID NO:175 which is encoded by nucleotides 4-507 of SEQ ID NO:174; amino acid residues 2-168 of SEQ ID NO:175 which is encoded by nucleotides 4-504 of SEQ ID NO:174; amino acid residues 2-167 of SEQ ID NO:175 which is encoded by nucleotides 4-501 of SEQ ID NO:174; amino acid residues 2-166 of SEQ ID NO:175 which is encoded by nucleotides 4-498 of SEQ ID NO:174; amino acid residues 3-176 of SEQ ID NO:175 which is encoded by nucleotides 7-528 of SEQ ID NO:174; amino acid residues 3-175 of SEQ ID NO:175 which is encoded by nucleotides 7-525 of SEQ ID NO:174; amino acid residues 3-174 of SEQ ID NO:175 which is encoded by nucleotides 7-522 of SEQ ID NO:174; amino acid residues 3-173 of SEQ ID NO:175 which is encoded by nucleotides 7-519 of SEQ ID NO:174; amino acid residues 3-172 of SEQ ID NO:175 which is encoded by nucleotides 7-516 of SEQ ID NO:174; amino acid residues 3-171 of SEQ ID NO:175 which is encoded by nucleotides 7-513 of SEQ ID NO:174; amino acid residues 3-

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513 of SEQ ID NO:174; amino acid residues 9-170 of SEQ ID NO:175 which is encoded by nucleotides 25-510 of SEQ ID NO:174; amino acid residues 9-169 of SEQ ID NO:175 which is encoded by nucleotides 25-507 of SEQ ID NO:174; amino acid residues 9-168 of SEQ ID NO:175 which is encoded by nucleotides 25-504 of SEQ ID NO:174; amino acid residues 9-167 of SEQ ID NO:175 which is encoded by nucleotides 25-501 of SEQ ID NO:174; amino acid residues 9-166 of SEQ ID NO:175 which is encoded by nucleotides 25-498 of SEQ ID NO:174; amino acid residues 10-176 of SEQ ID NO:175 which is encoded by nucleotides 28-528 of SEQ ID NO:174; amino acid residues 10-175 of SEQ ID NO:175 which is encoded by nucleotides 28-525 of SEQ ID NO:174; amino acid residues 10-174 of SEQ ID NO:175 which is encoded by nucleotides 28-522 of SEQ ID NO:174; amino acid residues 10-173 of SEQ ID NO:175 which is encoded by nucleotides 28-519 of SEQ ID NO:174; amino acid residues 10-172 of SEQ ID NO:175 which is encoded by nucleotides 28-516 of SEQ ID NO:174; amino acid residues 10-171 of SEQ ID NO:175 which is encoded by nucleotides 28-513 of SEQ ID NO:174; amino acid residues 10-170 of SEQ ID NO:175 which is encoded by nucleotides 28-510 of SEQ ID NO:174; amino acid residues 10-169 of SEQ ID NO:175 which is encoded by nucleotides 28-507 of SEQ ID NO:174; amino acid residues 10-168 of SEQ ID NO:175 which is encoded by nucleotides 28-504 of SEQ ID NO:174; amino acid residues 10-167 of SEQ ID NO:175 which is encoded by nucleotides 28-501 of SEQ ID NO:174; and amino acid residues 10-166 of SEQ ID NO:175 which is encoded by nucleotides 28-498 of SEQ ID NO:174. The N-terminally and C-terminally modified biologically active mutants of IL-29 C5 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[91] In addition to the IL-29 C5 mutants, the present invention also includes IL-29 polypeptides comprising a mutation at the first cysteine position, C1, of the mature polypeptide. For example, C1 from the N-terminus of the polypeptide of SEQ ID NO:4, is the cysteine at position 15, or position 16 (additional N-terminal Met) if expressed in *E. coli* (see, for example, SEQ ID NO:15). These IL-29 C1 mutant polypeptides will thus have a predicted disulfide bond pattern of C2(Cys49 of SEQ ID NO:4)/C4(Cys145 of SEQ ID NO:4) and C3(Cys112 of SEQ ID NO:4)/C5(Cys171 of SEQ ID NO:4). Additional IL-29 C1 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:74, 76, 78, and 80, including DNA and RNA molecules, that encode IL-29 C1 mutant polypeptides as shown in SEQ ID NOs:75, 77, 79 and 81, respectively. Additional IL-29 C1 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:90, 92, 98, and 100, including DNA and RNA molecules, that encode IL-29 C1 mutant polypeptides as shown in SEQ ID NOs:91, 93, 99, and 101, respectively (PCT publication WO 03/066002 (Kotenko et al.)). Additional, IL-29 C1 mutant molecules of the present invention include polynucleotide molecules as shown in SEQ ID NOs:106, 108, 114, and 116, including DNA and RNA molecules, that encode IL-29 C1 mutant polypeptides as shown in SEQ ID NOs:107, 109, 115, and 117, respectively (PCT publication WO 02/092762 (Baum et al.)).

[92] The present invention also includes biologically active mutants of IL-29 C1 cysteine mutants which provide, at least partially, anti-tumor activity and/or immune regulatory activity. The first cysteine or C1 from the N-terminus of IL-29 can be mutated to any amino acid that does not form a disulfide bond with another cysteine, e.g., serine, alanine, threonine, valine or asparagine. The biologically active mutants of IL-29 C1 cysteine mutants of the present invention include N-, C-, and N- and C-terminal deletions of IL-29, e.g., the polypeptide of SEQ ID NO:171 encoded by the polynucleotide of SEQ ID NO:170.

[93] N-terminally modified biologically active mutants of IL-29 C1 mutants include, for example, amino acid residues 2-182 of SEQ ID NO:171 which is encoded by nucleotides 4-546 of SEQ ID NO:170; amino acid residues 3-182 of SEQ ID NO:171 which is encoded by nucleotides 7-546 of SEQ ID NO:170; amino acid residues 4-182 of SEQ ID NO:171 which is encoded by nucleotides 10-546 of SEQ ID NO:170; amino acid residues 5-182 of SEQ ID NO:171 which is encoded by nucleotides 13-546 of SEQ ID NO:170; amino acid residues 6-182 of SEQ ID NO:171 which is encoded by nucleotides 16-546 of SEQ ID NO:170; amino acid residues 7-182 of SEQ ID NO:171 which is encoded by nucleotides 19-546 of SEQ ID NO:170; amino acid residues 8-182 of SEQ ID NO:171 which is encoded by nucleotides 22-546 of SEQ ID NO:170; amino acid residues 9-182 of SEQ ID NO:171 which is encoded by nucleotides 25-546 of SEQ ID NO:170; amino acid residues 10-182 of SEQ ID NO:171 which is encoded by nucleotides 28-546 of SEQ ID NO:170; amino acid residues 11-182 of SEQ ID NO:171 which is encoded by nucleotides 31-546 of SEQ ID NO:170; amino acid residues 12-182 of SEQ ID NO:171 which is encoded by nucleotides 34-546 of SEQ ID NO:170; amino acid residues 13-182 of SEQ ID NO:171 which is encoded by nucleotides 37-546 of SEQ ID NO:170; amino acid residues 14-182 of SEQ ID NO:171 which is encoded by nucleotides 40-546 of SEQ ID NO:170; amino acid residues 15-182 of SEQ ID NO:171 which is encoded by nucleotides 43-546 of SEQ ID NO:170; and amino acid residues 16-182 of SEQ ID NO:171 which is encoded by nucleotides 46-546 of SEQ ID NO:170. The N-terminally modified biologically active mutants of IL-29 C1 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[94] C-terminally modified biologically active mutants of IL-29 C1 mutants include, for example, amino acid residues 1-181 of SEQ ID NO:171 which is encoded by nucleotides 1-543 of SEQ ID NO:170; amino acid residues 1-180 of SEQ ID NO:171 which is encoded by nucleotides 1-540 of SEQ ID NO:170; amino acid residues 1-179 of SEQ ID NO:171 which is encoded by nucleotides 1-537 of SEQ ID NO:170; amino acid residues 1-178 of SEQ ID NO:171 which is encoded by nucleotides 1-534 of SEQ ID NO:170; amino acid residues 1-177 of SEQ ID NO:171 which is encoded by nucleotides 1-531 of SEQ ID NO:170; amino acid residues 1-176 of SEQ ID NO:171 which is encoded by nucleotides 1-528 of SEQ ID NO:170; amino acid residues 1-175 of SEQ ID NO:171 which is encoded by nucleotides 1-525 of SEQ ID NO:170; amino acid residues 1-

174 of SEQ ID NO:171 which is encoded by nucleotides 1-522 of SEQ ID NO:170; amino acid residues 1-173 of SEQ ID NO:171 which is encoded by nucleotides 1-519 of SEQ ID NO:170; and amino acid residues 1-172 of SEQ ID NO:171 which is encoded by nucleotides 1-516 of SEQ ID NO:170.

[95] N-terminally and C-terminally modified biologically active mutants of IL-29 C1 mutants include, for example, amino acid residues 2-181 of SEQ ID NO:171 which is encoded by nucleotides 4-543 of SEQ ID NO:170; amino acid residues 2-180 of SEQ ID NO:171 which is encoded by nucleotides 4-540 of SEQ ID NO:170; amino acid residues 2-179 of SEQ ID NO:171 which is encoded by nucleotides 4-537 of SEQ ID NO:170; amino acid residues 2-178 of SEQ ID NO:171 which is encoded by nucleotides 4-534 of SEQ ID NO:170; amino acid residues 2-177 of SEQ ID NO:171 which is encoded by nucleotides 4-531 of SEQ ID NO:170; amino acid residues 2-176 of SEQ ID NO:171 which is encoded by nucleotides 4-528 of SEQ ID NO:170; amino acid residues 2-175 of SEQ ID NO:171 which is encoded by nucleotides 4-525 of SEQ ID NO:170; amino acid residues 2-174 of SEQ ID NO:171 which is encoded by nucleotides 4-522 of SEQ ID NO:170; amino acid residues 2-173 of SEQ ID NO:171 which is encoded by nucleotides 4-519 of SEQ ID NO:170; amino acid residues 2-172 of SEQ ID NO:171 which is encoded by nucleotides 4-516 of SEQ ID NO:170; amino acid residues 3-181 of SEQ ID NO:171 which is encoded by nucleotides 7-543 of SEQ ID NO:170; amino acid residues 3-180 of SEQ ID NO:171 which is encoded by nucleotides 7-540 of SEQ ID NO:170; amino acid residues 3-179 of SEQ ID NO:171 which is encoded by nucleotides 7-537 of SEQ ID NO:170; amino acid residues 3-178 of SEQ ID NO:171 which is encoded by nucleotides 7-534 of SEQ ID NO:170; amino acid residues 3-177 of SEQ ID NO:171 which is encoded by nucleotides 7-531 of SEQ ID NO:170; amino acid residues 3-176 of SEQ ID NO:171 which is encoded by nucleotides 7-528 of SEQ ID NO:170; amino acid residues 3-175 of SEQ ID NO:171 which is encoded by nucleotides 7-525 of SEQ ID NO:170; amino acid residues 3-174 of SEQ ID NO:171 which is encoded by nucleotides 7-522 of SEQ ID NO:170; amino acid residues 3-173 of SEQ ID NO:171 which is encoded by nucleotides 7-519 of SEQ ID NO:170; amino acid residues 3-172 of SEQ ID NO:171 which is encoded by nucleotides 7-516 of SEQ ID NO:170; amino acid residues 4-181 of SEQ ID NO:171 which is encoded by nucleotides 10-543 of SEQ ID NO:170; amino acid residues 4-180 of SEQ ID NO:171 which is encoded by nucleotides 10-540 of SEQ ID NO:170; amino acid residues 4-179 of SEQ ID NO:171 which is encoded by nucleotides 10-537 of SEQ ID NO:170; amino acid residues 4-178 of SEQ ID NO:171 which is encoded by nucleotides 10-534 of SEQ ID NO:170; amino acid residues 4-177 of SEQ ID NO:171 which is encoded by nucleotides 10-531 of SEQ ID NO:170; amino acid residues 4-176 of SEQ ID NO:171 which is encoded by nucleotides 10-528 of SEQ ID NO:170; amino acid residues 4-175 of SEQ ID NO:171 which is encoded by nucleotides 10-525 of SEQ ID NO:170; amino acid residues 4-174 of SEQ ID NO:171 which is encoded by nucleotides 10-522 of SEQ ID NO:170; amino acid

[illegible]

SEQ ID NO:170; amino acid residues 8-180 of SEQ ID NO:171 which is encoded by nucleotides 22-540 of SEQ ID NO:170; amino acid residues 8-179 of SEQ ID NO:171 which is encoded by nucleotides 22-537 of SEQ ID NO:170; amino acid residues 8-178 of SEQ ID NO:171 which is encoded by nucleotides 22-534 of SEQ ID NO:170; amino acid residues 8-177 of SEQ ID NO:171 which is encoded by nucleotides 22-531 of SEQ ID NO:170; amino acid residues 8-176 of SEQ ID NO:171 which is encoded by nucleotides 22-528 of SEQ ID NO:170; amino acid residues 8-175 of SEQ ID NO:171 which is encoded by nucleotides 22-525 of SEQ ID NO:170; amino acid residues 8-174 of SEQ ID NO:171 which is encoded by nucleotides 22-522 of SEQ ID NO:170; amino acid residues 8-173 of SEQ ID NO:171 which is encoded by nucleotides 22-519 of SEQ ID NO:170; amino acid residues 8-172 of SEQ ID NO:171 which is encoded by nucleotides 22-516 of SEQ ID NO:170; amino acid residues 9-181 of SEQ ID NO:171 which is encoded by nucleotides 25-543 of SEQ ID NO:170; amino acid residues 9-180 of SEQ ID NO:171 which is encoded by nucleotides 25-540 of SEQ ID NO:170; amino acid residues 9-179 of SEQ ID NO:171 which is encoded by nucleotides 25-537 of SEQ ID NO:170; amino acid residues 9-178 of SEQ ID NO:171 which is encoded by nucleotides 25-534 of SEQ ID NO:170; amino acid residues 9-177 of SEQ ID NO:171 which is encoded by nucleotides 25-531 of SEQ ID NO:170; amino acid residues 9-176 of SEQ ID NO:171 which is encoded by nucleotides 25-528 of SEQ ID NO:170; amino acid residues 9-175 of SEQ ID NO:171 which is encoded by nucleotides 25-525 of SEQ ID NO:170; amino acid residues 9-174 of SEQ ID NO:171 which is encoded by nucleotides 25-522 of SEQ ID NO:170; amino acid residues 9-173 of SEQ ID NO:171 which is encoded by nucleotides 25-519 of SEQ ID NO:170; amino acid residues 9-172 of SEQ ID NO:171 which is encoded by nucleotides 25-516 of SEQ ID NO:170; amino acid residues 10-181 of SEQ ID NO:171 which is encoded by nucleotides 28-543 of SEQ ID NO:170; amino acid residues 10-180 of SEQ ID NO:171 which is encoded by nucleotides 28-540 of SEQ ID NO:170; amino acid residues 10-179 of SEQ ID NO:171 which is encoded by nucleotides 28-537 of SEQ ID NO:170; amino acid residues 10-178 of SEQ ID NO:171 which is encoded by nucleotides 28-534 of SEQ ID NO:170; amino acid residues 10-177 of SEQ ID NO:171 which is encoded by nucleotides 28-531 of SEQ ID NO:170; amino acid residues 10-176 of SEQ ID NO:171 which is encoded by nucleotides 28-528 of SEQ ID NO:170; amino acid residues 10-175 of SEQ ID NO:171 which is encoded by nucleotides 28-525 of SEQ ID NO:170; amino acid residues 10-174 of SEQ ID NO:171 which is encoded by nucleotides 28-522 of SEQ ID NO:170; amino acid residues 10-173 of SEQ ID NO:171 which is encoded by nucleotides 28-519 of SEQ ID NO:170; amino acid residues 10-172 of SEQ ID NO:171 which is encoded by nucleotides 28-516 of SEQ ID NO:170; amino acid residues 11-181 of SEQ ID NO:171 which is encoded by nucleotides 31-543 of SEQ ID NO:170; amino acid residues 11-180 of SEQ ID NO:171 which is encoded by nucleotides 31-540 of SEQ ID NO:170; amino acid residues 11-179 of SEQ ID NO:171 which is encoded by nucleotides 31-537 of SEQ ID NO:170; amino acid residues 11-178 of SEQ ID NO:171 which is

[illegible]

SEQ ID NO:171 which is encoded by nucleotides 40-525 of SEQ ID NO:170; amino acid residues 14-174 of SEQ ID NO:171 which is encoded by nucleotides 40-522 of SEQ ID NO:170; amino acid residues 14-173 of SEQ ID NO:171 which is encoded by nucleotides 40-519 of SEQ ID NO:170; amino acid residues 14-172 of SEQ ID NO:171 which is encoded by nucleotides 40-516 of SEQ ID NO:170; amino acid residues 15-181 of SEQ ID NO:171 which is encoded by nucleotides 43-543 of SEQ ID NO:170; amino acid residues 15-180 of SEQ ID NO:171 which is encoded by nucleotides 43-540 of SEQ ID NO:170; amino acid residues 15-179 of SEQ ID NO:171 which is encoded by nucleotides 43-537 of SEQ ID NO:170; amino acid residues 15-178 of SEQ ID NO:171 which is encoded by nucleotides 43-534 of SEQ ID NO:170; amino acid residues 15-177 of SEQ ID NO:171 which is encoded by nucleotides 43-531 of SEQ ID NO:170; amino acid residues 15-176 of SEQ ID NO:171 which is encoded by nucleotides 43-528 of SEQ ID NO:170; amino acid residues 15-175 of SEQ ID NO:171 which is encoded by nucleotides 43-525 of SEQ ID NO:170; amino acid residues 15-174 of SEQ ID NO:171 which is encoded by nucleotides 43-522 of SEQ ID NO:170; amino acid residues 15-173 of SEQ ID NO:171 which is encoded by nucleotides 43-519 of SEQ ID NO:170; amino acid residues 15-172 of SEQ ID NO:171 which is encoded by nucleotides 43-516 of SEQ ID NO:170; amino acid residues 16-181 of SEQ ID NO:171 which is encoded by nucleotides 46-543 of SEQ ID NO:170; amino acid residues 16-180 of SEQ ID NO:171 which is encoded by nucleotides 46-540 of SEQ ID NO:170; amino acid residues 16-179 of SEQ ID NO:171 which is encoded by nucleotides 46-537 of SEQ ID NO:170; amino acid residues 16-178 of SEQ ID NO:171 which is encoded by nucleotides 46-534 of SEQ ID NO:170; amino acid residues 16-177 of SEQ ID NO:171 which is encoded by nucleotides 46-531 of SEQ ID NO:170; amino acid residues 16-176 of SEQ ID NO:171 which is encoded by nucleotides 46-528 of SEQ ID NO:170; amino acid residues 16-175 of SEQ ID NO:171 which is encoded by nucleotides 46-525 of SEQ ID NO:170; amino acid residues 16-174 of SEQ ID NO:171 which is encoded by nucleotides 46-522 of SEQ ID NO:170; amino acid residues 16-173 of SEQ ID NO:171 which is encoded by nucleotides 46-519 of SEQ ID NO:170; and amino acid residues 16-172 of SEQ ID NO:171 which is encoded by nucleotides 46-516 of SEQ ID NO:170. The N-terminally and C-terminally modified biologically active mutants of IL-29 C1 mutants of the present invention may also include an N-terminal Methionine if expressed, for instance, in *E. coli*.

[96] The IL-29 polypeptides of the present invention include, for example, SEQ ID NOs:4, 15, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 171, 173 and 175, which are encoded by IL-29 polynucleotide molecules as shown in SEQ ID NOs:3, 14, 26, 28, 40, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 138, 140, 142, 144, 146, 148, 175, 152, 154, 156, 158, 160, 170, 172 and 174, respectively, C1 mutants thereof, N-terminally modified C1 mutants thereof, C-terminally modified C1 mutants thereof, N-terminally and

C-terminally C1 mutants thereof, C5 mutants thereof, N-terminally modified C5 mutants thereof, C-terminally modified C5 mutants thereof, N-terminally and C-terminally modified C5 mutants thereof, fragments thereof, and fusion proteins thereof. The IL-29 polypeptides may further include a signal sequence as shown in SEQ ID NO:119 or a signal sequence as shown in SEQ ID NO:121. A polynucleotide molecule encoding the signal sequence polypeptide of SEQ ID NO:119 is shown as SEQ ID NO:118. A polynucleotide molecule encoding the signal sequence polypeptide of SEQ ID NO:120 is shown as SEQ ID NO:121.

[97] Table 3 sets forth the one-letter codes used within SEQ IDs 30, 31, 32, 33, 34, and 35 to denote degenerate nucleotide positions. "Resolutions" are the nucleotides denoted by a code letter. "Complement" indicates the code for the complementary nucleotide(s). For example, the code Y denotes either C or T, and its complement R denotes A or G, with A being complementary to T, and G being complementary to C.

Table 3

Nucleotide	Resolution	Complement	Resolution
e		t	
A	A	T	T
C	C	G	G
G	G	C	C
T	T	A	A
R	A G	Y	C T
Y	C T	R	A G
M	A C	K	G T
K	G T	M	A C
S	C G	S	C G
W	A T	W	A T
H	A C T	D	A G T
B	C G T	V	A C G
V	A C G	B	C G T
D	A G T	H	A C T
N	A C G T	N	A C G T

[98] The degenerate codons used in SEQ ID NOs: 30, 31, 32, 33, 34, and 35, encompassing all possible codons for a given amino acid, are set forth in Table 4.

Table 4

Amino Acid	One Letter Code	Codons						Degenerate Codon
Cys	C	TGC	TGT					TGY
Ser	S	AGC	AGT	TCA	TCC	TCG	TCT	WSN
Thr	T	ACA	ACC	ACG	ACT			ACN
Pro	P	CCA	CCC	CCG	CCT			CCN
Ala	A	GCA	GCC	GCG	GCT			GCN
Gly	G	GGA	GGC	GGG	GGT			GGN
Asn	N	AAC	AAT					AAY
Asp	D	GAC	GAT					GAY
Glu	E	GAA	GAG					GAR
Gln	Q	CAA	CAG					CAR
His	H	CAC	CAT					CAY
Arg	R	AGA	AGG	CGA	CGC	CGG	CGT	MGN
Lys	K	AAA	AAG					AAR
Met	M	ATG						ATG
Ile	I	ATA	ATC	ATT				ATH
Leu	L	CTA	CTC	CTG	CTT	TTA	TTG	YTN
Val	V	GTA	GTC	GTG	GTT			GTN
Phe	F	TTC	TTT					TTY
Tyr	Y	TAC	TAT					TAY
Trp	W	TGG						TGG
Ter	.	TAA	TAG	TGA				TRR
Asn Asp	B							RAY
Glu Gln	Z							SAR
Any	X							NNN

[99] One of ordinary skill in the art will appreciate that some ambiguity is introduced in determining a degenerate codon, representative of all possible codons encoding each amino acid. For example, the degenerate codon for serine (WSN) can, in some circumstances, encode arginine (AGR), and the degenerate codon for arginine (MGN) can, in some circumstances, encode serine (AGY). A similar relationship exists between codons encoding phenylalanine and leucine. Thus, some polynucleotides encompassed by the degenerate sequence may encode variant amino acid sequences, but one of ordinary skill in the art can easily identify such variant sequences by reference to the amino

acid sequence of SEQ ID NOS:19, 21, 23, 25, 27, and 29. Variant sequences can be readily tested for functionality as described herein.

[100] One of ordinary skill in the art will also appreciate that different species can exhibit “preferential codon usage.” In general, see, Grantham, et al., Nuc. Acids Res. 8:1893-912, 1980; Haas, et al. Curr. Biol. 6:315-24, 1996; Wain-Hobson, et al., Gene 13:355-64, 1981; Grosjean and Fiers, Gene 18:199-209, 1982; Holm, Nuc. Acids Res. 14:3075-87, 1986; Ikemura, J. Mol. Biol. 158:573-97, 1982. As used herein, the term “preferential codon usage” or “preferential codons” is a term of art referring to protein translation codons that are most frequently used in cells of a certain species, thus favoring one or a few representatives of the possible codons encoding each amino acid (See Table 4). For example, the amino acid Threonine (Thr) may be encoded by ACA, ACC, ACG, or ACT, but in mammalian cells ACC is the most commonly used codon; in other species, for example, insect cells, yeast, viruses or bacteria, different Thr codons may be preferential. Preferential codons for a particular species can be introduced into the polynucleotides of the present invention by a variety of methods known in the art. Introduction of preferential codon sequences into recombinant DNA can, for example, enhance production of the protein by making protein translation more efficient within a particular cell type or species. Therefore, the degenerate codon sequence disclosed in SEQ ID NOS: 30, 31, 32, 33, 34, and 35 serves as a template for optimizing expression of polynucleotides in various cell types and species commonly used in the art and disclosed herein. Sequences containing preferential codons can be tested and optimized for expression in various species, and tested for functionality as disclosed herein.

[101] As previously noted, the isolated polynucleotides of the present invention include DNA and RNA. Methods for preparing DNA and RNA are well known in the art. In general, RNA is isolated from a tissue or cell that produces large amounts of IL-28 or IL-29 RNA. Such tissues and cells are identified by Northern blotting (Thomas, Proc. Natl. Acad. Sci. USA 77:5201, 1980), or by screening conditioned medium from various cell types for activity on target cells or tissue. Once the activity or RNA producing cell or tissue is identified, total RNA can be prepared using guanidinium isothiocyanate extraction followed by isolation by centrifugation in a CsCl gradient (Chirgwin et al., Biochemistry 18:52-94, 1979). Poly (A)⁺ RNA is prepared from total RNA using the method of Aviv and Leder (Proc. Natl. Acad. Sci. USA 69:1408-12, 1972). Complementary DNA (cDNA) is prepared from poly(A)⁺ RNA using known methods. In the alternative, genomic DNA can be isolated. Polynucleotides encoding IL-28 or IL-29 polypeptides are then identified and isolated by, for example, hybridization or PCR.

[102] A full-length clones encoding IL-28 or IL-29 can be obtained by conventional cloning procedures. Complementary DNA (cDNA) clones are preferred, although for some applications (e.g., expression in transgenic animals) it may be preferable to use a genomic clone, or to modify a cDNA clone to include at least one genomic intron. Methods for preparing cDNA and genomic clones are

well known and within the level of ordinary skill in the art, and include the use of the sequence disclosed herein, or parts thereof, for probing or priming a library. Expression libraries can be probed with antibodies to IL-28 receptor fragments, or other specific binding partners.

[103] Those skilled in the art will recognize that the sequence disclosed in, for example, SEQ ID NOs:1, 3, and 5, respectively, represent mutations of single alleles of human IL-28 and IL-29 bands, and that allelic variation and alternative splicing are expected to occur. For example, an IL-29 variant has been identified where amino acid residue 169 (Asn) as shown in SEQ ID NO:4 is an Arg residue, as described in WO 02/086087. Such allelic variants are included in the present invention. Allelic variants of this sequence can be cloned by probing cDNA or genomic libraries from different individuals according to standard procedures. Allelic variants of the DNA sequence shown in SEQ ID NOs:1, 3 and 5, including those containing silent mutations and those in which mutations result in amino acid sequence changes, in addition to the cysteine mutations, are within the scope of the present invention, as are proteins which are allelic variants of SEQ ID NOs:2, 4, and 6. cDNAs generated from alternatively spliced mRNAs, which retain the properties of IL-28 or IL-29 polypeptides, are included within the scope of the present invention, as are polypeptides encoded by such cDNAs and mRNAs. Allelic variants and splice variants of these sequences can be cloned by probing cDNA or genomic libraries from different individuals or tissues according to standard procedures known in the art, and mutations to the polynucleotides encoding cysteines or cysteine residues can be introduced as described herein.

[104] Within embodiments of the invention, isolated IL-28- and IL-29-encoding nucleic acid molecules can hybridize under stringent conditions to nucleic acid molecules having the nucleotide sequence selected from the group of SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 and 174 or to nucleic acid molecules having a nucleotide sequence complementary to SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 and 174. In general, stringent conditions are selected to be about 5°C lower than the thermal melting point (T_m) for the specific sequence at a defined ionic strength and pH. The T_m is the temperature (under defined ionic strength and pH) at which 50% of the target sequence hybridizes to a perfectly matched probe.

[105] A pair of nucleic acid molecules, such as DNA-DNA, RNA-RNA and DNA-RNA, can hybridize if the nucleotide sequences have some degree of complementarity. Hybrids can tolerate mismatched base pairs in the double helix, but the stability of the hybrid is influenced by the degree of mismatch. The T_m of the mismatched hybrid decreases by 1°C for every 1-1.5% base pair mismatch.

Varying the stringency of the hybridization conditions allows control over the degree of mismatch that will be present in the hybrid. The degree of stringency increases as the hybridization temperature increases and the ionic strength of the hybridization buffer decreases.

[106] It is well within the abilities of one skilled in the art to adapt these conditions for use with a particular polynucleotide hybrid. The T_m for a specific target sequence is the temperature (under defined conditions) at which 50% of the target sequence will hybridize to a perfectly matched probe sequence. Those conditions which influence the T_m include, the size and base pair content of the polynucleotide probe, the ionic strength of the hybridization solution, and the presence of destabilizing agents in the hybridization solution. Numerous equations for calculating T_m are known in the art, and are specific for DNA, RNA and DNA-RNA hybrids and polynucleotide probe sequences of varying length (see, for example, Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, Second Edition (Cold Spring Harbor Press 1989); Ausubel *et al.*, (eds.), Current Protocols in Molecular Biology (John Wiley and Sons, Inc. 1987); Berger and Kimmel (eds.), Guide to Molecular Cloning Techniques, (Academic Press, Inc. 1987); and Wetmur, Crit. Rev. Biochem. Mol. Biol. 26:227 (1990)). Sequence analysis software such as OLIGO 6.0 (LSR; Long Lake, MN) and *Primer Premier 4.0* (Premier Biosoft International; Palo Alto, CA), as well as sites on the Internet, are available tools for analyzing a given sequence and calculating T_m based on user defined criteria. Such programs can also analyze a given sequence under defined conditions and identify suitable probe sequences. Typically, hybridization of longer polynucleotide sequences, >50 base pairs, is performed at temperatures of about 20-25°C below the calculated T_m . For smaller probes, <50 base pairs, hybridization is typically carried out at the T_m or 5-10°C below the calculated T_m . This allows for the maximum rate of hybridization for DNA-DNA and DNA-RNA hybrids.

[107] Following hybridization, the nucleic acid molecules can be washed to remove non-hybridized nucleic acid molecules under stringent conditions, or under highly stringent conditions. Typical stringent washing conditions include washing in a solution of 0.5x - 2x SSC with 0.1% sodium dodecyl sulfate (SDS) at 55 - 65°C. That is, nucleic acid molecules encoding a variant, cysteine mutant, or IL-28 or IL-29 polypeptides hybridize with a nucleic acid molecule having the nucleotide sequence selected from the group of SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 and 174 (or its complement) under stringent washing conditions, in which the wash stringency is equivalent to 0.5x - 2x SSC with 0.1% SDS at 55 - 65°C, including 0.5x SSC with 0.1% SDS at 55°C, or 2x SSC with 0.1% SDS at 65°C. One of skill in the art can readily devise equivalent conditions, for example, by substituting SSPE for SSC in the wash solution.

[108] Typical highly stringent washing conditions include washing in a solution of 0.1x - 0.2x SSC with 0.1% sodium dodecyl sulfate (SDS) at 50 - 65°C. In other words, nucleic acid

molecules encoding a variant of a IL-28 or IL-29 polypeptide hybridize with a nucleic acid molecule having the nucleotide sequence selected from the group of SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 and 174 (or its complement) under highly stringent washing conditions, in which the wash stringency is equivalent to 0.1x - 0.2x SSC with 0.1% SDS at 50 - 65°C, including 0.1x SSC with 0.1% SDS at 50°C, or 0.2x SSC with 0.1% SDS at 65°C.

[109] The present invention also provides IL-28 or IL-29 polypeptides that have a substantially similar sequence identity to the polypeptides of the present invention, for example SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The term “substantially similar sequence identity” is used herein to denote polypeptides comprising at least 80%, at least 90%, at least 95%, or greater than 95%, 96%, 97%, 98%, 99%, 99.5% sequence identity to the sequences shown in SEQ ID NOs: 2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175 respectively, or their orthologs. The present invention also includes polypeptides that comprise an amino acid sequence having at least 80%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.5%, or greater than 99.5% sequence identity to a polypeptide or fragment thereof of the present invention. The present invention further includes nucleic acid molecules that encode such polypeptides. The IL-28 and IL-29 polypeptides of the present invention are preferably recombinant polypeptides. In another aspect, the IL-28 and IL-29 polypeptides of the present invention have at least 15, at least 30, at least 45, or at least 60 sequential amino acids. For example, an IL-29 polypeptide of the present invention relates to a polypeptide having at least 15, at least 30, at least 45, or at least 60 sequential amino acids from SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175. Methods for determining percent identity are described below.

[110] The present invention also contemplates variant nucleic acid molecules that can be identified using two criteria: a determination of the similarity between the encoded polypeptide with the amino acid sequence of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175, and/or a hybridization assay, as described above. Such variants include nucleic acid

molecules: (1) that hybridize with a nucleic acid molecule having the nucleotide sequence of SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 or 174 (or its complement) under stringent washing conditions, in which the wash stringency is equivalent to 0.5x - 2x SSC with 0.1% SDS at 55 - 65°C; or (2) that encode a polypeptide having at least 80%, at least 90%, at least 95% or greater than 95%, 96%, 97%, 98%, 99% sequence identity to the amino acid sequence of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175. Alternatively, variants can be characterized as nucleic acid molecules: (1) that hybridize with a nucleic acid molecule having the nucleotide sequence of SEQ ID NOs:1, 3, 5, 12, 14, 16, 18, 20, 22, 24, 26, 28, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172 or 174 (or its complement) under highly stringent washing conditions, in which the wash stringency is equivalent to 0.1x - 0.2x SSC with 0.1% SDS at 50 - 65°C; and (2) that encode a polypeptide having at least 80%, at least 90%, at least 95% or greater than 95%, 96%, 97%, 98%, 99% sequence identity to the amino acid sequence of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 162, 164, 166, 168, 170, 172 or 174.

[111] The present invention further provides a polynucleotide encoding a polypeptide that treats, prevents, inhibits the progression of, delay the onset of, and/or reduce the severity or inhibit at least one of the conditions or symptoms of a cancer as disclosed herein wherein the encoded polypeptide is a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175.

[112] Percent sequence identity is determined by conventional methods. See, for example, Altschul et al., Bull. Math. Bio. 48:603 (1986), and Henikoff and Henikoff, Proc. Natl. Acad. Sci. USA 89:10915 (1992). Briefly, two amino acid sequences are aligned to optimize the alignment scores using a gap opening penalty of 10, a gap extension penalty of 1, and the "BLOSUM62" scoring matrix of Henikoff and Henikoff (*ibid.*) as shown in Table 5 (amino acids are indicated by the standard one-letter codes).

[113] Total number of identical matches

- [114] _____ x 100
- [115] [length of the longer sequence plus the
- [116] number of gaps introduced into the longer
- [117] sequence in order to align the two sequences]

Table 5

	A	R	N	D	C	Q	E	G	H	I	L	K	M	F	P	S	T	W	Y	V
A	4																			
R	-1	5																		
N	-2	0	6																	
D	-2	-2	1	6																
C	0	-3	-3	-3	9															
Q	-1	1	0	0	-3	5														
E	-1	0	0	2	-4	2	5													
G	0	-2	0	-1	-3	-2	-2	6												
H	-2	0	1	-1	-3	0	0	-2	8											
I	-1	-3	-3	-3	-1	-3	-3	-4	-3	4										
L	-1	-2	-3	-4	-1	-2	-3	-4	-3	2	4									
K	-1	2	0	-1	-3	1	1	-2	-1	-3	-2	5								
M	-1	-1	-2	-3	-1	0	-2	-3	-2	1	2	-1	5							
F	-2	-3	-3	-3	-2	-3	-3	-3	-1	0	0	-3	0	6						
P	-1	-2	-2	-1	-3	-1	-1	-2	-2	-3	-1	-2	-4	7						
S	1	-1	1	0	-1	0	0	0	-1	-2	-2	0	-1	-2	-1	4				
T	0	-1	0	-1	-1	-1	-1	-2	-2	-1	-1	-1	-1	-2	-1	1	5			
W	-3	-3	-4	-4	-2	-2	-3	-2	-2	-3	-2	-3	-1	1	-4	-3	-2	11		
Y	-2	-2	-2	-3	-2	-1	-2	-3	2	-1	-1	-2	-1	3	-3	-2	-2	2	7	
V	0	-3	-3	-3	-1	-2	-2	-3	-3	3	1	-2	1	-1	-2	-2	0	-3	-1	4

[118] Those skilled in the art appreciate that there are many established algorithms available to align two amino acid sequences. The "FASTA" similarity search algorithm of Pearson and Lipman is a suitable protein alignment method for examining the level of identity shared by an amino acid sequence disclosed herein and the amino acid sequence of a putative variant IL-28 or IL-29. The FASTA algorithm is described by Pearson and Lipman, Proc. Nat'l Acad. Sci. USA 85:2444 (1988), and by Pearson, Meth. Enzymol. 183:63 (1990).

[119] Briefly, FASTA first characterizes sequence similarity by identifying regions shared by the query sequence (*e.g.*, SEQ ID NO:2) and a test sequence that have either the highest density of identities (if the ktup variable is 1) or pairs of identities (if ktup=2), without considering conservative amino acid substitutions, insertions, or deletions. The ten regions with the highest density of identities are then rescored by comparing the similarity of all paired amino acids using an amino acid substitution matrix, and the ends of the regions are "trimmed" to include only those residues that contribute to the highest score. If there are several regions with scores greater than the "cutoff" value (calculated by a predetermined formula based upon the length of the sequence and the ktup value), then the trimmed initial regions are examined to determine whether the regions can be joined to form an approximate alignment with gaps. Finally, the highest scoring regions of the two amino acid sequences are aligned using a modification of the Needleman-Wunsch-Sellers algorithm (Needleman and Wunsch, J. Mol. Biol. 48:444 (1970); Sellers, SIAM J. Appl. Math. 26:787 (1974)), which allows for amino acid insertions and deletions. Preferred parameters for FASTA analysis are: ktup=1, gap opening penalty=10, gap extension penalty=1, and substitution matrix=BLOSUM62. These parameters can be introduced into a FASTA program by modifying the scoring matrix file ("SMATRIX"), as explained in Appendix 2 of Pearson, Meth. Enzymol. 183:63 (1990).

[120] FASTA can also be used to determine the sequence identity of nucleic acid molecules using a ratio as disclosed above. For nucleotide sequence comparisons, the ktup value can range between one to six, preferably from three to six, most preferably three, with other parameters set as default.

[121] Variant IL-28 or IL-29 polypeptides or polypeptides with substantially similar sequence identity are characterized as having one or more amino acid substitutions, deletions or additions. These changes are preferably of a minor nature, that is conservative amino acid substitutions (see Table 6) and other substitutions that do not significantly affect the folding or activity of the polypeptide; small deletions, typically of one to about 30 amino acids; and amino- or carboxyl-terminal extensions, such as an amino-terminal methionine residue, a small linker peptide of up to about 20-25 residues, or an affinity tag. The present invention thus includes polypeptides that comprise a sequence that is at least 80%, preferably at least 90%, and more preferably at least 95%, at least 96%, at least 97%, at least 98%, at least 99% or greater than 99% identical to the corresponding region of SEQ ID NOs: 2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91,

93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175. Polypeptides comprising affinity tags can further comprise a proteolytic cleavage site between the IL-28 and IL-29 polypeptide and the affinity tag. Preferred such sites include thrombin cleavage sites and factor Xa cleavage sites.

Table 6Conservative amino acid substitutions

Basic:	arginine
	lysine
	histidine
Acidic:	glutamic acid
	aspartic acid
Polar:	glutamine
	asparagine
Hydrophobic:	leucine
	isoleucine
	valine
Aromatic:	phenylalanine
	tryptophan
	tyrosine
Small:	glycine
	alanine
	serine
	threonine
	methionine

[122] Determination of amino acid residues that comprise regions or domains that are critical to maintaining structural integrity can be determined. Within these regions one can determine specific residues that will be more or less tolerant of change and maintain the overall tertiary structure of the molecule. Methods for analyzing sequence structure include, but are not limited to alignment of multiple sequences with high amino acid or nucleotide identity, secondary structure propensities, binary patterns, complementary packing and buried polar interactions (Barton, Current Opin. Struct. Biol. 5:372-376, 1995 and Cordes et al., Current Opin. Struct. Biol. 6:3-10, 1996). In general, when designing modifications to molecules or identifying specific fragments determination of structure will be accompanied by evaluating activity of modified molecules.

[123] Amino acid sequence changes are made in IL-28 or IL-29 polypeptides so as to minimize disruption of higher order structure essential to biological activity. For example, where the IL-28 or IL-29 polypeptide comprises one or more helices, changes in amino acid residues will be made so as not to disrupt the helix geometry and other components of the molecule where changes in

conformation abate some critical function, for example, binding of the molecule to its binding partners. The effects of amino acid sequence changes can be predicted by, for example, computer modeling as disclosed above or determined by analysis of crystal structure (see, e.g., Lapthorn et al., Nat. Struct. Biol. 2:266-268, 1995). Other techniques that are well known in the art compare folding of a variant protein to a standard molecule (e.g., the native protein). For example, comparison of the cysteine pattern in a variant and standard molecules can be made. Mass spectrometry and chemical modification using reduction and alkylation provide methods for determining cysteine residues which are associated with disulfide bonds or are free of such associations (Bean et al., Anal. Biochem. 201:216-226, 1992; Gray, Protein Sci. 2:1732-1748, 1993; and Patterson et al., Anal. Chem. 66:3727-3732, 1994). It is generally believed that if a modified molecule does not have the same cysteine pattern as the standard molecule folding would be affected. Another well known and accepted method for measuring folding is circular dichroism (CD). Measuring and comparing the CD spectra generated by a modified molecule and standard molecule is routine (Johnson, Proteins 7:205-214, 1990). Crystallography is another well known method for analyzing folding and structure. Nuclear magnetic resonance (NMR), digestive peptide mapping and epitope mapping are also known methods for analyzing folding and structural similarities between proteins and polypeptides (Schaanan et al., Science 257:961-964, 1992).

[124] A Hopp/Woods hydrophilicity profile of the IL-28 or IL-29 polypeptide sequence as shown in SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 or 175 can be generated (Hopp et al., Proc. Natl. Acad. Sci. 78:3824-3828, 1981; Hopp, J. Immun. Meth. 88:1-18, 1986 and Triquier et al., Protein Engineering 11:153-169, 1998). The profile is based on a sliding six-residue window. Buried G, S, and T residues and exposed H, Y, and W residues were ignored. Those skilled in the art will recognize that hydrophilicity or hydrophobicity will be taken into account when designing modifications in the amino acid sequence of a IL-28 or IL-29 polypeptide, so as not to disrupt the overall structural and biological profile. Of particular interest for replacement are hydrophobic residues selected from the group consisting of Val, Leu and Ile or the group consisting of Met, Gly, Ser, Ala, Tyr and Trp.

[125] The identities of essential amino acids can also be inferred from analysis of sequence similarity between IFN- α and members of the family of IL-28A, IL-28B, and IL-29 (as shown in Tables 1 and 2). Using methods such as "FASTA" analysis described previously, regions of high similarity are identified within a family of proteins and used to analyze amino acid sequence for conserved regions. An alternative approach to identifying a variant polynucleotide on the basis of structure is to determine whether a nucleic acid molecule encoding a potential variant IL-28 or IL-29 gene can hybridize to a nucleic acid molecule as discussed above.

[126] Other methods of identifying essential amino acids in the polypeptides of the present invention are procedures known in the art, such as site-directed mutagenesis or alanine-scanning mutagenesis (Cunningham and Wells, Science 244:1081 (1989), Bass et al., Proc. Natl Acad. Sci. USA 88:4498 (1991), Coombs and Corey, "Site-Directed Mutagenesis and Protein Engineering," in Proteins: Analysis and Design, Angeletti (ed.), pages 259-311 (Academic Press, Inc. 1998)). In the latter technique, single alanine mutations are introduced at every residue in the molecule, and the resultant molecules are tested for biological or biochemical activity as disclosed below to identify amino acid residues that are critical to the activity of the molecule. See also, Hilton *et al.*, J. Biol. Chem. 271:4699 (1996).

[127] The present invention also includes functional fragments of IL-28 or IL-29 polypeptides and nucleic acid molecules encoding such functional fragments. A "functional" IL-28 or IL-29 or fragment thereof as defined herein is characterized by its proliferative or differentiating activity, by its ability to induce or inhibit specialized cell functions, or by its ability to bind specifically to an anti-IL-28 or IL-29 antibody or IL-28 receptor (either soluble or immobilized). The specialized activities of IL-28 or IL-29 polypeptides and how to test for them are disclosed herein. As previously described herein, IL-28 and IL-29 polypeptides are characterized by a six-helical-bundle. Thus, the present invention further provides fusion proteins encompassing: (a) polypeptide molecules comprising one or more of the helices described above; and (b) functional fragments comprising one or more of these helices. The other polypeptide portion of the fusion protein may be contributed by another helical-bundle cytokine or interferon, such as IFN- α , or by a non-native and/or an unrelated secretory signal peptide that facilitates secretion of the fusion protein.

[128] The IL-28 or IL-29 polypeptides of the present invention, including full-length polypeptides, cysteine mutant polypeptides, biologically active fragments, and fusion polypeptides can be produced according to conventional techniques using cells into which have been introduced an expression vector encoding the polypeptide. As used herein, "cells into which have been introduced an expression vector" include both cells that have been directly manipulated by the introduction of exogenous DNA molecules and progeny thereof that contain the introduced DNA. Suitable host cells are those cell types that can be transformed or transfected with exogenous DNA and grown in culture, and include bacteria, fungal cells, and cultured higher eukaryotic cells. Techniques for manipulating cloned DNA molecules and introducing exogenous DNA into a variety of host cells are disclosed by Sambrook et al., Molecular Cloning: A Laboratory Manual, 2nd ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1989, and Ausubel et al., eds., Current Protocols in Molecular Biology, John Wiley and Sons, Inc., NY, 1987.

[129] In general, a DNA sequence encoding a IL-28 or IL-29 polypeptide of the present invention is operably linked to other genetic elements required for its expression, generally including a transcription promoter and terminator, within an expression vector. The vector will also commonly

contain one or more selectable markers and one or more origins of replication, although those skilled in the art will recognize that within certain systems selectable markers may be provided on separate vectors, and replication of the exogenous DNA may be provided by integration into the host cell genome. Selection of promoters, terminators, selectable markers, vectors and other elements is a matter of routine design within the level of ordinary skill in the art. Many such elements are described in the literature and are available through commercial suppliers.

[130] To direct a IL-28 or IL-29 polypeptide into the secretory pathway of a host cell, a secretory signal sequence (also known as a leader sequence, prepro sequence or pre sequence) is provided in the expression vector. The secretory signal sequence may be, for example, that of Cysteine mutant IL-28 or IL-29, e.g., SEQ ID NO:119 or SEQ ID NO:121, or may be derived from another secreted protein (e.g., t-PA; see, U.S. Patent No. 5,641,655) or synthesized *de novo*. The secretory signal sequence is operably linked to the IL-28 or IL-29 DNA sequence, i.e., the two sequences are joined in the correct reading frame and positioned to direct the newly synthesized polypeptide into the secretory pathway of the host cell. Secretory signal sequences are commonly positioned 5' to the DNA sequence encoding the polypeptide of interest, although certain signal sequences may be positioned elsewhere in the DNA sequence of interest (see, e.g., Welch et al., U.S. Patent No. 5,037,743; Holland et al., U.S. Patent No. 5,143,830).

[131] A wide variety of suitable recombinant host cells includes, but is not limited to, gram-negative prokaryotic host organisms. Suitable strains of *E. coli* include W3110, K12-derived strains MM294, TG-1, JM-107, BL21, and UT5600. Other suitable strains include: BL21(DE3), BL21(DE3)pLysS, BL21(DE3)pLysE, DH1, DH4I, DH5, DH5I, DH5IF', DH5IMCR, DH10B, DH10B/p3, DH11S, C600, HB101, JM101, JM105, JM109, JM110, K38, RR1, Y1088, Y1089, CSH18, ER1451, ER1647, *E. coli* K12, *E. coli* K12 RV308, *E. coli* K12 C600, *E. coli* HB101, *E. coli* K12 C600 R.sub.k-M.sub.k-, *E. coli* K12 RR1 (see, for example, Brown (ed.), Molecular Biology Labfax (Academic Press 1991)). Other gram-negative prokaryotic hosts can include *Serratia*, *Pseudomonas*, *Caulobacter*. Prokaryotic hosts can include gram-positive organisms such as *Bacillus*, for example, *B. subtilis* and *B. thuringiensis*, and *B. thuringiensis* var. *israelensis*, as well as *Streptomyces*, for example, *S. lividans*, *S. ambofaciens*, *S. fradiae*, and *S. griseofuscus*. Suitable strains of *Bacillus subtilis* include BR151, YB886, MI119, MI120, and B170 (see, for example, Hardy, "Bacillus Cloning Methods," in DNA Cloning: A Practical Approach, Glover (ed.) (IRL Press 1985)). Standard techniques for propagating vectors in prokaryotic hosts are well-known to those of skill in the art (see, for example, Ausubel *et al.* (eds.), Short Protocols in Molecular Biology, 3rd Edition (John Wiley & Sons 1995); Wu *et al.*, Methods in Gene Biotechnology (CRC Press, Inc. 1997)). In one embodiment, the methods of the present invention use IL-28 or IL-29 expressed in the W3110 strain, which has been deposited at the American Type Culture Collection (ATCC) as ATCC # 27325.

[132] When large scale production of IL-28 or IL-29 using the expression system of the present invention is required, batch fermentation can be used. Generally, batch fermentation comprises that a first stage seed flask is prepared by growing *E. coli* strains expressing IL-28 or IL-29 in a suitable medium in shake flask culture to allow for growth to an optical density (OD) of between 5 and 20 at 600 nm. A suitable medium would contain nitrogen from a source(s) such as ammonium sulfate, ammonium phosphate, ammonium chloride, yeast extract, hydrolyzed animal proteins, hydrolyzed plant proteins or hydrolyzed caseins. Phosphate will be supplied from potassium phosphate, ammonium phosphate, phosphoric acid or sodium phosphate. Other components would be magnesium chloride or magnesium sulfate, ferrous sulfate or ferrous chloride, and other trace elements. Growth medium can be supplemented with carbohydrates, such as fructose, glucose, galactose, lactose, and glycerol, to improve growth. Alternatively, a fed batch culture is used to generate a high yield of IL-28 or IL-29 protein. The IL-28 or IL-29 producing *E. coli* strains are grown under conditions similar to those described for the first stage vessel used to inoculate a batch fermentation.

[133] Following fermentation the cells are harvested by centrifugation, re-suspended in homogenization buffer and homogenized, for example, in an APV-Gaulin homogenizer (Invensys APV, Tonawanda, New York) or other type of cell disruption equipment, such as bead mills or sonicators. Alternatively, the cells are taken directly from the fermentor and homogenized in an APV-Gaulin homogenizer. The washed inclusion body prep can be solubilized using guanidine hydrochloride (5-8 M) or urea (7 – 8 M) containing a reducing agent such as beta mercaptoethanol (10 – 100 mM) or dithiothreitol (5-50 mM). The solutions can be prepared in Tris, phosphate, HEPES or other appropriate buffers. Inclusion bodies can also be solubilized with urea (2-4 M) containing sodium lauryl sulfate (0.1-2%). In the process for recovering purified IL-28 or IL-29 from transformed *E. coli* host strains in which the IL-28 or IL-29 is accumulates as refractile inclusion bodies, the cells are disrupted and the inclusion bodies are recovered by centrifugation. The inclusion bodies are then solubilized and denatured in 6 M guanidine hydrochloride containing a reducing agent. The reduced IL-28 or IL-29 is then oxidized in a controlled renaturation step. Refolded IL-28 or IL-29 can be passed through a filter for clarification and removal of insoluble protein. The solution is then passed through a filter for clarification and removal of insoluble protein. After the IL-28 or IL-29 protein is refolded and concentrated, the refolded IL-28 or IL-29 protein is captured in dilute buffer on a cation exchange column and purified using hydrophobic interaction chromatography.

[134] Cultured mammalian cells are suitable hosts within the present invention. Methods for introducing exogenous DNA into mammalian host cells include calcium phosphate-mediated transfection (Wigler et al., Cell 14:725, 1978; Corsaro and Pearson, Somatic Cell Genetics 7:603, 1981; Graham and Van der Eb, Virology 52:456, 1973), electroporation (Neumann et al., EMBO J. 1:841-5, 1982), DEAE-dextran mediated transfection (Ausubel et al., ibid.), and liposome-mediated

transfection (Hawley-Nelson et al., *Focus* 15:73, 1993; Ciccarone et al., *Focus* 15:80, 1993, and viral vectors (Miller and Rosman, *BioTechniques* 7:980-90, 1989; Wang and Finer, *Nature Med.* 2:714-6, 1996). The production of recombinant polypeptides in cultured mammalian cells is disclosed, for example, by Levinson et al., U.S. Patent No. 4,713,339; Hagen et al., U.S. Patent No. 4,784,950; Palmiter et al., U.S. Patent No. 4,579,821; and Ringold, U.S. Patent No. 4,656,134. Suitable cultured mammalian cells include the COS-1 (ATCC No. CRL 1650), COS-7 (ATCC No. CRL 1651), BHK (ATCC No. CRL 1632), BHK 570 (ATCC No. CRL 10314), 293 (ATCC No. CRL 1573; Graham et al., *J. Gen. Virol.* 36:59-72, 1977) and Chinese hamster ovary (e.g. CHO-K1; ATCC No. CCL 61) cell lines. Additional suitable cell lines are known in the art and available from public depositories such as the American Type Culture Collection, Manassas, VA. In general, strong transcription promoters are preferred, such as promoters from SV-40 or cytomegalovirus. See, e.g., U.S. Patent No. 4,956,288. Other suitable promoters include those from metallothionein genes (U.S. Patent Nos. 4,579,821 and 4,601,978) and the adenovirus major late promoter.

[135] Drug selection is generally used to select for cultured mammalian cells into which foreign DNA has been inserted. Such cells are commonly referred to as "transfectants". Cells that have been cultured in the presence of the selective agent and are able to pass the gene of interest to their progeny are referred to as "stable transfectants." A preferred selectable marker is a gene encoding resistance to the antibiotic neomycin. Selection is carried out in the presence of a neomycin-type drug, such as G-418 or the like. Selection systems can also be used to increase the expression level of the gene of interest, a process referred to as "amplification." Amplification is carried out by culturing transfectants in the presence of a low level of the selective agent and then increasing the amount of selective agent to select for cells that produce high levels of the products of the introduced genes. A preferred amplifiable selectable marker is dihydrofolate reductase, which confers resistance to methotrexate. Other drug resistance genes (e.g. hygromycin resistance, multi-drug resistance, puromycin acetyltransferase) can also be used. Alternative markers that introduce an altered phenotype, such as green fluorescent protein, or cell surface proteins such as CD4, CD8, Class I MHC, placental alkaline phosphatase may be used to sort transfected cells from untransfected cells by such means as FACS sorting or magnetic bead separation technology.

[136] Other higher eukaryotic cells can also be used as hosts, including plant cells, insect cells and avian cells. The use of *Agrobacterium rhizogenes* as a vector for expressing genes in plant cells has been reviewed by Sinkar et al., *J. Biosci. (Bangalore)* 11:47-58, 1987. Transformation of insect cells and production of foreign polypeptides therein is disclosed by Guarino et al., U.S. Patent No. 5,162,222 and WIPO publication WO 94/06463. Insect cells can be infected with recombinant baculovirus, commonly derived from *Autographa californica nuclear polyhedrosis virus* (AcNPV). See, King, L.A. and Possee, R.D., *The Baculovirus Expression System: A Laboratory Guide*, London, Chapman & Hall; O'Reilly, D.R. et al., *Baculovirus Expression Vectors: A Laboratory*

Manual, New York, Oxford University Press., 1994; and, Richardson, C. D., Ed., Baculovirus Expression Protocols. Methods in Molecular Biology, Totowa, NJ, Humana Press, 1995. The second method of making recombinant baculovirus utilizes a transposon-based system described by Luckow (Luckow, V.A, et al., J Virol 67:4566-79, 1993). This system is sold in the Bac-to-Bac kit (Life Technologies, Rockville, MD). This system utilizes a transfer vector, pFastBac1™ (Life Technologies) containing a Tn7 transposon to move the DNA encoding the IL-28 or IL-29 polypeptide into a baculovirus genome maintained in E. coli as a large plasmid called a "bacmid." The pFastBac1™ transfer vector utilizes the AcNPV polyhedrin promoter to drive the expression of the gene of interest, in this case IL-28 or IL-29. However, pFastBac1™ can be modified to a considerable degree. The polyhedrin promoter can be removed and substituted with the baculovirus basic protein promoter (also known as *Pcor*, p6.9 or MP promoter) which is expressed earlier in the baculovirus infection, and has been shown to be advantageous for expressing secreted proteins. See, Hill-Perkins, M.S. and Possee, R.D., J. Gen. Virol. 71:971-6, 1990; Bonning, B.C. et al., J. Gen. Virol. 75:1551-6, 1994; and, Chazenbalk, G.D., and Rapoport, B., J. Biol. Chem. 270:1543-9, 1995. In such transfer vector constructs, a short or long version of the basic protein promoter can be used. Moreover, transfer vectors can be constructed which replace the native IL-28 or IL-29 secretory signal sequences with secretory signal sequences derived from insect proteins. For example, a secretory signal sequence from Ecdysteroid Glucosyltransferase (EGT), honey bee Melittin (Invitrogen, Carlsbad, CA), or baculovirus gp67 (PharMingen, San Diego, CA) can be used in constructs to replace the native IL-28 or IL-29 secretory signal sequence. In addition, transfer vectors can include an in-frame fusion with DNA encoding an epitope tag at the C- or N-terminus of the expressed IL-28 or IL-29 polypeptide, for example, a Glu-Glu epitope tag (Grussenmeyer, T. et al., Proc. Natl. Acad. Sci. 82:7952-4, 1985). Using techniques known in the art, a transfer vector containing IL-28 or IL-29 is transformed into *E. Coli*, and screened for bacmids which contain an interrupted lacZ gene indicative of recombinant baculovirus. The bacmid DNA containing the recombinant baculovirus genome is isolated, using common techniques, and used to transfect *Spodoptera frugiperda* cells, e.g. Sf9 cells. Recombinant virus that expresses IL-28 or IL-29 is subsequently produced. Recombinant viral stocks are made by methods commonly used the art.

[137] The recombinant virus is used to infect host cells, typically a cell line derived from the fall armyworm, *Spodoptera frugiperda*. See, in general, Glick and Pasternak, Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press, Washington, D.C., 1994. Another suitable cell line is the High FiveO™ cell line (Invitrogen) derived from *Trichoplusia ni* (U.S. Patent No. 5,300,435)..

[138] Fungal cells, including yeast cells, can also be used within the present invention. Yeast species of particular interest in this regard include *Saccharomyces cerevisiae*, *Pichia pastoris*,

and *Pichia methanolica*. Methods for transforming *S. cerevisiae* cells with exogenous DNA and producing recombinant polypeptides therefrom are disclosed by, for example, Kawasaki, U.S. Patent No. 4,599,311; Kawasaki et al., U.S. Patent No. 4,931,373; Brake, U.S. Patent No. 4,870,008; Welch et al., U.S. Patent No. 5,037,743; and Murray et al., U.S. Patent No. 4,845,075. Transformed cells are selected by phenotype determined by the selectable marker, commonly drug resistance or the ability to grow in the absence of a particular nutrient (e.g., leucine). A preferred vector system for use in *Saccharomyces cerevisiae* is the *POT1* vector system disclosed by Kawasaki et al. (U.S. Patent No. 4,931,373), which allows transformed cells to be selected by growth in glucose-containing media. Suitable promoters and terminators for use in yeast include those from glycolytic enzyme genes (see, e.g., Kawasaki, U.S. Patent No. 4,599,311; Kingsman et al., U.S. Patent No. 4,615,974; and Bitter, U.S. Patent No. 4,977,092) and alcohol dehydrogenase genes. See also U.S. Patents Nos. 4,990,446; 5,063,154; 5,139,936 and 4,661,454. Transformation systems for other yeasts, including *Hansenula polymorpha*, *Schizosaccharomyces pombe*, *Kluyveromyces lactis*, *Kluyveromyces fragilis*, *Ustilago maydis*, *Pichia pastoris*, *Pichia methanolica*, *Pichia guilliermondii* and *Candida maltosa* are known in the art. See, for example, Gleeson et al., *J. Gen. Microbiol.* 132:3459-65, 1986 and Cregg, U.S. Patent No. 4,882,279. *Aspergillus* cells may be utilized according to the methods of McKnight et al., U.S. Patent No. 4,935,349. Methods for transforming *Acremonium chrysogenum* are disclosed by Sumino et al., U.S. Patent No. 5,162,228. Methods for transforming *Neurospora* are disclosed by Lambowitz, U.S. Patent No. 4,486,533. The use of *Pichia methanolica* as host for the production of recombinant proteins is disclosed in U.S. Patent Nos. 5,955,349, 5,888,768 and 6,001,597, U.S. Patent No. 5,965,389, U.S. Patent No. 5,736,383, and U.S. Patent No. 5,854,039.

[139] It is preferred to purify the polypeptides and proteins of the present invention to $\geq 80\%$ purity, more preferably to $\geq 90\%$ purity, even more preferably $\geq 95\%$ purity, and particularly preferred is a pharmaceutically pure state, that is greater than 99.9% pure with respect to contaminating macromolecules, particularly other proteins and nucleic acids, and free of infectious and pyrogenic agents. Preferably, a purified polypeptide or protein is substantially free of other polypeptides or proteins, particularly those of animal origin.

[140] Expressed recombinant IL-28 or IL-29 proteins (including chimeric polypeptides and multimeric proteins) are purified by conventional protein purification methods, typically by a combination of chromatographic techniques. See, in general, Affinity Chromatography: Principles & Methods, Pharmacia LKB Biotechnology, Uppsala, Sweden, 1988; and Scopes, Protein Purification: Principles and Practice, Springer-Verlag, New York, 1994. Proteins comprising a polyhistidine affinity tag (typically about 6 histidine residues) are purified by affinity chromatography on a nickel chelate resin. See, for example, Houchuli et al., Bio/Technol. 6: 1321-1325, 1988. Proteins comprising a glu-glu tag can be purified by immunoaffinity chromatography according to

conventional procedures. See, for example, Grussenmeyer et al., *supra*. Maltose binding protein fusions are purified on an amylose column according to methods known in the art.

[141] IL-28 or IL-29 polypeptides can also be prepared through chemical synthesis according to methods known in the art, including exclusive solid phase synthesis, partial solid phase methods, fragment condensation or classical solution synthesis. See, for example, Merrifield, *J. Am. Chem. Soc.* **85**:2149, 1963; Stewart et al., *Solid Phase Peptide Synthesis* (2nd edition), Pierce Chemical Co., Rockford, IL, 1984; Bayer and Rapp, *Chem. Pept. Prot.* **3**:3, 1986; and Atherton et al., *Solid Phase Peptide Synthesis: A Practical Approach*, IRL Press, Oxford, 1989. In vitro synthesis is particularly advantageous for the preparation of smaller polypeptides.

[142] Using methods known in the art, IL-28 or IL-29 proteins can be prepared as monomers or multimers; glycosylated or non-glycosylated; pegylated or non-pegylated; fusion proteins; and may or may not include an initial methionine amino acid residue. IL-28 or IL-29 conjugates used for therapy may comprise pharmaceutically acceptable water-soluble polymer moieties. Conjugation of interferons with water-soluble polymers has been shown to enhance the circulating half-life of the interferon, and to reduce the immunogenicity of the polypeptide (see, for example, Nieforth *et al.*, *Clin. Pharmacol. Ther.* **59**:636 (1996), and Monkarsh *et al.*, *Anal. Biochem.* **247**:434 (1997)).

[143] Suitable water-soluble polymers include polyethylene glycol (PEG), monomethoxy-PEG, mono-(C1-C10)alkoxy-PEG, aryloxy-PEG, poly-(N-vinyl pyrrolidone)PEG, tresyl monomethoxy PEG, monomethoxy-PEG propionaldehyde, PEG propionaldehyde, *bis*-succinimidyl carbonate PEG, propylene glycol homopolymers, a polypropylene oxide/ethylene oxide co-polymer, polyoxyethylated polyols (*e.g.*, glycerol), monomethoxy-PEG butyraldehyde, PEG butyraldehyde, monomethoxy-PEG acetaldehyde, PEG acetaldehyde, methoxyl PEG-succinimidyl propionate, methoxyl PEG-succinimidyl butanoate, polyvinyl alcohol, dextran, cellulose, or other carbohydrate-based polymers. Suitable PEG may have a molecular weight from about 600 to about 60,000, including, for example, 5,000 daltons, 12,000 daltons, 20,000 daltons, 30,000 daltons, and 40,000 daltons, which can be linear or branched. A IL-28 or IL-29 conjugate can also comprise a mixture of such water-soluble polymers.

[144] One example of a IL-28 or IL-29 conjugate comprises a IL-28 or IL-29 moiety and a polyalkyl oxide moiety attached to the *N*-terminus of the IL-28 or IL-29 moiety. PEG is one suitable polyalkyl oxide. As an illustration, IL-28 or IL-29 can be modified with PEG, a process known as "PEGylation." PEGylation of IL-28 or IL-29 can be carried out by any of the PEGylation reactions known in the art (see, for example, EP 0 154 316, Delgado *et al.*, *Critical Reviews in Therapeutic Drug Carrier Systems* **9**:249 (1992), Duncan and Spreafico, *Clin. Pharmacokinet.* **27**:290 (1994), and Francis *et al.*, *Int J Hematol* **68**:1 (1998)). For example, PEGylation can be performed by an acylation reaction or by an alkylation reaction with a reactive polyethylene glycol molecule. In an alternative

approach, IL-28 or IL-29 conjugates are formed by condensing activated PEG, in which a terminal hydroxy or amino group of PEG has been replaced by an activated linker (see, for example, Karasiewicz *et al.*, U.S. Patent No. 5,382,657).

[145] PEGylation by acylation typically requires reacting an active ester derivative of PEG with a IL-28 or IL-29 polypeptide. An example of an activated PEG ester is PEG esterified to *N*-hydroxysuccinimide. As used herein, the term "acylation" includes the following types of linkages between IL-28 or IL-29 and a water-soluble polymer: amide, carbamate, urethane, and the like. Methods for preparing PEGylated IL-28 or IL-29 by acylation will typically comprise the steps of (a) reacting an IL-28 or IL-29 polypeptide with PEG (such as a reactive ester of an aldehyde derivative of PEG) under conditions whereby one or more PEG groups attach to IL-28 or IL-29, and (b) obtaining the reaction product(s). Generally, the optimal reaction conditions for acylation reactions will be determined based upon known parameters and desired results. For example, the larger the ratio of PEG: IL-28 or IL-29, the greater the percentage of polyPEGylated IL-28 or IL-29 product.

[146] PEGylation by alkylation generally involves reacting a terminal aldehyde, e.g., propionaldehyde, butyraldehyde, acetaldehyde, and the like, derivative of PEG with IL-28 or IL-29 in the presence of a reducing agent. PEG groups are preferably attached to the polypeptide via a -CH₂-NH₂ group.

[147] Derivatization via reductive alkylation to produce a monoPEGylated product takes advantage of the differential reactivity of different types of primary amino groups available for derivatization. Typically, the reaction is performed at a pH that allows one to take advantage of the pK_a differences between the ε-amino groups of the lysine residues and the α-amino group of the *N*-terminal residue of the protein. By such selective derivatization, attachment of a water-soluble polymer that contains a reactive group such as an aldehyde, to a protein is controlled. The conjugation with the polymer occurs predominantly at the *N*-terminus of the protein without significant modification of other reactive groups such as the lysine side chain amino groups.

[148] Reductive alkylation to produce a substantially homogenous population of monopolymer IL-28 or IL-29 conjugate molecule can comprise the steps of: (a) reacting a IL-28 or IL-29 polypeptide with a reactive PEG under reductive alkylation conditions at a pH suitable to permit selective modification of the α-amino group at the amino terminus of the IL-28 or IL-29, and (b) obtaining the reaction product(s). The reducing agent used for reductive alkylation should be stable in aqueous solution and preferably be able to reduce only the Schiff base formed in the initial process of reductive alkylation. Preferred reducing agents include sodium borohydride, sodium cyanoborohydride, dimethylamine borane, trimethylamine borane, and pyridine borane.

[149] For a substantially homogenous population of monopolymer IL-28 or IL-29 conjugates, the reductive alkylation reaction conditions are those that permit the selective attachment of the water-soluble polymer moiety to the *N*-terminus of IL-28 or IL-29. Such reaction conditions

generally provide for pKa differences between the lysine amino groups and the α -amino group at the *N*-terminus. The pH also affects the ratio of polymer to protein to be used. In general, if the pH is lower, a larger excess of polymer to protein will be desired because the less reactive the *N*-terminal α -group, the more polymer is needed to achieve optimal conditions. If the pH is higher, the polymer: IL-28 or IL-29 need not be as large because more reactive groups are available. Typically, the pH will fall within the range of 3 - 9, or 3 - 6. Another factor to consider is the molecular weight of the water-soluble polymer. Generally, the higher the molecular weight of the polymer, the fewer number of polymer molecules which may be attached to the protein. For PEGylation reactions, the typical molecular weight is about 2 kDa to about 100 kDa, about 5 kDa to about 50 kDa, about 12 kDa to about 40 kDa, or about 20kDa to about 30 kDa. The molar ratio of water-soluble polymer to IL-28 or IL-29 will generally be in the range of 1:1 to 100:1. Typically, the molar ratio of water-soluble polymer to IL-28 or IL-29 will be 1:1 to 20:1 for polyPEGylation, and 1:1 to 5:1 for monoPEGylation.

[150] General methods for producing conjugates comprising interferon and water-soluble polymer moieties are known in the art. See, for example, Karasiewicz *et al.*, U.S. Patent No. 5,382,657, Greenwald *et al.*, U.S. Patent No. 5,738, 846, Nieforth *et al.*, Clin. Pharmacol. Ther. 59:636 (1996), Monkarsh *et al.*, Anal. Biochem. 247:434 (1997). PEGylated species can be separated from unconjugated IL-28 or IL-29 polypeptides using standard purification methods, such as dialysis, ultrafiltration, ion exchange chromatography, affinity chromatography, size exclusion chromatography, and the like.

[151] The IL-28 or IL-29 molecules of the present invention are capable of specifically binding the IL-28 receptor and/or acting as an antumor agent. The binding of IL-28 or IL-29 polypeptides to the IL-28 receptor can be assayed using established approaches. IL-28 or IL-29 can be iodinated using an iodobead (Pierce, Rockford, IL) according to manufacturer's directions, and the ^{125}I -IL-28 or ^{125}I -IL-29 can then be used as described below.

[152] In a first approach fifty nanograms of ^{125}I -IL-28 or ^{125}I -IL-29 can be combined with 1000ng of IL-28 receptor human IgG fusion protein, in the presence or absence of possible binding competitors including unlabeled IL-28 or IL-29. The same binding reactions would also be performed substituting other cytokine receptor human IgG fusions as controls for specificity. Following incubation at 4°C, protein-G (Zymed, San Francisco, CA) is added to the reaction, to capture the receptor-IgG fusions and any proteins bound to them, and the reactions are incubated another hour at 4°C. The protein-G sepharose is then collected, washed three times with PBS and ^{125}I -IL-28 or ^{125}I -IL-29 bound is measured by gamma counter (Packard Instruments, Downers Grove, IL).

[153] In a second approach, the ability of molecules to inhibit the binding of ^{125}I -IL-28 or ^{125}I -IL-29 to plate bound receptors can be assayed. A fragment of the IL-28 receptor, representing the extracellular, ligand binding domain, can be adsorbed to the wells of a 96 well plate by incubating 100

μ l of 1 g/mL solution of receptor in the plate overnight. In a second form, a receptor-human IgG fusion can be bound to the wells of a 96 well plate that has been coated with an antibody directed against the human IgG portion of the fusion protein. Following coating of the plate with receptor the plate is washed, blocked with SUPERBLOCK (Pierce, Rockford, IL) and washed again. Solutions containing a fixed concentration of ^{125} I-IL-28 or ^{125} I-IL-29 with or without increasing concentrations of potential binding competitors including, IL-28, IL-29, IL-28 and IL-29, and 100 μ l of the solution added to appropriate wells of the plate. Following a one hour incubation at 4°C the plate is washed and the amount ^{125} I-IL-28 or ^{125} I-IL-29 bound determined by counting (Topcount, Packard Instruments, Downers grove, IL). The specificity of binding of ^{125} I-IL-28 or ^{125} I-IL-29 can be defined by receptor molecules used in these binding assays as well as by the molecules used as inhibitors.

[154] In addition to pegylation, human albumin can be genetically coupled to a polypeptide of the present invention to prolong its half-life. Human albumin is the most prevalent naturally occurring blood protein in the human circulatory system, persisting in circulation in the body for over twenty days. Research has shown that therapeutic proteins genetically fused to human albumin have longer half-lives. An IL28 or IL29 albumin fusion protein, like pegylation, may provide patients with long-acting treatment options that offer a more convenient administration schedule, with similar or improved efficacy and safety compared to currently available treatments (U.S. Patent No. 6,165,470; Syed et al., Blood, 89(9):3243-3253 (1997); Yeh et al., Proc. Natl. Acad. Sci. USA, 89:1904-1908 (1992); and Zeisel et al., Horm. Res., 37:5-13 (1992)).

[155] Like the aforementioned pegylation and human albumin, an Fc portion of the human IgG molecule can be fused to a polypeptide of the present invention. The resultant fusion protein may have an increased circulating half-life due to the Fc moiety (U.S. Patent No. 5,750,375, U.S. Patent No. 5,843,725, U.S. Patent No. 6,291,646; Barouch et al., Journal of Immunology, 61:1875-1882 (1998); Barouch et al., Proc. Natl. Acad. Sci. USA, 97(8):4192-4197 (April 11, 2000); and Kim et al., Transplant Proc., 30(8):4031-4036 (Dec. 1998)).

[156] As used herein, the term "antibodies" includes polyclonal antibodies, monoclonal antibodies, antigen-binding fragments thereof such as F(ab')₂ and Fab fragments, single chain antibodies, and the like, including genetically engineered antibodies. Non-human antibodies may be humanized by grafting non-human CDRs onto human framework and constant regions, or by incorporating the entire non-human variable domains (optionally "cloaking" them with a human-like surface by replacement of exposed residues, wherein the result is a "veneered" antibody). In some instances, humanized antibodies may retain non-human residues within the human variable region framework domains to enhance proper binding characteristics. Through humanizing antibodies, biological half-life may be increased, and the potential for adverse immune reactions upon administration to humans is reduced. One skilled in the art can generate humanized antibodies with specific and different constant domains (i.e., different Ig subclasses) to facilitate or inhibit various

immune functions associated with particular antibody constant domains. Antibodies are defined to be specifically binding if they bind to IL-28 or IL-29 polypeptide or protein with an affinity at least 10-fold greater than the binding affinity to control (non- IL-28 and IL-29) polypeptide or protein. The affinity of a monoclonal antibody can be readily determined by one of ordinary skill in the art (see, for example, Scatchard, Ann. NY Acad. Sci. 51: 660-672, 1949).

[157] Methods for preparing polyclonal and monoclonal antibodies are well known in the art (see for example, Hurrell, J. G. R., Ed., Monoclonal Hybridoma Antibodies: Techniques and Applications, CRC Press, Inc., Boca Raton, FL, 1982, which is incorporated herein by reference). The polypeptide immunogen may be a full-length molecule or a portion thereof. If the polypeptide portion is "hapten-like", such portion may be advantageously joined or linked to a macromolecular carrier (such as keyhole limpet hemocyanin (KLH), bovine serum albumin (BSA) or tetanus toxoid) for immunization.

[158] A variety of assays known to those skilled in the art can be utilized to detect antibodies which specifically bind to IL-28 or IL-29 polypeptides. Exemplary assays are described in detail in Using Antibodies: A Laboratory Manual, Harlow and Lane (Eds.), Cold Spring Harbor Laboratory Press, 1999. Representative examples of such assays include: concurrent immunoelectrophoresis, radio-immunoassays, radio-immunoprecipitations, enzyme-linked immunosorbent assays (ELISA), dot blot assays, Western blot assays, inhibition or competition assays, and sandwich assays.

[159] For certain applications, including *in vitro* and *in vivo* diagnostic uses, it is advantageous to employ labeled antibodies. Suitable direct tags or labels include radionuclides, enzymes, substrates, cofactors, inhibitors, fluorescent markers, chemiluminescent markers, magnetic particles and the like; indirect tags or labels may feature use of biotin-avidin or other complement/anti-complement pairs as intermediates. Antibodies of the present invention may also be directly or indirectly conjugated to drugs, toxins, radionuclides and the like, and these conjugates used for *in vivo* diagnostic or therapeutic applications(e.g., inhibition of cell proliferation). See, in general, Ramakrishnan et al., Cancer Res. 56:1324-1330, 1996.

[160] Administration of a pharmaceutical formulation to a patient can be topical, inhalant, intravenous, intraarterial, intraperitoneal, intramuscular, subcutaneous, intrapleural, intrathecal, by perfusion through a regional catheter, or by direct intralesional injection. When administering therapeutic proteins by injection, the administration may be by continuous infusion or by single or multiple boluses. In general, pharmaceutical formulations will include a IL-28 or IL-29 polypeptide in combination with a pharmaceutically acceptable vehicle, such as saline, buffered saline, 5% dextrose in water, or the like. Formulations may further include one or more excipients, preservatives, solubilizers, buffering agents, albumin to prevent protein loss on vial surfaces, etc. Methods of formulation are well known in the art and are disclosed, for example, in *Remington: The*

Science and Practice of Pharmacy, Gennaro, ed., Mack Publishing Co., Easton, PA, 19th ed., 1995. An IL-28 or IL-29 polypeptide will preferably be used in a concentration of about 10 to 100 µg/ml of total volume, although concentrations in the range of 1 ng/ml to 1000 µg/ml may be used. For topical application, such as for the promotion of wound healing, the protein will be applied in the range of 0.1-10 µg/cm² of wound area, with the exact dose determined by the clinician according to accepted standards, taking into account the nature and severity of the condition to be treated, patient traits, etc. Determination of dose is within the level of ordinary skill in the art. Dosing is daily or intermittently over the period of treatment. Intravenous administration will be by bolus injection or infusion over a typical period of one to several hours. Sustained release formulations can also be employed. In general, a therapeutically effective amount of IL-28 or IL-29 is an amount sufficient to produce a clinically significant change in the treated condition, such as a clinically significant change in hematopoietic or immune function, a significant reduction in morbidity, or a significantly increased histological score.

[161] As an illustration, pharmaceutical formulations may be supplied as a kit comprising a container that comprises an IL-28 or IL29 polypeptide of the present invention. Therapeutic polypeptides can be provided in the form of an injectable solution for single or multiple doses, or as a sterile powder that will be reconstituted before injection. Alternatively, such a kit can include a dry-powder disperser, liquid aerosol generator, or nebulizer for administration of a therapeutic polypeptide. Such a kit may further comprise written information on indications and usage of the pharmaceutical composition. Moreover, such information may include a statement that the IL-28 or IL29 polypeptide formulation is contraindicated in patients with known hypersensitivity to IL-28 or IL29 polypeptide.

B. The Use of IL-28 and IL-29 to Treat Cancer

[162] IL-28 and IL-29 polypeptides of the present invention have been shown to have an antiviral effect that is similar to interferon-α (See WO 04/037995). Interferon has been approved in the United States for treatment of autoimmune diseases, condyloma acuminatum, chronic hepatitis C, bladder carcinoma, cervical carcinoma, laryngeal papillomatosis, fungoides mycosis, chronic hepatitis B, Kaposi's sarcoma in patients infected with human immunodeficiency virus, malignant melanoma, hairy cell leukemia, and multiple sclerosis. In addition, IL-28 and IL-29 polypeptides may be used to treat forms of arteriosclerosis, such as atherosclerosis, by inhibiting cell proliferation. Accordingly, the present invention contemplates the use of IL-28 or IL-29 polypeptides, fusion proteins, and fragments thereof having IL-28 and IL-29 activity to treat such conditions, as well as to treat retinopathy.

[163] The IL-28 polypeptides of the present invention encompass IL-28A and IL-28B polypeptides. IL-28A polypeptides of the present invention include, for example, SEQ ID NOs:2, 13,

19, 21, 23, 25, 163 and 165 which are encoded by IL-28A polynucleotide molecules as shown in SEQ ID NOs:1, 12, 18, 20, 22, 24, 162 and 164, respectively. In addition, the present invention also provides for IL-28A polypeptides as shown in SEQ ID NOs:36, 37, 38, and 39, C2 mutants thereof, N-terminally modified C2 mutants thereof, C-terminally modified C2 mutants thereof, N-terminally and C-terminally C2 mutants thereof, C3 mutants thereof, N-terminally modified C3 mutants thereof, C-terminally modified C3 mutants thereof, N-terminally and C-terminally modified C3 mutants thereof, fragments thereof, and fusion proteins thereof. The IL-28B polypeptides of the present invention include, for example, SEQ ID NOs:6, 17, 123, 125, 127, 129, 131, 133, 135, 137, 167 and 169, which are encoded by IL-28B polynucleotide molecules as shown in SEQ ID NOs:5, 16, 122, 124, 126, 128, 130, 132, 134, 136, 166 and 168, respectively, C2 mutants thereof, N-terminally modified C2 mutants thereof, C-terminally modified C2 mutants thereof, N-terminally and C-terminally C2 mutants thereof, C3 mutants thereof, N-terminally modified C3 mutants thereof, C-terminally modified C3 mutants thereof, N-terminally and C-terminally modified C3 mutants thereof, fragments thereof, and fusion proteins thereof.

[164] The IL-29 polypeptides of the present invention include, for example, SEQ ID NOs:4, 15, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 171, 173 and 175, which are encoded by IL-29 polynucleotide molecules as shown in SEQ ID NOs:3, 14, 26, 28, 40, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 138, 140, 142, 144, 146, 148, 175, 152, 154, 156, 158, 160, 170, 172 and 174, respectively, C1 mutants thereof, N-terminally modified C1 mutants thereof, C-terminally modified C1 mutants thereof, N-terminally and C-terminally C1 mutants thereof, C5 mutants thereof, N-terminally modified C5 mutants thereof, C-terminally modified C5 mutants thereof, N-terminally and C-terminally modified C5 mutants thereof, fragments thereof, and fusion proteins thereof. The IL-29 polypeptides may further include a signal sequence as shown in SEQ ID NO:119 or a signal sequence as shown in SEQ ID NO:121. A polynucleotide molecule encoding the signal sequence polypeptide of SEQ ID NO:119 is shown as SEQ ID NO:118. A polynucleotide molecule encoding the signal sequence polypeptide of SEQ ID NO:120 is shown as SEQ ID NO:121.

[165] The present invention provides for the use of these IL-28 and IL-29 proteins, polypeptides, and peptides having IL-28 and IL-29 activity to treat, prevent, inhibit the progression of, delay the onset of, and/or reduce at least one of the conditions or symptoms associated with the lymphoproliferative disorders, including for instance, B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia. In addition, the present invention further provides for the use of IL-28 and IL-29 proteins, polypeptides, and peptides having IL-28 and IL-29 activity to treat, prevent, inhibit the progression of, delay the onset of, and/or reduce the severity or

inhibit at least one of the conditions or symptoms associated with the following cancers selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer (e.g., small cell lung cancer, non-small cell lung cancer such as Squamous cell carcinoma, Adenocarcinoma and Large cell carcinoma, and mesothelioma), pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma).

[166] Interferons have also been shown to induce the expression of antigens by cultured cells (see, for example, Auth *et al.*, Hepatology 18:546 (1993), Guadagni *et al.*, Int. J. Biol. Markers 9:53 (1994), Girolomoni *et al.*, Eur. J. Immunol. 25:2163 (1995), and Maciejewski *et al.*, Blood 85:3183 (1995). This activity enhances the ability to identify new tumor associated antigens *in vitro*. Moreover, the ability of interferons to augment the level of expression of human tumor antigens indicates that interferons can be useful in an adjuvant setting for immunotherapy or enhance immunoscintigraphy using anti-tumor antigen antibodies (Guadagni *et al.*, Cancer Immunol. Immunother. 26:222 (1988); Guadagni *et al.*, Int. J. Biol. Markers 9:53 (1994)). Thus, the present invention includes the use of IL-28 or IL-29 proteins, polypeptides and peptides having IL-28 and IL-29 activity as an adjuvant for immunotherapy or to improve immunoscintigraphy using anti-tumor antigen antibodies.

[167] The activity and effect of an IL-28 or IL-29 polypeptide on tumor progression and metastasis can be measured *in vivo*. Several syngeneic mouse models have been developed to study the influence of polypeptides, compounds or other treatments on tumor progression. In these models, tumor cells passaged in culture are implanted into mice of the same strain as the tumor donor. The cells will develop into tumors having similar characteristics in the recipient mice, and metastasis will also occur in some of the models. Appropriate tumor models for our studies include the Lewis lung carcinoma (ATCC No. CRL-1642) and B16 melanoma (ATCC No. CRL-6323), amongst others. These are both commonly used tumor lines, syngeneic to the C57BL6 mouse, that are readily cultured and manipulated *in vitro*. Tumors resulting from implantation of either of these cell lines are capable of metastasis to the lung in C57BL6 mice. The Lewis lung carcinoma model has recently been used in mice to identify an inhibitor of angiogenesis (O'Reilly MS, et al. Cell 79: 315-328,1994). C57BL6/J mice are treated with an experimental agent either through daily injection of recombinant

protein, agonist or antagonist or a one-time injection of recombinant adenovirus. Three days following this treatment, 10^5 to 10^6 cells are implanted under the dorsal skin. Alternatively, the cells themselves may be infected with recombinant adenovirus, such as one expressing IL-28 and IL-29, before implantation so that the protein is synthesized at the tumor site or intracellularly, rather than systemically. The mice normally develop visible tumors within 5 days. The tumors are allowed to grow for a period of up to 3 weeks, during which time they may reach a size of 1500 - 1800 mm³ in the control treated group. Tumor size and body weight are carefully monitored throughout the experiment. At the time of sacrifice, the tumor is removed and weighed along with the lungs and the liver. The lung weight has been shown to correlate well with metastatic tumor burden. As an additional measure, lung surface metastases are counted. The resected tumor, lungs and liver are prepared for histopathological examination, immunohistochemistry, and *in situ* hybridization, using methods known in the art and described herein. The influence of the expressed polypeptide in question, e.g., Cysteine mutant IL-28 and IL-29, on the ability of the tumor to recruit vasculature and undergo metastasis can thus be assessed. In addition, aside from using adenovirus, the implanted cells can be transiently transfected with IL-28 and IL-29. Use of stable IL-28 or IL-29 transfectants as well as use of induceable promoters to activate IL-28 or IL-29 expression *in vivo* are known in the art and can be used in this system to assess induction of metastasis. Moreover, purified IL-28 or IL-29 conditioned media can be directly injected in to this mouse model, and hence be used in this system. For general reference see, O'Reilly MS, et al. *Cell* 79:315-328, 1994; and Rusciano D, et al. *Murine Models of Liver Metastasis. Invasion Metastasis* 14:349-361, 1995.

[168] The present invention provides for a method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175 wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[169] The present invention also provides a method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[170] The present invention also provides a method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; and a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone

cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[171] The present invention also provides a method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about

20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[172] The present invention also provides a method of inhibiting the progressive of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[173] The present invention also provides a method of inhibiting the progression of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as

Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[174] The present invention also provides a method of delaying the onset of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung, cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[175] The present invention also provides a method of delaying the onset of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[176] The present invention also provides a method of reducing the severity of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia,

chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[177] The present invention also provides a method of reducing the severity of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer, Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about

20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[178] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[179] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of renal cell carcinoma, hepatocellular carcinoma, cervical cancer (e.g., squamous type and adenocarcinoma), head and neck tumours (e.g., Hypopharyngeal Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Metastatic Squamous Neck Cancer with Occult Primary, Nasopharyngeal Cancer, Oropharyngeal Cancer,

Paranasal Sinus and Nasal Cavity Cancer, Parathyroid Cancer, and Salivary Gland Cancer), melanoma (e.g., malignant melanoma such as Superficial spreading melanoma, Nodular melanoma, and Lentigo maligna melanoma), thyroid carcinoma (e.g., Papillary, Follicular, Medullary, and Anaplastic), malignant gliomas (e.g., glioblastoma multiforme and anaplastic astrocytoma), breast cancer (e.g., ductal carcinoma), colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer (e.g., Osteosarcoma, Ewing's sarcoma, Chondrosarcoma, Spindle cell sarcoma, and Chordoma). The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[180] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of non-Hodgkin's lymphoma comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of painless swelling of a lymph node in the neck, armpit or groin, night sweats, unexplained fever, weight loss, and excessive tiredness. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[181] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of non-Hodgkin's lymphoma comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; and a pharmaceutically acceptable vehicle; wherein the at least one of the conditions or symptoms is selected from the group of painless swelling of a lymph node in the neck, armpit or groin, night sweats, unexplained fever, weight loss, and excessive tiredness. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[182] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of multiple myeloma comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of back pain, loss of height, anaemia, kidney damage, repeated respiratory infections, and hypercalcaemia. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD.

The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[183] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of multiple myeloma comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; and a pharmaceutically acceptable vehicle; wherein the at least one of the conditions or symptoms is selected from the group of back pain, loss of height, anaemia, kidney damage, repeated respiratory infections, and hypercalcaemia. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[184] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of head and neck tumours comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of an ulcer or sore area in the head or neck that does not heal within a few weeks, difficulty in swallowing, trouble with breathing or speaking, a numb feeling in the mouth, nose bleeds, persistent earache, difficulty in hearing, and swelling or lump in the mouth or neck. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide

may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[185] The present invention also provides a method of inhibiting at least one of the conditions or symptoms of head and neck tumours comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 90% or 95% sequence identity with a sequence selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175; a second polypeptide; and a pharmaceutically acceptable vehicle; wherein the at least one of the conditions or symptoms is selected from the group of an ulcer or sore area in the head or neck that does not heal within a few weeks, difficulty in swallowing, trouble with breathing or speaking, a numb feeling in the mouth, nose bleeds, persistent earache, difficulty in hearing, and swelling or lump in the mouth or neck. The polypeptide may have at least 15, at least 30, at least 45, or at least 60 sequential amino acids to SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173 and 175. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human. The second polypeptide may be an Interferon molecule, such as Interferon-alpha, Interferon-beta, or Interferon-gamma, another therapeutic agent, such as IL-2 or IL-21, or combination thereof.

[186] There are four main types of malignant melanoma which occur in the skin. These are known as cutaneous melanoma:

[187] Superficial spreading melanoma is the most common type of melanoma. About 7 out of 10 (70%) are this type. They occur mostly in middle-aged people. The most common place in women is on the legs, while in men it is more common on the trunk, particularly the back. They tend to start by spreading out across the surface of the skin: this is known as the radial growth phase. If the melanoma is removed at this stage there is a very high chance of cure. If the melanoma is not removed, it will start to grow down deeper into the layers of the skin. There is then a risk that it will spread in the bloodstream or lymph system to other parts of the body. Nodular melanoma occurs

most often on the chest or back. It is most commonly found in middle-aged people. It tends to grow deeper into the skin quite quickly if it is not removed. This type of melanoma is often raised above the rest of the skin surface and feels like a bump. It may be very dark brown-black or black. Lentigo maligna melanoma is most commonly found on the face, particularly in older people. It grows slowly and may take several years to develop. Acral melanoma is usually found on the palms of the hands, soles of the feet or around the toenails. Other very rare types of melanoma of the skin include amelanotic melanoma (in which the melanoma loses its pigment and appears as a white area) and desmoplastic melanoma (which contains fibrous scar tissue). Malignant melanoma can start in parts of the body other than the skin but this is very rare. The parts of the body that may be affected are the eye, the mouth, under the fingernails (known as subungual melanoma) the vulval or vaginal tissues, or internally (cancerbacup internet website).

[188] Most melanomas start with a change in the appearance of normal skin. This can look like an abnormal new mole. Less than a third develop in existing moles. It can be difficult to tell the difference between a mole and a melanoma, but the following checklist can be used to help. It is known as the ABCD list. Asymmetry – Ordinary moles are usually symmetrical in shape. Melanomas are likely to be irregular or asymmetrical. Border – Moles usually have a well-defined regular border. Melanomas are more likely to have an irregular border with jagged edges. Colour – Moles are usually a uniform brown. Melanomas tend to have more than one colour. They may be varying shades of brown mixed with black, red, pink, white or a bluish tint. Diameter – Moles are normally no bigger than the blunt end of a pencil (about 6mm across). Melanomas are usually more than 7mm in diameter. Normal moles can be raised up from the skin and/or may be hairy. Itching, crusting or bleeding may also occur in melanomas – these are less common signs but should not be ignored (cancerbacup internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine melanoma model similar to that described in Hermans et al., Cancer Res. 2003 Dec 1;63(23):8408-13; Ramont et al., Exp Cell Res. 2003 Nov 15;291(1):1-10; Safwat et al., J Exp Ther Oncol. 2003 Jul-Aug;3(4):161-8; and Fidler, I.J., Nat New Biol. 1973 Apr 4;242(118):148-9.

[189] Chronic myeloid leukaemia (CML) is a rare type of cancer affecting mostly adults. It is a cancer of granulocytes (one of the main types of white blood cells). In CML too many granulocytes are produced and they are released into the blood when they are immature and unable to work properly. The immature white blood cells are known as blasts. The production of other types of blood cells is also disrupted. Normally, white blood cells repair and reproduce themselves in an orderly and controlled manner, but in chronic myeloid leukaemia the process gets out of control and the cells continue to divide and mature abnormally. The disease usually develops very slowly, which is why it is called 'chronic' myeloid leukaemia (cancerbacup internet website).

[190] Because CML develops (progresses) slowly, it is difficult to detect in its early stages. Sometimes it is discovered only when a blood test is done for another reason. The symptoms of CML are often vague and non-specific and are caused by the increased number of abnormal white blood cells in the bone marrow and the reduced number of normal blood cells: a feeling of fullness or a tender lump on the left side of the abdomen. This is because, in CML, the spleen can become enlarged. The spleen is an organ which lies just below the ribs on the left side of the abdomen. It filters the blood and removes worn-out red blood cells. The swelling of the spleen may also cause pressure on the stomach, which can lead to indigestion and poor appetite some people feel tired and look pale, due to a lack of red blood cells (anaemia) due to a lower number of platelets in the blood some people may notice that they bleed or bruise more easily. As well as bruising more easily than normal, a special type of bruising can be seen. This consists of small blood-like spots usually seen on the legs or in the mouth and is called petechiae. Women may find that their periods become very much heavier. However, these symptoms and signs are rare some people may notice a generalised itching. Chronic myeloid leukaemia can occur at any age, but it more commonly affects middle-aged and older people. It is rare in children (cancerbacup internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine chronic myeloid leukaemia model similar to that described in Ren, R., Oncogene. 2002 Dec 9;21(56):8629-42; Wertheim et al., Oncogene. 2002 Dec 9;21(56):8612-28; and Wolff et al., Blood. 2001 Nov 1;98(9):2808-16.

[191] Non-Hodgkin's lymphomas are a type of cancer of the lymphatic system. There are two main types of lymphoma. One is called Hodgkin's disease (named after Dr Hodgkin, who first described it). The other is called non-Hodgkin's lymphoma. There are about 20 different types of non-Hodgkin's lymphoma. In most cases of Hodgkin's disease, a particular cell known as the Reed-Sternberg cell is found in the biopsies. This cell is not usually found in other lymphomas, so they are called non-Hodgkin's lymphoma. This may not seem a very big difference, but it is important because the treatment for Hodgkin's and non-Hodgkin's lymphomas can be very different (cancerbacup internet website).

[192] Often, the first sign of a non-Hodgkin's lymphoma is a painless swelling of a lymph node in the neck, armpit or groin. Other symptoms may include any of the following: night sweats or unexplained high temperatures (fever); loss of appetite, unexplained weight loss and excessive tiredness; children may develop a cough or breathlessness. They may also complain of abdominal pain or you may notice a lump in your child's abdomen persistent itching of the skin all over the body (cancerbacup internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine non-Hodgkin's lymphoma model similar to that described in Ansell et al., Leukemia. 2004 Mar;18(3):616-23; De Jonge et al., J Immunol. 1998 Aug 1;161(3):1454-61; and Slavin et al., Nature. 1978 Apr 13;272(5654):624-6.

[193] Renal cell carcinoma, a form of kidney cancer that involves cancerous changes in the cells of the renal tubule, is the most common type of kidney cancer in adults. Why the cells become cancerous is not known. A history of smoking greatly increases the risk for developing renal cell carcinoma. Some people may also have inherited an increased risk to develop renal cell carcinoma, and a family history of kidney cancer increases the risk. People with von Hippel-Lindau disease, a hereditary disease that affects the capillaries of the brain, commonly also develop renal cell carcinoma. Kidney disorders that require dialysis for treatment also increase the risk for developing renal cell carcinoma. The first symptom is usually blood in the urine. Sometimes both kidneys are involved. The cancer metastasizes or spreads easily, most often to the lungs and other organs, and about one-third of patients have metastasis at the time of diagnosis (Medline Plus Medical Encyclopedia Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine renal cell carcinoma model similar to that described in Sayers et al., Cancer Res. 1990 Sep 1;50(17):5414-20; Salup et al., Immunol. 1987 Jan 15;138(2):641-7; and Luan et al., Transplantation. 2002 May 27;73(10):1565-72.

[194] The cervix is the neck of the uterus that opens into the vagina. Cervical cancer, also called cervical carcinoma, develops from abnormal cells on the surface of the cervix. Cervical cancer is one of the most common cancers affecting women. Cervical cancer is usually preceded by dysplasia, precancerous changes in the cells on the surface of the cervix. These abnormal cells can progress to invasive cancer. Once the cancer appears it can progress through four stages. The stages are defined by the extent of spread of the cancer. The more the cancer has spread, the more extensive the treatment is likely to be. There are 2 main types of cervical cancer: (1) Squamous type (epidermoid cancer): This is the most common type, accounting for about 80% to 85% of cervical cancers. This cancer may be caused by sexually transmitted diseases. One such sexual disease is the human papillomavirus, which causes venereal warts. The cancerous tumor grows on and into the cervix. This cancer generally starts on the surface of the cervix and may be diagnosed at an early stage by a Pap smear. (2) Adenocarcinoma: This type of cervical cancer develops from the tissue in the cervical glands in the canal of the cervix. Early cervical cancer usually causes no symptoms. The cancer is usually detected by a Pap smear and pelvic exam. This is why you should start having Pap smears and pelvic exams as soon as you become sexually active. Healthy young women who have never been sexually active should have their first annual pelvic exam by age 18. Later stages of cervical cancer cause abnormal vaginal bleeding or a bloodstained discharge at unexpected times, such as between menstrual periods, after intercourse, or after menopause. Abnormal vaginal discharge may be cloudy or bloody or may contain mucus with a bad odor. Advanced stages of the cancer may cause pain (University of Michigan Health System Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine cervical cancer model similar to that described in Ahn et al., Hum Gene Ther. 2003 Oct

10;14(15):1389-99; Hussain et al., Oncology. 1992;49(3):237-40; and Sengupta et al., Oncology. 1991;48(3):258-61.

[195] Most cancers of the head and neck are of a type called carcinoma (in particular squamous cell carcinoma). Carcinomas of the head and neck start in the cells that form the lining of the mouth, nose, throat or ear, or the surface layer covering the tongue. However, cancers of the head and neck can develop from other types of cells. Lymphoma develops from the cells of the lymphatic system. Sarcoma develops from the supportive cells which make up muscles, cartilage or blood vessels. Melanoma starts from cells called melanocytes, which give colour to the eyes and skin. The symptoms of a head and neck cancer will depend on where it is - for example, cancer of the tongue may cause some slurring of speech. The most common symptoms are an ulcer or sore area in the head or neck that does not heal within a few weeks; difficulty in swallowing, or pain when chewing or swallowing; trouble with breathing or speaking, such as persistent noisy breathing, slurred speech or a hoarse voice; a numb feeling in the mouth; a persistent blocked nose, or nose bleeds; persistent earache, ringing in the ear, or difficulty in hearing; a swelling or lump in the mouth or neck; pain in the face or upper jaw; in people who smoke or chew tobacco, pre-cancerous changes can occur in the lining of the mouth, or on the tongue. These can appear as persistent white patches (leukoplakia) or red patches (erythroplakia). They are usually painless but can sometimes be sore and may bleed (Cancerbacup Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a murine head and neck tumor model similar to that described in Kuriakose et al., Head Neck. 2000 Jan;22(1):57-63; Cao et al., Clin Cancer Res. 1999 Jul;5(7):1925-34; Hier et al., Laryngoscope. 1995 Oct;105(10):1077-80; Braakhuis et al., Cancer Res. 1991 Jan 1;51(1):211-4; Baker, S.R., Laryngoscope. 1985 Jan;95(1):43-56; and Dong et al., Cancer Gene Ther. 2003 Feb;10(2):96-104.

[196] Papillary and follicular thyroid cancers account for 80 to 90 percent of all thyroid cancers. Both types begin in the follicular cells of the thyroid. Most papillary and follicular thyroid cancers tend to grow slowly. If they are detected early, most can be treated successfully. Medullary thyroid cancer accounts for 5 to 10 percent of thyroid cancer cases. It arises in C cells, not follicular cells. Medullary thyroid cancer is easier to control if it is found and treated before it spreads to other parts of the body. Anaplastic thyroid cancer is the least common type of thyroid cancer (only 1 to 2 percent of cases). It arises in the follicular cells. The cancer cells are highly abnormal and difficult to recognize. This type of cancer is usually very hard to control because the cancer cells tend to grow and spread very quickly. Early thyroid cancer often does not cause symptoms. But as the cancer grows, symptoms may include: A lump, or nodule, in the front of the neck near the Adam's apple; Hoarseness or difficulty speaking in a normal voice; Swollen lymph nodes, especially in the neck; Difficulty swallowing or breathing; or Pain in the throat or neck (National Cancer Institute's Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response

can be evaluated in a murine or rat thyroid tumor model similar to that described in Quidville et al., Endocrinology. 2004 May;145(5):2561-71 (mouse model); Cranston et al., Cancer Res. 2003 Aug 15;63(16):4777-80 (mouse model); Zhang et al., Clin Endocrinol (Oxf). 2000 Jun;52(6):687-94 (rat model); and Zhang et al., Endocrinology. 1999 May;140(5):2152-8 (rat model).

[197] Tumors that begin in brain tissue are known as primary tumors of the brain. Primary brain tumors are named according to the type of cells or the part of the brain in which they begin. The most common primary brain tumors are gliomas. They begin in glial cells. There are many types of gliomas. (1) Astrocytoma - The tumor arises from star-shaped glial cells called astrocytes. In adults, astrocytomas most often arise in the cerebrum. In children, they occur in the brain stem, the cerebrum, and the cerebellum. A grade III astrocytoma is sometimes called an anaplastic astrocytoma. A grade IV astrocytoma is usually called a glioblastoma multiforme. (2) Brain stem glioma - The tumor occurs in the lowest part of the brain. Brain stem gliomas most often are diagnosed in young children and middle-aged adults. (3) Ependymoma - The tumor arises from cells that line the ventricles or the central canal of the spinal cord. They are most commonly found in children and young adults. (4) Oligodendroglioma - This rare tumor arises from cells that make the fatty substance that covers and protects nerves. These tumors usually occur in the cerebrum. They grow slowly and usually do not spread into surrounding brain tissue. They are most common in middle-aged adults. The symptoms of brain tumors depend on tumor size, type, and location. Symptoms may be caused when a tumor presses on a nerve or damages a certain area of the brain. They also may be caused when the brain swells or fluid builds up within the skull. These are the most common symptoms of brain tumors: Headaches (usually worse in the morning); Nausea or vomiting; Changes in speech, vision, or hearing; Problems balancing or walking; Changes in mood, personality, or ability to concentrate; Problems with memory; Muscle jerking or twitching (seizures or convulsions); and Numbness or tingling in the arms or legs (National Cancer Institute's Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a glioma animal model similar to that described in Schueneman et al., Cancer Res. 2003 Jul 15;63(14):4009-16; Martinet et al., Eur J Surg Oncol. 2003 May;29(4):351-7; Bello et al., Clin Cancer Res. 2002 Nov;8(11):3539-48; Ishikawa et al., Cancer Sci. 2004 Jan;95(1):98-103; Degen et al., J Neurosurg. 2003 Nov;99(5):893-8; Engelhard et al., Neurosurgery. 2001 Mar;48(3):616-24; Watanabe et al., Neurol Res. 2002 Jul;24(5):485-90; and Lumniczky et al., Cancer Gene Ther. 2002 Jan;9(1):44-52.

[198] Multiple myeloma is a type of cancer. It affects certain white blood cells called plasma cells. When cancer involves plasma cells, the body keeps producing more and more of these cells. The unneeded plasma cells -- all abnormal and all exactly alike -- are called myeloma cells. Myeloma cells tend to collect in the bone marrow and in the hard, outer part of bones. Sometimes they collect in only one bone and form a single mass, or tumor, called a plasmacytoma. In most cases,

however, the myeloma cells collect in many bones, often forming many tumors and causing other problems. When this happens, the disease is called multiple myeloma.

[199] Myeloma cells tend to collect in the bone marrow and in the hard, outer part of bones. Sometimes they collect in only one bone and form a single mass, or tumor, called a plasmacytoma. In most cases, however, the myeloma cells collect in many bones, often forming many tumors and causing other problems. When this happens, the disease is called multiple myeloma. Because people with multiple myeloma have an abnormally large number of identical plasma cells, they also have too much of one type of antibody. These myeloma cells and antibodies can cause a number of serious medical problems: (1) As myeloma cells increase in number, they damage and weaken bones, causing pain and sometimes fractures. Bone pain can make it difficult for patients to move; (2) When bones are damaged, calcium is released into the blood. This may lead to hypercalcemia -- too much calcium in the blood. Hypercalcemia can cause loss of appetite, nausea, thirst, fatigue, muscle weakness, restlessness, and confusion; (3) Myeloma cells prevent the bone marrow from forming normal plasma cells and other white blood cells that are important to the immune system. Patients may not be able to fight infection and disease; (4) The cancer cells also may prevent the growth of new red blood cells, causing anemia. Patients with anemia may feel unusually tired or weak; and (5) Multiple myeloma patients may have serious problems with their kidneys. Excess antibody proteins and calcium can prevent the kidneys from filtering and cleaning the blood properly. Symptoms of multiple myeloma depend on how advanced the disease is. In the earliest stage of the disease, there may be no symptoms. When symptoms do occur, patients commonly have bone pain, often in the back or ribs. Patients also may have broken bones, weakness, fatigue, weight loss, or repeated infections. When the disease is advanced, symptoms may include nausea, vomiting, constipation, problems with urination, and weakness or numbness in the legs (National Cancer Institute's Internet website). The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a multiple myeloma murine model similar to that described in Oyajobi et al., Blood. 2003 Jul 1;102(1):311-9; Croucher et al., J Bone Miner Res. 2003 Mar;18(3):482-92; Asosingh et al., Hematol J. 2000;1(5):351-6; and Miyakawa et al., Biochem Biophys Res Commun. 2004 Jan 9;313(2):258-62.

[200] The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a human small/non-small cell lung carcinoma xenograft model. Briefly, human tumors are grafted into immunodeficient mice and these mice are treated with IL-28 or IL-29 polypeptide, fragment, or fusion proteins alone or in combination with other agents which can be used to demonstrate the efficacy of the treatment by evaluating tumor growth (Nemati et al., Clin Cancer Res. 2000 May;6(5):2075-86; and Hu et al., Clin Cancer Res. 2004 Nov 15;10(22):7662-70).

[201] There are two different types of primary liver cancer. The most common kind is called hepatoma or hepatocellular carcinoma (HCC), and arises from the main cells of the liver (the hepatocytes). This type is usually confined to the liver, although occasionally it spreads to other

organs. It occurs mostly in people with a liver disease called cirrhosis. There is also a rarer sub-type of hepatoma called Fibrolamellar hepatoma, which may occur in younger people and is not related to previous liver disease. The other type of primary liver cancer is called cholangiocarcinoma or bile duct cancer, because it starts in the cells lining the bile ducts. Most people who develop hepatoma usually also have a condition called cirrhosis of the liver. This is a fine scarring throughout the liver which is due to a variety of causes including infection and heavy alcohol drinking over a long period of time. However, only a small proportion of people who have cirrhosis of the liver develop primary liver cancer. Infection with either the hepatitis B or hepatitis C virus can lead to liver cancer, and can also be the cause of cirrhosis, which increases the risk of developing hepatoma. People who have a rare condition called haemochromatosis, which causes excess deposits of iron in the body, have a higher chance of developing hepatoma. Thus, the IL-28 and IL-29 polypeptides, fragments, and/or fusion proteins of the present invention may be used to treat, prevent, inhibit the progression of, delay the onset of, and/or reduce the severity or inhibit at least one of the conditions or symptoms associated with hepatocellular carcinoma. The hepatocellular carcinoma may or may not be associated with an hepatitis (e.g., hepatitis A, hepatitis B, hepatitis C and hepatitis D) infection.

[202] The effects of an IL-28 or IL-29 polypeptide, fragment, or fusion protein on tumor response can be evaluated in a hepatocellular carcinoma transgenic mouse model, which includes the overexpression of transforming growth factor- α (TFG- α) alone (Jhappan et al., Cell, 61:1137-1146 (1990); Sandgren et al., Mol. Cell Biol., 13:320-330 (1993); Sandgren et al., Oncogene, 4:715-724 (1989); and Lee et al., Cancer Res., 52:5162:5170 (1992)) or in combination with c-myc (Murakami et al., Cancer Res., 53:1719-1723 (1993), mutated H-ras (Saitoh et al., Oncogene, 5:1195-2000 (1990)), hepatitis B viral genes encoding HbsAg and HBx (Toshkov et al., Hepatology, 20:1162-1172 (1994) and Koike et al., Hepatology, 19:810-819 (1994)), SV40 large T antigen (Sepulveda et al., Cancer Res., 49:6108-6117 (1989) and Schirmacher et al., Am. J. Pathol., 139:231-241 (1991)) and FGF19 (Nicholes et al., American Journal of Pathology, 160(6):2295-2307 (June 2002)).

[203] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with hepatocellular carcinoma, such other agents include chemotherapeutic agents (e.g., adriamycin, 5-FU), Bevacizumab, erlotinib, Lapatinib, Doxorubicin, bortezomib, Thalidomide, Gemcitabine, Oxaliplatin, and epirubicin.

[204] The powerful inducer of apoptosis Apo2L/TNF-related apoptosis-inducing ligand (TRAIL) has generated exciting promise as a potential tumour specific cancer therapeutic agent, since it selectively induces apoptosis in transformed versus normal cells. Interferons (IFNs) are important modulators of TRAIL expression, thus the ligand appears to play an important role in surveillance against viral infection and malignant transformation. Fiorucci et al., Curr Pharm Des.

2005;11(7):933-44. IL-28 and IL-29 also appear to be important regulators of TRAIL (See Example 41 where TRAIL is upregulated by IL-29).

[205] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with prostate cancer such as radiation therapy, chemotherapy (e.g., docetaxel, paclitaxel, estramustine, mitoxantrone), estramustine, docetaxel, Paclitaxel. Estramustine/etoposide. Estramustine/vinblastine, Estramustine/paclitaxel, mitoxantrone, zoledronate, prednisolone, celecoxib, etoposide, Erlotinib, Lapatinib and Sorafenib.

[206] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with pancreatic carcinoma such as fluorouracil (5-FU) chemotherapy, radiation therapy, gemcitabine, fluorouracil, oxaliplatin, irinotecan, leucovorin, capecitabine, Dalteparin, Bevacizumab, and Tarceva.

[207] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with colorectal carcinoma such as folic acid, fluorouracil [5-FU], irinotecan, leucovorin, irinotecan, levamisole, bevacizumab, IFL-bevacizumab, and cetuximab.

[208] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with renal cell carcinoma such as kinase inhibitors (e.g., sunitinib and sorafenib), IL-2, interferon-alpha, and Vinblastine.

[209] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with melanoma such as Interferon alpha 2b, dacarbazine (DTIC), nitrosoureas, carmustine (BCNU), lomustine, tamoxifen, cisplatin, and IL-2.

[210] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with esophageal cancer such as chemotherapeutic agents (e.g., Cisplatin, bleomycin, 5FU, paclitaxel, VP-16; irinotecan, Interferon-alpha, taxotere, gemcitabine, venorelbine, carboplatin, mitomycin-C, doxorubicin (adriamycin), methotrexate, Methyl-GAG).

[211] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with ovarian epithelial carcinoma such as chemotherapeutic agents (paclitaxel, cisplatin, carboplatin, paclitaxel, doxorubicin, cyclophosphamide), Topotecan, Liposomal doxorubicin and topotecan, Gemcitabine, Fluorouracil and leucovorin, Tamoxifen, Etoposide, Ifosfamide, Hexamethylmelamine (HMM), and Capecitabine.

[212] The IL-28 and IL-29 polypeptides, proteins, fusions and fragments thereof of the present invention can be used in combination with other agents in treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with Non-small cell lung carcinoma such as cisplatin, carboplatin, mitomycin, paclitaxel, docetaxel, topotecan, irinotecan, vinorelbine, vinorelbine, gemcitabine, IRESSA, TARCEVA, bevacizumab, Sorafenib, Celecoxib,

The Use of IL-28 and IL-29 to Treat Autoimmune Disorders

[213] The present invention provides for a method of treating, preventing, inhibiting the progression of, delaying the onset of, and/or reducing at least one of the conditions or symptoms associated with autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide selected from the group of SEQ ID NOs:2, 4, 6, 13, 15, 17, 19, 21, 23, 25, 27, 29, 36, 37, 38, 39, 40, 41, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, and 161 wherein the autoimmune disorder is selected from the group of selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, inflammatory bowel disease, systemic lupus erythematosus, and psoriasis. The polypeptide may further optionally include a polyethylene glycol moiety, which can be covalently linked to the polypeptide (e.g., amino-terminally). The polyethylene glycol may be linear or branched. The polyethylene glycol may have a molecular weight of about 20kD, 30kD, or 40kD. The polyethylene glycol may be monomethoxy-PEG propionaldehyde. The patient upon which the polypeptide is administered may be a mammal, such as a human.

[214] The present invention provides for a method of treating an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the autoimmune disorder is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

[215] The present invention provides for a method of treating an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a

polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the autoimmune disorder is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

[216] The present invention provides for a method of an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

[217] The present invention provides for a method of inhibiting the progression of an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175; a second polypeptide; a pharmaceutically acceptable vehicle; and wherein the cancer is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

[218] The present invention provides for a method of delaying a multiple sclerosis relapse in a patient comprising administering to the patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175; a pharmaceutically acceptable vehicle.

[219] The present invention provides for a method of reducing the severity of a multiple sclerosis relapse in a patient comprising administering to the patient in need thereof a therapeutically effective amount of a formulation comprising: a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175; a pharmaceutically acceptable vehicle.

Rheumatoid Arthritis

[220] Rheumatoid arthritis is an autoimmune disorder where the immune responses of the body are targeted against the body's own proteins, in particular collagen, a protein that is the foundation of multiple tissues, specifically joints. The resulting immune response against collagen leads to destruction of the joints. Over time, the patient can lose the ability to move their fingers and toes and can experience acute pain in the joints and knees. Serum from arthritis patients have increased amounts of TNF α (tumor necrosis factor) and antibodies against collagen, both of which are

not only indicators of chronic disease but also contribute towards the pathology of the disease. (Smolen and Stein+er G, Nat. Rev. Drug Discov., 2:473–488, 2003; Firestein, Nature 423:356-361, 2003.) Furthermore, the disease is initiated and mediated by CD4⁺ T cells. DCs present collagen as an antigen to CD4⁺ T cells. The collagen-induced arthritis (CIA) model is a mouse model for rheumatoid arthritis that reflects to large extent the disease seen in humans. (Moore, Methods Mol. Biol. 225:175-179, 2003; Waksman, Scand. J. Immunol., 56:12-34, 2002). Mice are immunized with 2 doses of collagen emulsified in CFA at the base of the tail. This results in swelling of the paws that increases over a period of time and can be both visually scored and measured using calipers. IL-28A, IL-28B, or IL-29 is administered to groups of collagen-immunized mice, and effects on disease scores are evaluated. Inhibition of paw scores and thickness by IL-28A, IL-28B, and IL-29 is indicative of it's inhibitory effect on an ongoing autoimmune response.

Inflammatory Bowel Disease

[221] Inflammation in the gut resulting from defective immune regulation, known as inflammatory bowel disease (IBD) is characterized into two broad disease definitions, Crohn's disease (CD) and Ulcerative colitis (UC). Generally, CD is thought to be due to dysfunction in the regulation of Th1 responses, and UC is believed to be due to dysfunction in the regulation of Th2 responses. Multiple cytokines, chemokines, and matrix metalloproteinases have been shown to be upregulated in inflamed lesions from IBD patients. These include IL-1, IL-12, IL-18, IL-15, TNF- α , IFN- γ , MIP1 α , MIP1 β , and MIP2. Currently REMICADE® (Centocor, Malvern, PA) is the only drug that has successfully been used to target the disease itself when treating CD patients, with other treatments generally improving the quality of life of patients. IL-28A, IL-28B, and IL-29 inhibition of the autoimmune response associated with IBD is demonstrated in IBD models, such as the mouse DSS, TNBS, CD4+CD45Rb^{hi}, mdrla^{-/-} and graft v. host disease (GVHD) intestinal inflammation models. (Stadnicki A and Colman RW, Arch Immunol Ther Exp 51:149-155, 2003; Pizarro TT et al., Trends in Mol Med 9:218-222, 2003). One experimental model for human IBD is the oral administration of dextran sodium sulfate (DSS) to rodents. DSS induces both acute and chronic ulcerative colitis with features somewhat resembling histological findings in humans. Colitis induced by DSS involves gut bacteria, macrophages and neutrophils, with a minor role for T and B cells (Mahler et al., Am. J. Physiol. 274:G544-G551, 1998; Egger et al., Digestion 62:240-248, 2000). TNBS-induced colitis is considered a Th1 mediated disease and therefore resembles CD more than UC in humans. Tri-nitro benzene sulfonic acid (TNBS) is infused into mice intra-rectally in varying doses (strain dependent) to induce antigen specific (TNBS) T cell response that involves secretion of Th1-like cytokines IL-12, IL-18 and IFN γ . Colitis involves recruitment of antigen-specific T cells, macrophages and neutrophils to the site of inflammation (Neurath et al., Int. Rev. Immunol., 19:51-62, 2000; Dohi T et al., J. Exp. Med. 189:1169-1179, 1999). Another relatively new model for colitis is the CD4+CD45Rb^{hi} transfer

model into SCID mice. CD4⁺ T cells can be divided broadly into 2 categories based on expression of CD45Rb. CD4⁺CD45Rb^{hi} cells are considered naïve T cells whereas CD4⁺CD45Rb^{lo} cells are considered regulatory T cells. Transfer of whole CD4⁺ T cells into syngenic SCID mice does not induce symptoms of colitis. However, if only the CD4⁺CD45Rb^{hi} T cells are injected into SCID mice, mice develop colitis over a period of 3-6 weeks. Co-transfer of the CD4⁺CD45Rb^{lo} regulatory T cells along with the naïve T cells inhibits colitis suggesting that the regulatory T cells play an important role in regulating the immune response (Leach et al., Am. J. Pathol., 148:1503-1515, 1996; Powrie et al., J. Exp. Med., 179:589-600, 1999). This model will demonstrate that IL-28A, IL-28B, and IL-29 inhibit colitis by upregulating T regulatory function via its ability to generate tolerogenic DCs in mice. A clinically relevant model of colitis associated with bone marrow transplantation is GVHD-induced colitis. Graft-versus-host disease (GVHD) develops in immunoincompetent, histocompatible recipients of effector cells, which proliferate and attack host cells. Patients receiving allogeneic bone marrow transplantation or severe aplastic anemia are at risk for GVHD. In both mice and humans, diarrhea is a common and serious symptom of the syndrome. In human, both colonic and small intestinal disease have been observed. Mouse models for GVHD-induced colitis show similar histological disease as seen in humans. These mouse models can therefore be used to assess the efficacy of colitis inhibiting drugs for GVHD (Eigenbrodt et al., Am. J. Pathol., 137:1065-1076, 1990; Thiele et al., J. Clin. Invest., 84:1947-1956, 1989).

Systemic Lupus Erythematosus

[222] Systemic lupus erythematosus (SLE) is an immune-complex related disorder characterized by chronic IgG antibody production directed at ubiquitous self antigens (anti-dsDNA). The effects of SLE are systemic, rather than localized to a specific organ. Multiple chromosomal loci have been associated with the disease and may contribute towards different aspects of the disease, such as anti-dsDNA antibodies and glomerulonephritis. CD4⁺ T cells have been shown to play an active part in mouse models of SLE (Horwitz, Lupus 10:319-320, 2001; Yellin and Thienel, Curr. Rheumatol. Rep., 2:24-37, 2000). The role for CD8⁺ T cells is not clearly defined, but there is evidence to suggest that “suppressor” CD8⁺ T cell function is impaired in lupus patients (Filaci et al., J. Immunol., 166:6452-6457, 2001; Sakane et al., J. Immunol., 137:3809-3813, 1986).

[223] Sera from human SLE patients and mouse models are assayed for IL-28A, IL-28B, and IL-29 activity. CD8⁺ T cell suppressor activity in PBLs from human SLE patients after culture with IL-28A, IL-28B, or IL-29 is evaluated in vitro. Suppressor activity of CD8⁺ T cells from SLE patients is evaluated by their ability to inhibit anti-CD3 induced proliferation of autologous PBMC. Inhibition function correlates with secretion of IFN γ and IL-6 in the cultures. Increased IFN γ and IL-6 in cultures from IL-28A, IL-28B, or IL-29 treated patients might indicate higher suppressor activity (Filaci et al., J. Immunol. 166:6452-6457, 2001)

Psoriasis

[224] Psoriasis is a chronic inflammatory skin disease that is associated with hyperplastic epidermal keratinocytes and infiltrating mononuclear cells, including CD4⁺ memory T cells, neutrophils and macrophages (Christophers, *Int. Arch. Allergy Immunol.*, 110:199, 1996). It is currently believed that environmental antigens play a significant role in initiating and contributing to the pathology of the disease. However, it is the loss of tolerance to self antigens that is thought to mediate the pathology of psoriasis. Dendritic cells and CD4⁺ T cells are thought to play an important role in antigen presentation and recognition that mediate the immune response leading to the pathology. A model of psoriasis based on the CD4⁺CD45RB transfer model was recently developed (Davenport et al., *Internat. Immunopharmacol.*, 2:653-672 (2002)). IL-28A, IL-28B, or IL-29 is administered to mice that are injected with psoriasis inducing cells and the effects on clinical score (skin disease) is evaluated, showing beneficial effects of IL-28A, IL-28B, and IL-29.

[225] IL-28A, IL-28B, or IL-29 can be administered in combination with other agents already in use in autoimmunity and/or cancer including agents such as interferon-alpha (IFN- α , e.g., PEGASYS®, PEG-INTRON®, INFERGEN®, Albuferon-Alpha™), interferon-beta (INF- β , e.g., AVONEX®, BETASERON®, REBIF®), interferon-gamma (IFN γ , e.g., ACTIMMUNE®), NOVANTRONE®, ENBREL®, REMICADE®, LEUKINE®, APO2L/TNF-Related Apoptosis-Inducing Ligand (TRAIL), IL-21 and IL-2. Establishing the optimal dose level and scheduling for IL-28A, IL-28B, and IL-29 is done by a variety of means, including study of the pharmacokinetics and pharmacodynamics of IL-28A, IL-28B, and IL-29; determination of effective doses in animal models, and evaluation of the toxicity of IL-28A, IL-28B, and IL-29. Direct pharmacokinetic measurements done in primates and clinical trials can then be used to predict theoretical doses in patients that achieve plasma IL-28A, IL-28B, and IL-29 levels that are of sufficient magnitude and duration to achieve a biological response in patients.

[226] The invention is further illustrated by the following non-limiting example.

EXAMPLES

Example 1Mammalian Expression plasmids

[227] An expression plasmid containing zcyto20 and zcyto21 was constructed via homologous recombination. Fragments of zcyto20 and zcyto21 cDNA were generated using PCR amplification. The primers for PCR were as follows:

[228] zcyto20/pZMP21: zc40923, and zc43152 SEQ ID NOS: 42 and 43, respectively; and zcyto21/pZMP21: zc40922, and zc43153 SEQ ID NOS: 72 and 73, respectively.

[229] The PCR reaction mixture was run on a 1% agarose gel and a band corresponding to the size of the insert was gel-extracted using a QIAquick™ Gel Extraction Kit (Qiagen, Valencia, CA).

[230] The plasmid pZMP21, which was cut with BglII, was used for recombination with the PCR insert fragment. Plasmid pZMP21 is a mammalian expression vector containing an expression cassette having the MPSV promoter, and multiple restriction sites for insertion of coding sequences; an *E. coli* origin of replication; a mammalian selectable marker expression unit comprising an SV40 promoter, enhancer and origin of replication, a DHFR gene, and the SV40 terminator; and URA3 and CEN-ARS sequences required for selection and replication in *S. cerevisiae*. It was constructed from pZP9 (deposited at the American Type Culture Collection, 10801 University Boulevard, Manassas, VA 20110-2209, under Accession No. 98668) with the yeast genetic elements taken from pRS316 (deposited at the American Type Culture Collection, 10801 University Boulevard, Manassas, VA 20110-2209, under Accession No. 77145), an internal ribosome entry site (IRES) element from poliovirus, and the extracellular domain of CD8 truncated at the C-terminal end of the transmembrane domain.

[231] One hundred microliters of competent yeast (*S. cerevisiae*) cells were independently combined with 10 μ l of the insert DNA and 100ng of the cut pZMP21 vector above, and the mix was transferred to a 0.2-cm electroporation cuvette. The yeast/DNA mixture was electropulsed using power supply (BioRad Laboratories, Hercules, CA) settings of 0.75 kV (5 kV/cm), ∞ ohms, and 25 μ F. Six hundred μ l of 1.2 M sorbitol was added to the cuvette, and the yeast was plated in a 100- μ l and 300 μ l aliquot onto two URA-D plates and incubated at 30°C. After about 72 hours, the Ura⁺ yeast transformants from a single plate were resuspended in 1 ml H₂O and spun briefly to pellet the yeast cells. The cell pellet was resuspended in 0.5 ml of lysis buffer (2% Triton X-100, 1% SDS, 100 mM NaCl, 10 mM Tris, pH 8.0, 1 mM EDTA). The five hundred microliters of the lysis mixture was added to an Eppendorf tube containing 250 μ l acid-washed glass beads and 300 μ l phenol-chloroform, was vortexed for 3 minutes, and spun for 5 minutes in an Eppendorf centrifuge at maximum speed. Three hundred microliters of the aqueous phase was transferred to a fresh tube, and the DNA was precipitated with 600 μ l ethanol (EtOH) and 30 μ l 3M sodium acetate, followed by centrifugation for 30 minutes at maximum speed. The DNA pellet was resuspended in 30 μ l TE.

[232] Transformation of electrocompetent *E. coli* host cells (MC1061) was done using 5 μ l of the yeast DNA prep and 50 μ l of cells. The cells were electropulsed at 2.0 kV, 25 μ F, and 400 ohms. Following electroporation, 1 ml SOC (2% Bacto™ Tryptone (Difco, Detroit, MI), 0.5% yeast extract (Difco), 10 mM NaCl, 2.5 mM KCl, 10 mM MgCl₂, 10 mM MgSO₄, 20 mM glucose) was

added and then the cells were plated in a 50 μ l and 200 μ l aliquot on two LB AMP plates (LB broth (Lennox), 1.8% Bacto™ Agar (Difco), 100 mg/L Ampicillin).

[233] The inserts of three clones for each construct were subjected to sequence analysis and one clone for each construct, containing the correct sequence, was selected. Larger scale plasmid DNA was isolated using a commercially available kit (QIAGEN Plasmid Mega Kit, Qiagen, Valencia, CA) according to manufacturer's instructions. The correct constructs were designated zcyto20/pZMP21 and zcyto21/pZMP21.

Example 2

Expression of Mammalian Constructs in CHO cells

[234] 200 μ g of a zcyto20/pZMP21 and zcyto21/pZMP21 construct were digested with 200 units of Pvu I at 37°C for three hours and then were precipitated with IPA and spun down in a 1.5 mL microfuge tube. The supernatant was decanted off the pellet, and the pellet was washed with 1 mL of 70% ethanol and allowed to incubate for 5 minutes at room temperature. The tube was spun in a microfuge for 10 minutes at 14,000 RPM and the supernatant was aspirated off the pellet. The pellet was then resuspended in 750 μ l of PF-CHO media in a sterile environment, and allowed to incubate at 60°C for 30 minutes. CHO cells were spun down and resuspended using the DNA-media solution. The DNA/cell mixture was placed in a 0.4 cm gap cuvette and electroporated using the following parameters: 950 μ F, high capacitance, and 300 V. The contents of the cuvette were then removed and diluted to 25 mLs with PF-CHO media and placed in a 125 mL shake flask. The flask was placed in an incubator on a shaker at 37°C, 6% CO₂, and shaking at 120 RPM.

Example 3

Purification and Analysis of zcyto20-CHO Protein

[235] *Purification of Zcyto20-CHO Protein*

[236] Recombinant zcyto20 (IL-28A) protein was produced from a pool of DXB11-CHO cell lines. Cultures were harvested, and the media were sterile filtered using a 0.2 μ m filter.

[237] The purification of zcyto20-CHO protein was achieved by the sequential use of a Poros HS 50 column (Applied Biosystems, Framingham, MA), a Monolithic WCX column (Isco, Inc., Lincoln, NE), a ToyoPearl Butyl 650S column (TosoH, Montgomeryville, PA), and a Superdex 75 column (Amersham Biosciences, Piscataway, NJ). Culture media from DXB111-CHO were adjusted to pH 6.0 before loading onto a Poros 50 HS column. The column was washed with 50 mM MES (2-Morpholinoethanesulfonic acid), 100 mM NaCl, pH 6 and the bound protein was eluted with a 10 column volumes (CV) linear gradient to 60% of 50 mM MES, 2 M NaCl, pH 6. The eluting fractions were collected and the presence of zcyto20 protein was confirmed by SDS-PAGE with a Coomassie staining. This fractions containing zcyto20 protein were pooled, diluted with double distilled water to

a conductivity of about 20 mS, and loaded onto a Monolithic WCX column. The column was washed with 93% of 50 mM MES, 100 mM NaCl, pH 6, and 7% of 50 mM MES, 2 M NaCl, pH 6. The bound protein was eluted with a 25-CV linear gradient from 7% to 50% of 50 mM MES, 2 M NaCl, pH 6. The eluting fractions were collected and the presence of zcyto20 protein was confirmed by SDS-PAGE with a Coomassie staining. The fractions containing zcyto20 protein were pooled, adjusted to 1 M ammonium sulfate and loaded onto a ToyoPearl Butyl 650S column. Zcyto20 was eluted with a decreasing ammonium sulfate gradient and the fractions containing the pure zcyto20 were pooled and concentrated for injection into a Superdex 75 column. Fractions containing zcyto20 protein from the gel filtration column was pooled, concentrated, filtered through a 0.2 µm filter and frozen at -80°C. The concentration of the final purified protein was determined by a BCA assay (Pierce Chemical Co., Rockford, IL) and HPLC-amino acid analysis.

[238] *SDS-PAGE and Western blotting analysis of zcyto20-CHO protein*

[239] Recombinant zcyto20 protein was analyzed by SDS-PAGE (Nupage 4-12% Bis-Tris, Invitrogen, Carlsbad, CA) and Western blot using rabbit anti-zcyto21-CEE-BV IgG as the primary antibody that cross-reacts to zcyto20-CHO protein. The gel was electrophoresed using Invitrogen's Xcell II mini-cell (Carlsbad, CA) and transferred to a 0.2 µm nitrocellulose membrane (Bio-Rad Laboratories, Hercules, CA) using Invitrogen's Xcell II blot module according to directions provided in the instrument manual. The transfer was run at 500 mA for 50 minutes in a buffer containing 25 mM Tris base, 200 mM glycine, and 20% methanol. The membrane was blocked with 10% non-fat dry milk in 1x PBS for 10 minutes then probed with the primary antibody in 1x PBS containing 2.5% non-fat dry milk. The blot was labeled for one hour at room temperature while shaking. For the secondary antibody labeling, blot was washed three times for 10 minutes each with PBS and then probed with goat anti-rabbit IgG-HRP (Pierce Chemical Co., Rockford, IL) for one hour. The blot was washed three times with 1x PBS for 10 minutes each and developed using a 1:1 mixture of SuperSignal® ULTRA reagents (Pierce Chemical Co., Rockford, IL) and the signal was captured using a Lumi-Imager (Boehringer Mannheim GmbH, Germany).

[240] *Summary of protein purification and analysis*

[241] The purified zcyto20 protein from the CHO media migrated predominantly as a doublet at approximately 20 kDa and a minor triplet dimer at about 38 kDa on a 4-12% Bis-Tris gel under non-reducing conditions. They all collapsed into a single 20 kDa band under reducing conditions. MS peptide mapping indicated a mixture of two isomers with respect to disulfide linkage and the presence of O-linked glycosylation site.

Example 4

Purification and Analysis of zcyto21-CHO Protein

[242] *Purification of Zcyto21-CHO Protein*

[243] Recombinant zcyto21 was produced from stable DXB11-CHO cell lines. Cultures were harvested, and the media were sterile filtered using a 0.2 μ m filter. Proteins were purified from the conditioned media by starting with a combination of cationic and anionic exchange chromatography followed by a hydrophobic interaction chromatography and a size exclusion chromatography. DXB111-CHO culture media were adjusted to pH 6.0 before loading onto a Poros 50 HS column (Applied Biosystems, Framingham, MA). The column was washed with 1x PBS, pH 6 and the bound protein was eluted with 5x PBS, pH 8.4. The eluting fraction was collected and the presence of zcyto21 protein was confirmed by SDS-PAGE with a Coomassie stain. This fraction was then diluted to a conductivity of 13 mS and its pH adjusted to 8.4 and flowed through a Poros 50 HQ column (Applied Biosystems, Framingham, MA). The flow-through containing zcyto21 protein were then adjusted to about 127 mS with ammonium sulfate and loaded onto a Toyopearl Phenyl 650S column (TosoH, Montgomeryville, PA). Zcyto21 protein was eluted with a decreasing ammonium sulfate gradient and the fractions containing the pure zcyto21 were pooled and concentrated for injection into a Superdex 75 column (Amersham Biosciences, Piscataway, NJ). The concentration of the final purified protein was determined by a BCA assay (Pierce Chemical Co., Rockford, IL) and HPLC-amino acid analysis.

[244] *SDS-PAGE and Western blotting analysis of zcyto21-CHO protein*

[245] Recombinant zcyto21 protein was analyzed by SDS-PAGE (Nupage 4-12% Bis-Tris, Invitrogen, Carlsbad, CA) and Western blot using rabbit anti-zcyto21-CEE-BV IgG as the primary antibody. The gel was electrophoresed using Invitrogen's Xcell II mini-cell (Carlsbad, CA) and transferred to a 0.2 μ m nitrocellulose membrane (Bio-Rad Laboratories, Hercules, CA) using Invitrogen's Xcell II blot module according to directions provided in the instrument manual. The transfer was run at 500 mA for 50 minutes in a buffer containing 25 mM Tris base, 200 mM glycine, and 20% methanol. The transferred blot was blocked with 10% non-fat dry milk in 1x PBS for 10 minutes then probed with the primary antibody in 1x PBS containing 2.5% non-fat dry milk. The blot was labeled for one hour at room temperature while shaking. For the secondary antibody labeling, blot was washed three times for 10 minutes each with PBS and then probed with goat anti-rabbit IgG-HRP (Pierce Chemical Co., Rockford, IL) for one hour. The blot was washed three times with 1x PBS for 10 minutes each and developed using a 1:1 mixture of SuperSignal® ULTRA reagents (Pierce Chemical Co., Rockford, IL) and the signal was captured using a Lumi-Imager (Boehringer Mannheim GmbH, Germany).

[246] *Summary of protein purification and analysis*

[247] The purified zcyto21 protein from the CHO media migrated as two or more approximately 28 kDa bands on a 4-12% Bis-Tris gel under both reducing and non-reducing conditions. MS peptide mapping indicated a mixture of two isomers with respect to disulfide linkage and the presence of one N-linked glycosylation and several O-linked glycosylation sites.

Example 5

Identification of IL-29 Forms

[248] Peak fractions from purified pools of IL-29 were digested overnight at 37°C with sequencing grade trypsin (Roche Applied Science, Indianapolis, IN) in phosphate buffer at approximately pH 6.3 to limit disulfide re-arrangement. Each digest was analyzed by reversed-phase HPLC (Agilent, Palo Alto, CA) connected in-line to a quadrupole-time of flight hybrid mass spectrometer (Micromass, Milford MA). Spectra were collected, converted from mass to charge ratio to mass, and compared to all theoretical peptides and disulfide-linked peptide combinations resulting from trypsin digestion of IL-29. Disulfides were assigned by comparing spectra before and after reduction with assignment of appropriate masses to disulfide linked peptides in IL-29. The material from fraction #20 showed the disulfide pattern C15 – C112 and C49 – C145 with C171 observed as a S-glutathionyl cysteine (all referring to SEQ ID NO: 4). The material from fraction #51 showed the disulfide pattern C49 – C145 and C112 – C171 with C15 observed as an S-glutathionyl cysteine (referring to SEQ ID NO:4).

Example 6

E. coli Expression Plasmids

[249] *Construction of expression vector, pTAP237*

[250] Plasmid pTAP237 was generated by inserting a PCR-generated linker into the SmaI site of pTAP186 by homologous recombination. Plasmid pTAP186 was derived from the plasmids pRS316 (a *Saccharomyces cerevisiae* shuttle vector) and pMAL-c2, an *E. coli* expression plasmid derived from pKK223-3 and comprising the *tac* promoter and the *rrnB* terminator.. Plasmid pTAP186 contains a kanamycin resistance gene in which the Sma I site has been destroyed and has NotI and SfiI sites flanking the yeast ARS-CEN6 and URA3 sequences, facilitating their removal from the plasmid by digestion with NotI. The PCR-generated linker replaced the expression coupler sequence in pTAP186 with the synthetic RBS II sequence. It was prepared from 100 pmoles each of oligonucleotides zc29,740 and zc29,741, as shown in SEQ ID NOS: 44 and 45, respectively, and approximately 5 pmoles each of oligonucleotides zc29,736 and zc29,738, as shown in SEQ ID NOS: 46 and 47, respectively. These oligonucleotides were combined by PCR for ten cycles of 94°C for 30 seconds, 50°C for 30 seconds, and 72°C for 30 seconds, followed by 4°C soak. The resulting PCR products were concentrated by precipitation with two times the volume of 100% ethanol. Pellet was

resuspended in 10 μ L water to be used for recombining into the recipient vector pTAP186 digested with SmaI to produce the construct containing the synthetic RBS II sequence. Approximately 1 μ g of the PCR-generated linker and 100 ng of pTAP186 digested with SmaI were mixed together and transformed into competent yeast cells (*S. cerevisiae*). The yeast was then plated onto -URA D plates and left at room temperature for about 72 hours. Then the Ura⁺ transformants from a single plate were resuspended in 1 mL H₂O and spun briefly to pellet the yeast cells. The cell pellet was resuspended in 0.5 mL of lysis buffer. DNA was recovered and transformed into *E. coli* MC1061. Clones were screened by colony PCR as disclosed above using 20 pmoles each of oligonucleotides zc29,740 and zc29,741, as shown in SEQ ID NOS: 44 and 45, respectively. Clones displaying the correct size band on an agarose gel were subject to sequence analysis. The correct plasmid was designated pTAP237.

Example 7

Codon Optimization of IL-29 Cysteine mutant

[251] *Codon Optimization Generation of the IL-29 wildtype expression construct*

[252] Native human IL-29 gene sequence was not well expressed in *E. coli* strain W3110. Examination of the codons used in the IL-29 coding sequence indicated that it contained an excess of the least frequently used codons in *E. coli* with a CAI value equal to 0.206. The CAI is a statistical measure of synonymous codon bias and can be used to predict the level of protein production (Sharp et al., Nucleic Acids Res. 15(3):1281-95, 1987). Genes coding for highly expressed proteins tend to have high CAI values (> 0.6), while proteins encoded by genes with low CAI values (≤ 0.2) are generally inefficiently expressed. This suggested a reason for the poor production of IL-29 in *E. coli*. Additionally, the rare codons are clustered in the second half of the message leading to higher probability of translational stalling, premature termination of translation, and amino acid misincorporation (Kane JF. Curr. Opin. Biotechnol. 6(5):494-500, 1995).

[253] It has been shown that the expression level of proteins whose genes contain rare codons can be dramatically improved when the level of certain rare tRNAs is increased within the host (Zdanovsky et al., Applied Environmental Microb. 66:3166-3173, 2000; You et al., Biotechniques 27:950-954, 1999). The pRARE plasmid carries genes encoding the tRNAs for several codons that are rarely used *E. coli* (argU, argW, leuW, proL, ileX and glyT). The genes are under the control of their native promoters (Novy, *ibid.*) Co-expression with pRARE enhanced IL-29 production in *E. coli* and yield approximately 200 mg/L. These data suggest that re-synthesizing the gene coding for IL-29 with more appropriate codon usage provides an improved vector for expression of large amounts of IL-29.

[254] The codon optimized IL-29 coding sequence was constructed from sixteen overlapping oligonucleotides: zc44,566 (SEQ ID NO:48), zc44,565 (SEQ ID NO:49), zc44,564 (SEQ ID NO:50),

zc44,563 (SEQ ID NO:51), zc44,562 (SEQ ID NO:52), zc44,561 (SEQ ID NO:53), zc44,560 (SEQ ID NO:54), zc244,559 (SEQ ID NO:55), zc44,558 (SEQ ID NO:56), zc44,557 (SEQ ID NO:57). Primer extension of these overlapping oligonucleotides followed by PCR amplification produced a full length IL-29 gene with codons optimized for expression in *E. coli*. The final PCR product was inserted into expression vector pTAP237 by yeast homologous recombination. The expression construct was extracted from yeast and transformed into competent *E. coli* MC1061. Clones resistance to kanamycin were identified by colony PCR. A positive clone was verified by sequencing and subsequently transformed into production host strain W3110. The expression vector with the optimized IL-29 sequence was named pSDH184. The resulting gene was expressed very well in *E. coli*. expression levels with the new construct increased to around 250 mg/L.

[255] *Generation of the codon optimized zcyto21 C172S Cysteine mutant expression construct*

[256] The strategy used to generate the zcyto21 C172S Cysteine mutant is based on the QuikChange Site-Directed Mutagenesis Kit (Stratagene). Primers were designed to introduce the C172S mutation based on manufacturer's suggestions. These primers were designated ZG44,340 (SEQ ID NO: 58) and ZG44,341 (SEQ ID NO: 59). PCR was performed to generate the zcyto21 C172S Cysteine mutant according to QuikChange Mutagenesis instructions. Five identical 50 μ l reactions were set-up. 2.5 μ l pSDH175 (missing yeast vector backbone sequence) DNA was used as template per reaction. A PCR cocktail was made up using the following amounts of reagents: 30 μ l 10x PCR buffer, 125 ng (27.42 μ l) ZG44,340, 125 ng (9.18 μ l) ZG44,341, 6 μ l dNTP, 6 μ l Pfu Turbo polymerase (Stratagene, La Jolla, CA), and 206.4 μ l water. 47.5 μ l of the cocktail was aliquotted into each reaction. The PCR conditions were as follows: 1 cycle of 95°C for 30 seconds followed by 16 cycles of 95°C for 30 seconds, 55°C for 1 minute, 68°C for 7 minutes, followed by 1 cycle at 68°C for 7 minutes, and ending with a 4°C hold. All five PCR reactions were consolidated into one tube. As per manufacturer's instructions, 5 μ l DpnI restriction enzyme was added to the PCR reaction and incubated at 37°C for 2 hours. DNA was precipitated by adding 10% 3 Molar Sodium Acetate and two volumes of 100% ethanol. Precipitation was carried-out at -20°C for 20 minutes. DNA was spun at 14,000 rpm for 5 minutes and pellet was speed-vac dried. DNA pellet was resuspended in 20 μ l water. DNA resulting from PCR was transformed into *E. coli* strain DH10B. 5 μ l DNA was mixed with 40 μ l ElectroMAX DH10B cells (Invitrogen). Cells and DNA mixture were then electroporated in a 0.1cm cuvette (Bio-Rad) using a Bio-Rad Gene Pulser II™ set to 1.75 kV, 100 Ω , and 25 μ F. Electroporated cells were then outgrown at 37°C for 1 hour. Mixture was plated on an LB + 25 μ g/ml kanamycin plate and incubated at 37°C overnight. Ten clones were screened for presence of zcyto21 C172S insert. DNA was isolated from all ten clones using the QIAprep™ Spin Miniprep Kit (Qiagen,

Valencia, CA) and analyzed for presence of insert by cutting with XbaI and PstI restriction enzymes. Nine clones contained insert and were sequenced to insure the zcyto21 C172S mutation had been introduced. A clone was sequence verified and was subsequently labeled pSDH188.

Example 8

E. coli IL-29 expression construct

[257] A DNA fragment of IL-29 containing the wildtype sequence was isolated using PCR. Primers zc41,212 (SEQ ID NO: 60) containing 41 base pair (bp) of vector flanking sequence and 24 bp corresponding to the amino terminus of IL-29, and primer zc41,041 (SEQ ID NO: 61) contained 38 bp corresponding to the 3' end of the vector which contained the zcyto21 insert were used in the reaction. The PCR conditions were as follows: 25 cycles of 94°C for 30 seconds, 50°C for 30 seconds, and 72°C for 1 minute; followed by a 4°C soak. A small sample (2-4 µL) of the PCR sample was run on a 1% agarose gel with 1X TBE buffer for analysis, and the expected band of approximately 500 bp fragment was seen. The remaining volume of the 100 µL reaction was precipitated with 200 µL absolute ethanol. The pellet was resuspended in 10 µL water to be used for recombining into recipient vector pTAP238 cut with SmaI to produce the construct encoding the zcyto21 as disclosed above. The clone with correct sequence was designated as pTAP377. Clone pTAP377 was digested with NotI/NcoI (10µl DNA, 5µl buffer 3 New England BioLabs, 2 µL Not 1, 2 µL NcoI, 31 µL water for 1 hour at 37°C) and religated with T4 DNA ligase buffer (7 µL of the previous digest, 2 µL of 5X buffer, 1 µL of T4 DNA ligase). This step removed the yeast sequence, CEN-ARS, to streamline the vector. The pTAP377 DNA was diagnostically digested with Pvu2 and Pst1 to confirm the absence of the yeast sequence. P/taP377 DNA was transformed into *E. coli* strain W3110/pRARE, host strain carrying extra copies of rare *E. coli* tRNA genes.

Example 9

E. coli IL-28A expression construct

[258] A DNA fragment containing the wildtype sequence of zcyto20 (as shown in SEQ ID NO: 1) was isolated using PCR. Primers zc43,431 (SEQ ID NO: 62) containing 41 bp of vector flanking sequence and 24 bp corresponding to the amino terminus of zcyto20, and primer zc43,437 (SEQ ID NO: 63) contained 38 bp corresponding to the 3' end of the vector which contained the zcyto20 insert. The PCR conditions were as follows: 25 cycles of 94°C for 30 seconds, 50°C for 30 seconds, and 72°C for 1 minute; followed by a 4°C soak. A small sample (2-4 µL) of the PCR sample was run on a 1% agarose gel with 1X TBE buffer for analysis, and the expected band of approximately 500 bp fragment was seen. The remaining volume of the 100 µL reaction was precipitated with 200 µL absolute ethanol. . The pellet was resuspended in 10 µL water to be used

for recombining into recipient vector pTAP238 cut with SmaI to produce the construct encoding the zcyto20 as disclosed above. The clone with correct sequence was designated as pYEL7. It was digested with Not1/Nco1 (10µl DNA, 5µl buffer 3 New England BioLabs, 2 µL Not1, 2 µL Nco1, 31 µL water for 1 hour at 37°C) and religated with T4 DNA ligase buffer (7 µL of the previous digest, 2 µL of 5X buffer, 1 µL of T4 DNA ligase). This step removed the yeast sequence, CEN-ARS, to streamline the vector. The religated pYEL7 DNA was diagnostically digested with Pvu2 and Pst1 to confirm the absence of the yeast sequence. PYEL7 DNA was transformed into E. coli strain W3110/pRARE.

Example 10

zcyto21 C172S Cysteine mutant expression construct

[259] The strategy used to generate the zcyto21 C172S Cysteine mutant (SEQ ID NO: 28) is based on the QuikChange® Site-Directed Mutagenesis Kit (Stratagene, La Jolla, CA). Primers were designed to introduce the C172S mutation based on manufacturer's suggestions. These primers were designated ZG44,327 and ZG44,328 (SEQ ID NOS: 64 and 65, respectively). PCR was performed to generate the zcyto21 C172S Cysteine mutant according to QuikChange Mutagenesis instructions. Five identical 50 µl reactions were set-up. 2.5 µl pTAP377 (missing yeast vector backbone sequence) DNA was used as template per reaction. A PCR cocktail was made up using the following amounts of reagents: 30 µl 10x PCR buffer, 125 ng (27.42 µl) ZG44,327 (SEQ ID NO: 64), 125 ng (9.18 µl) ZG44,328 (SEQ ID NO: 65), 6 µl dNTP, 6 µl Pfu Turbo polymerase (Stratagene), and 206.4 µl water. 47.5 µl of the cocktail was aliquotted into each reaction. The PCR conditions were as follows: 1 cycle of 95°C for 30 seconds followed by 16 cycles of 95°C for 30 seconds, 55°C for 1 minute, 68°C for 7 minutes, followed by 1 cycle at 68°C for 7 minutes, and ending with a 4°C hold. All five PCR reactions were consolidated into one tube. As per manufacturer's instructions, 5 µl DpnI restriction enzyme was added to the PCR reaction and incubated at 37°C for 2 hours. DNA was precipitated by adding 10% 3 Molar Sodium Acetate and two volumes of 100% ethanol (Aaper Alcohol, Shelbyville, KY). Precipitation was carried-out at -20°C for 20 minutes. DNA was spun at 14,000 rpm for 5 minutes and pellet was speed-vac dried. DNA pellet was resuspended in 20 µl water. DNA resulting from PCR was transformed into E.coli strain DH10B. 5 µl DNA was mixed with 40 µl ElectromAX DH10B cells (Invitrogen, Carlsbad, CA). Cells and DNA mixture were then electroporated in a 0.1cm cuvette (Bio-Rad, Hercules, CA) using a Bio-Rad Gene Pulser II™ set to 1.75kV, 100Ω, and 25 µF. Electroporated cells were then outgrown at 37°C for 1 hour. Mixture was plated on an LB + 25 µg/ml kanamycin plate and incubated at 37°C overnight. Ten clones were screened for presence of IL-29 insert. DNA was isolated from all ten clones using the QIAprep™ Spin Miniprep Kit (Qiagen) and analyzed for presence of insert by cutting with XbaI (Roche) and PstI (New England Biolabs) restriction enzymes. Nine clones contained insert and were sequenced to

insure the zcyto21 C172S mutation had been introduced. A clone (isolet #6) was sequence verified and was subsequently labeled pSDH171. A similar strategy can be implemented to generate a zcyto21 C15S mutant.

Example 11

zcyto20 C49S Cysteine mutant expression construct

[260] The zcyto20 C49S Cysteine mutant coding sequence was generated by overlap PCR (SEQ ID NO: 20). The first 187 bases of the wildtype IL-28A sequence (SEQ ID NO:1) was generated by PCR amplification using pYEL7 (SEQ ID NO: 67) as template and oligonucleotide primers zc43,431 (SEQ ID NO: 62) and zc45,399 (SEQ ID NO: 66). The second DNA fragment from base 105 to 531 was generated by PCR amplification using pYEL7 (SEQ ID NO: 67) as template and oligonucleotide primers zc45,398 (SEQ ID NO: 68) and zc43,437 (SEQ ID NO: 63). Primers zc45,399 (SEQ ID NO: 66) and zc45,398 (SEQ ID NO: 68) contained the specific modified sequence which changed the cysteine 49 to a serine. These two PCR products were combined and PCR overlap amplified using oligonucleotide primers zc43,431 (SEQ ID NO: 62) and zc43,437 (SEQ ID NO: 63). The final PCR product was inserted into expression vector pTAP238 by yeast homologous recombination (Raymond et al. *Biotechniques*. Jan. 26(1):134-8, 140-1, 1999). The expression construct was extracted from yeast and transformed into competent *E. coli* DH10B. Kanamycin resistant clones were screened by colony PCR. A positive clone was verified by sequencing and subsequently transformed into production host strain W3110/pRARE. The expression construct with the zcyto20 C49S Cysteine mutant coding sequence was named pCHAN9.

Example 12

zcyto20 C51S Cysteine mutant expression construct

[261] The zcyto20 C51S Cysteine mutant coding sequence was generated by overlap PCR (SEQ ID NO: 24). The first 193 bases of the wildtype IL-28A sequence was generated by PCR amplification using pYEL7 (SEQ ID NO: 67) as template and oligonucleotide primers zc43,431 (SEQ ID NO: 62) and zc45,397 (SEQ ID NO: 63). The second DNA fragment from base 111 to 531 was generated by PCR amplification using pYEL7 (SEQ ID NO: 67) as template and oligonucleotide primers zc45,396 (SEQ ID NO:70) and zc43,437 (SEQ ID NO: 63). Primers zc45,397 (SEQ ID NO: 69) and zc45,396 (SEQ ID NO: 70) contained the specific modified sequence which changed the cysteine51 to a serine. These two PCR products were combined and PCR overlap amplified using oligonucleotide primers zc43,431 (SEQ ID NO: 62) and zc43,437 (SEQ ID NO: 63). The final PCR product was inserted into our in-house expression vector pTAP238 by yeast homologous recombination (Raymond et al. *supra*). The expression construct was extracted from yeast and transformed into competent *E. coli* DH10B. Kanamycin resistant clones were screened by colony

PCR. A positive clone was verified by sequencing and subsequently transformed into production host strain W3110/pRARE. The expression construct with the zcyto20 C50S Cysteine mutant coding sequence was named pCHAN10.

Example 13

Expression of IL-28A, IL-29 and Cys to Ser Cysteine mutants in *E. coli*

[262] In separate experiments, *E. coli* transformed with each of the expression vectors described in Examples 6-9 were inoculated into 100 mL Superbroth II medium (Becton Dickinson, San Diego, CA) with 0.01% Antifoam 289 (Sigma Aldrich, St. Louis, MO), 30 µg/ml kanamycin, 35 µg/ml chloramphenicol and cultured overnight at 37°C. A 5 mL inoculum was added to 500 mL of same medium in a 2 L culture flask which was shaken at 250 rpm at 37°C until the culture attained an OD600 of 4. IPTG was then added to a final concentration of 1 mM and shaking was continued for another 2.5 hours. The cells were centrifuged at 4,000 x g for 10 min at 4 °C. The cell pellets were frozen at -80°C until use at a later time.

Example 14

Refolding and Purification of IL-28

[263] *Inclusion body preparation*

[264] Human wildtype IL-29 was expressed in *E. coli* strain W3110 as inclusion bodies as described above. A cell pellet from a fed-batch fermentation was resuspended in 50 mM Tris, pH 7.3. The suspension was passed through an APV-Gaulin homogenizer (Invensys APV, Tonawanda, New York) three times at 8000 psi. The insoluble material was recovered by centrifugation at 15,000 g for 30 minutes. The pellet was washed consecutively with 50 mM Tris, 1% (v/v) Triton X100, pH 7.3 and 4 M Urea. The inclusion body was then dispersed in 50 mM Tris, 6 M guanidine hydrochloride, 5 mM DTT at room temperature for 1 hour. The material was then centrifuged at 15,000 g for 1 hour. The supernatant from this step contains reduced soluble IL-29.

[265] *Refolding*

[266] The solubilized IL-29 was diluted slowly into 50 mM Tris, pH 8, 0.75 M Arginine, 0.05% PEG3350, 2 mM MgCl₂, 2 mM CaCl₂, 0.4 mM KCl, 10 mM NaCl, 4 mM reduced Glutathione, 0.8 mM oxidized Glutathione at room temperature while stirring. The final concentration of IL-29 in the refolding buffer was 0.1 mg/ml. The refolding mixture was left at room temperature overnight. Concentrated acetic acid was then used to adjust the pH of the suspension to 5. The suspension was then filtered through a 0.2 µm filter. RP-HPLC analysis of the refolding mixture showed two prominent peaks.

[267] *Purification*

[268] The refolding mixture was in-line diluted (1:2) with 50 mM NaOAc at pH 5 and loaded onto a Pharmacia SP Sepharose Fast Flow cation exchange column (North Peapack, NJ). The column was washed with 3 column volumes of 50 mM NaOAc, 400 mM NaCl, pH 5. The bound IL-29 was eluted with 50 mM NaOAc, 1.4 M NaCl, pH 5. Solid $(\text{NH}_4)_2\text{SO}_4$ was added to the elute pool of the cation exchange step so that the final concentration of $(\text{NH}_4)_2\text{SO}_4$ was 0.5 M. The material was then loaded onto a ToyoPearl Phenyl 650S HIC column (Tosoh Biosep, Montgomery, PA). The column was then washed with 3 column volumes of 50 mM NaOAc, 1 M $(\text{NH}_4)_2\text{SO}_4$, pH 5. A linear gradient of 10 column volumes from 50 mM NaOAc, 1 M $(\text{NH}_4)_2\text{SO}_4$, pH 5 to 50 mM NaOAc, pH 5 was used to elute the bound zcyto21. Fractions were collected of the elute. Two prominent peaks were observed in this step. RP-HPLC analysis of the elute fractions was performed. Two products corresponding to two disulfide bond isomers were produced after final buffer exchange into PBS, pH 7.3.

Example 15

Refolding and Purification of IL-29 Cysteine mutant

[269] As described in Example 3, purification of IL-29 produced two disulfide bond isomers. A HIC FPLC step was employed to separate the two forms. The separation was not baseline resolved. Severe "Peak Shaving" had to be used to obtain substantially pure isomers (>95%). The yield for this step and by extension for the whole process suffered. The final yields were 8% and 9% for the C15-C112 form and C112-C171 form respectively. Wildtype IL-29 produced in CHO and baculovirus (BV) systems also showed similar phenomena. It was established that the C15-C112 form of the isomer is homologous in disulfide bond patterns to type I INF's. The C15-C112 form also demonstrated 30-fold higher bioactivity than the C112-C171 form in an ISRE assay (see below).

[270] *Refolding and purification of zcyto21 Cys172Ser mutein*

[271] The inclusion body preparation, refolding and purification of zcyto21 C172S polypeptide (SEQ ID NO:29) is essentially the same as those of IL-29 wild-type (SEQ ID NO:4). RP-HPLC analysis of the refolding mixture of the mutein showed only one prominent peak corresponding to the C15-C112 form of the wild-type IL-29. Subsequent HIC chromatography show only a single peak. It was therefore unnecessary to employ severe "peak shaving". The final yield for the entire process is close to 50%. The zcyto21 Cys172Ser polypeptide (SEQ ID NO:29) showed equivalent bioactivity to the C15-C112 form of wild-type IL-29 in ISRE assay shown in Example 16.

Example 16

IL-28RA mRNA expression in liver and lymphocyte subsets

[272] In order to further examine the mRNA distribution for IL-28RA, semi-quantitative RT-PCR was performed using the SDS 7900HT system (Applied Biosystems, CA). One-step RT-PCR was performed using 100ng total RNA for each sample and gene-specific primers. A standard curve was generated for each primer set using Bjab RNA and all sample values were normalized to HPRT. The normalized values for IFNAR2 and CRF2-4 are also shown.

[273] Table 7: B and T cells express significant levels of IL-28RA mRNA. Low levels are seen in dendritic cells and most monocytes.

Table 7

Cell/Tissue	IL-28RA	IFNAR2	CRF2-4
Dendritic Cells unstim	.04	5.9	9.8
Dendritic Cells +IFNg	.07	3.6	4.3
Dendritic Cells	.16	7.85	3.9
CD14+ stim'd with LPS/IFNg	.13	12	27
CD14+ monocytes resting	.12	11	15.4
Hu CD14+ Unact.	4.2	TBD	TBD
Hu CD14+ 1 ug/ml LPS act.	2.3	TBD	TBD
H. Inflamed tonsil	3	12.4	9.5
H. B-cells+PMA/Iono 4 & 24 hrs	3.6	1.3	1.4
Hu CD19+ resting	6.2	TBD	TBD
Hu CD19+ 4 hr. PMA/Iono	10.6	TBD	TBD
Hu CD19+ 24 hr Act. PMA/Iono	3.7	TBD	TBD
IgD+ B-cells	6.47	13.15	6.42
IgM+ B-cells	9.06	15.4	2.18
IgD- B-cells	5.66	2.86	6.76
NKCells + PMA/Iono	0	6.7	2.9
Hu CD3+ Unactivated	2.1	TBD	TBD
CD4+ resting	.9	8.5	29.1
CD4+ Unstim 18 hrs	1.6	8.4	13.2
CD4+ +Poly I/C	2.2	4.5	5.1
CD4+ + PMA/Iono	.3	1.8	.9
CD3 neg resting	1.6	7.3	46
CD3 neg unstim 18 hrs	2.4	13.2	16.8
CD3 neg+Poly I/C 18 hrs	5.7	7	30.2
CD3 neg+LPS 18 hrs	3.1	11.9	28.2
CD8+ unstim 18 hrs	1.8	4.9	13.1
CD8+ stim'd with PMA/Ion 18 hrs	.3	.6	1.1

[274] As shown in Table 8, normal liver tissue and liver derived cell lines display substantial levels of IL-28RA and CRF2-4 mRNA.

Table 8

Cell/Tissue	IL-28RA	IFNAR2	CRF2-4
HepG2	1.6	3.56	2.1
HepG2 UGAR 5/10/02	1.1	1.2	2.7
HepG2, CGAT HKES081501C	4.3	2.1	6
HuH7 5/10/02	1.63	16	2
HuH7 hepatoma - CGAT	4.2	7.2	3.1
Liver, normal - CGAT #HXYZ020801K	11.7	3.2	8.4
Liver, NAT - Normal adjacent tissue	4.5	4.9	7.7
Liver, NAT - Normal adjacent tissue	2.2	6.3	10.4
Hep SMVC hep vein	0	1.4	6.5
Hep SMCA hep. Artery	0	2.1	7.5
Hep. Fibro	0	2.9	6.2
Hep. Ca.	3.8	2.9	5.8
Adenoca liver	8.3	4.2	10.5
SK-Hep-1 adenoca. Liver	.1	1.3	2.5
AsPC-1 Hu. Pancreatic adenocarc.	.7	.8	1.3
Hu. Hep. Stellate cells	.025	4.4	9.7

[275] As shown in Table 9, primary airway epithelial cells contain abundant levels of IL-28RA and CRF2-4.

Table 9

Cell/Tissue	IL-28RA	IFNAR2	CRF2-4
U87MG - glioma	0	.66	.99
NHBE unstim	1.9	1.7	8.8
NHBE + TNF-alpha	2.2	5.7	4.6
NHBE + poly I/C	1.8	nd	nd
Small Airway Epithelial Cells	3.9	3.3	27.8
NHLF - Normal human lung fibroblasts	0	nd	nd

[276] As shown in Table 10, IL-28RA is present in normal and diseased liver specimens, with increased expression in tissue from Hepatitis C and Hepatitis B infected specimens.

Table 10

Cell/Tissue	IL-28RA	CRF2-4	IFNAR2
Liver with Coagulation Necrosis	8.87	15.12	1.72
Liver with Autoimmune Hepatitis	6.46	8.90	3.07
Neonatal Hepatitis	6.29	12.46	6.16
Endstage Liver disease	4.79	17.05	10.58
Fulminant Liver Failure	1.90	14.20	7.69
Fulminant Liver failure	2.52	11.25	8.84
Cirrhosis, primary biliary	4.64	12.03	3.62
Cirrhosis Alcoholic (Laennec's)	4.17	8.30	4.14
Cirrhosis, Cryptogenic	4.84	7.13	5.06
Hepatitis C+, with cirrhosis	3.64	7.99	6.62
Hepatitis C+	6.32	11.29	7.43
Fulminant hepatitis secondary to Hep A	8.94	21.63	8.48
Hepatitis C+	7.69	15.88	8.05
Hepatitis B+	1.61	12.79	6.93
Normal Liver	8.76	5.42	3.78
Normal Liver	1.46	4.13	4.83
Liver NAT	3.61	5.43	6.42
Liver NAT	1.97	10.37	6.31
Hu Fetal Liver	1.07	4.87	3.98
Hepatocellular Carcinoma	3.58	3.80	3.22
Adenocarcinoma Liver	8.30	10.48	4.17
hep. SMVC, hep. Vein	0.00	6.46	1.45
Hep SMCA hep. Artery	0.00	7.55	2.10
Hep. Fibroblast	0.00	6.20	2.94
HuH7 hepatoma	4.20	3.05	7.24
HepG2 Hepatocellular carcinoma	3.40	5.98	2.11
SK-Hep-1 adenocar. Liver	0.03	2.53	1.30
HepG2 Unstim	2.06	2.98	2.28
HepG2+zcyto21	2.28	3.01	2.53
HepG2+IFN α	2.61	3.05	3.00
Normal Female Liver - degraded	1.38	6.45	4.57
Normal Liver - degraded	1.93	4.99	6.25
Normal Liver - degraded	2.41	2.32	2.75
Disease Liver - degraded	2.33	3.00	6.04
Primary Hepatocytes from Clonetics	9.13	7.97	13.30

[277] As shown in Tables 11-15, IL-28RA is detectable in normal B cells, B lymphoma cell lines, T cells, T lymphoma cell lines (Jurkat), normal and transformed lymphocytes (B cells and T cells) and normal human monocytes.

Table 11

	HPRT Mean	IL-28RA Mean	IL-28RA norm	IFNAR2	IFNR2 norm	CRF2-4	CRF2-4 Norm
CD14+ 24hr unstim #A38	13.1	68.9	5.2	92.3	7.0	199.8	15.2
CD14+ 24 hr stim #A38	6.9	7.6	1.1	219.5	31.8	276.6	40.1
CD14+ 24 hr unstim #A112	17.5	40.6	2.3	163.8	9.4	239.7	13.7
CD14+ 24 hr stim #A112	11.8	6.4	0.5	264.6	22.4	266.9	22.6
CD14+ rest #X	32.0	164.2	5.1	1279.7	39.9	699.9	21.8
CD14+ +LPS #X	21.4	40.8	1.9	338.2	15.8	518.0	24.2
CD14+ 24 hr unstim #A39	26.3	86.8	3.3	297.4	11.3	480.6	18.3
CD14+ 24 hr stim #A39	16.6	12.5	0.8	210.0	12.7	406.4	24.5
HL60 Resting	161.2	0.2	0.0	214.2	1.3	264.0	1.6
HL60+PMA	23.6	2.8	0.1	372.5	15.8	397.5	16.8
U937 Resting	246.7	0.0	0.0	449.4	1.8	362.5	1.5
U937+PMA	222.7	0.0	0.0	379.2	1.7	475.9	2.1
Jurkat Resting	241.7	103.0	0.4	327.7	1.4	36.1	0.1
Jurkat Activated	130.7	143.2	1.1				
Colo205	88.8	43.5	0.5				
HT-29	26.5	30.5	1.2				

Table 12

	HPRT SD	IL-28RA SD
Mono 24hr unstim #A38	0.6	2.4
Mono 24 hr stim #A38	0.7	0.2
Mono 24 hr unstim #A112	2.0	0.7
Mono 24 hr stim #A112	0.3	0.1
Mono rest #X	5.7	2.2
Mono+LPS #X	0.5	1.0
Mono 24 hr unstim #A39	0.7	0.8
Mono 24 hr stim #A39	0.1	0.7
HL60 Resting	19.7	0.1
HL60+PMA	0.7	0.4
U937 Resting	7.4	0.0
U937+PMA	7.1	0.0
Jurkat Resting	3.7	1.1
Jurkat Activated	2.4	1.8
Colo205	1.9	0.7
HT-29	2.3	1.7

Table 13

	Mean Hprt	Mean IFNAR2	Mean IL-28RA	Mean CRF
CD3+/CD4+ 0	10.1	85.9	9.0	294.6
CD4/CD3+ Unstim 18 hrs	12.9	108.7	20.3	170.4
CD4+/CD3+ +Poly I/C 18 hrs	24.1	108.5	52.1	121.8
CD4+/CD3+ + PMA/Iono 18 hrs	47.8	83.7	16.5	40.8
CD3 neg 0	15.4	111.7	24.8	706.1
CD3 neg unstim 18 hrs	15.7	206.6	37.5	263.0
CD3 neg +Poly I/C 18 hrs	9.6	67.0	54.7	289.5
CD3 neg +LPS 18 hrs	14.5	173.2	44.6	409.3
CD8+ Unstim. 18 hrs	6.1	29.7	11.1	79.9
CD8+ + PMA/Iono 18 hrs	78.4	47.6	26.1	85.5
12.8.1 - NHBE Unstim	47.4	81.1	76.5	415.6
12.8.2 - NHBE+TNF-alpha	42.3	238.8	127.7	193.9
SAEC	15.3	49.9	63.6	426.0

Table 14

	IL-28RA Norm	CRF Norm	IFNAR2 Norm	IL-28RA SD	CRF SD	IFNAR2 SD
CD3+/CD4+ 0	0.9	29.1	8.5	0.1	1.6	0.4
CD4/CD3+ Unstim 18 hrs	1.6	13.2	8.4	0.2	1.6	1.4
CD4+/CD3+ +Poly I/C 18 hrs	2.2	5.1	4.5	0.1	0.3	0.5
CD4+/CD3+ + PMA/Iono 18 hrs	0.3	0.9	1.8	0.0	0.1	0.3
CD3 neg 0	1.6	46.0	7.3	0.2	4.7	1.3
CD3 neg unstim 18 hrs	2.4	16.8	13.2	0.4	2.7	2.3
CD3 neg +Poly I/C 18 hrs	5.7	30.2	7.0	0.3	1.7	0.8
CD3 neg +LPS 18 hrs	3.1	28.2	11.9	0.4	5.4	2.9
CD8+ Unstim. 18 hrs	1.8	13.1	4.9	0.1	1.1	0.3
CD8+ + PMA/Iono 18 hrs	0.3	1.1	0.6	0.0	0.1	0.0
12.8.1 - NHBE Unstim	1.6	8.8	1.7	0.1	0.4	0.1
12.8.2 - NHBE+TNF-alpha	3.0	4.6	5.7	0.1	0.1	0.1
SAEC	4.1	27.8	3.3	0.2	1.1	0.3

Table 15

	SD Hprt	SD IFNAR2	SD IL-28RA	SD CRF
CD3+/CD4+ 0	0.3	3.5	0.6	12.8
CD4/CD3+ Unstim 18 hrs	1.4	13.7	1.1	8.5
CD4+/CD3+ +Poly I/C 18 hrs	1.3	9.8	1.6	3.4
CD4+/CD3+ + PMA/Iono 18 hrs	4.0	10.3	0.7	3.7
CD3 neg 0	1.4	16.6	1.6	28.6
CD3 neg unstim 18 hrs	2.4	16.2	2.7	12.6
CD3 neg +Poly I/C 18 hrs	0.5	7.0	1.0	8.3
CD3 neg +LPS 18 hrs	1.0	39.8	5.6	73.6
CD8+ Unstim. 18 hrs	0.2	1.6	0.5	6.1
CD8+ + PMA/Iono 18 hrs	1.3	1.7	0.2	8.1
12.8.1 - NHBE Unstim	2.4	5.6	2.7	2.8
12.8.2 - NHBE+TNF-alpha	0.5	3.4	3.5	3.4
SAEC	0.5	4.8	1.8	9.9

Example 17Mouse IL-28 Does Not Have Antiproliferative Effect on Mouse B cells

[278] Mouse B cells were isolated from 2 Balb/C spleens (7 months old) by depleting CD43+ cells using MACS magnetic beads. Purified B cells were cultured in vitro with LPS, anti-IgM or anti-CD40 monoclonal antibodies. Mouse IL-28 or mouse IFN α was added to the cultures and ^3H -thymidine was added at 48 hrs. and ^3H -thymidine incorporation was measured after 72 hrs. culture.

[279] IFN α at 10 ng/ml inhibited ^3H -thymidine incorporation by mouse B cells stimulated with either LPS or anti-IgM. However mouse IL-28 did not inhibit ^3H -thymidine incorporation at any concentration tested including 1000 ng/ml. In contrast, both mIFN α and mouse IL-28 increased ^3H thymidine incorporation by mouse B cells stimulated with anti-CD40 MAb.

[280] These data demonstrate that mouse IL-28 unlike IFN α displays no antiproliferative activity even at high concentrations. In addition, zcyto24 enhances proliferation in the presence of anti-CD40 MAbs. The results illustrate that mouse IL-28 differs from IFN α in that mouse IL-28 does not display antiproliferative activity on mouse B cells, even at high concentrations. In addition, mouse IL-28 enhances proliferation in the presence of anti-CD40 monoclonal antibodies.

Example 18Bone marrow expansion assay

[281] Fresh human marrow mononuclear cells (Poietic Technologies, Gaithersburg, Md.) were adhered to plastic for 2 hrs in αMEM , 10% FBS, 50 micromolar β -mercaptoethanol, 2 ng/ml FLT3L at 37°C. Non adherent cells were then plated at 25,000 to 45,000 cells/well (96 well tissue culture plates) in αMEM , 10% FBS, 50 micromolar β -mercaptoethanol, 2 ng/ml FLT3L in the presence or absence of 1000 ng/ml IL-29-CEE, 100 ng/ml IL-29-CEE, 10 ng/ml IL-29-CEE, 100 ng/ml IFN- α 2a, 10 ng/ml IFN- α 2a or 1 ng/ml IFN- α 2a. These cells were incubated with a variety of cytokines to test for expansion or differentiation of hematopoietic cells from the marrow (20 ng/ml IL-2, 2 ng/ml IL-3, 20 ng/ml IL-4, 20 ng/ml IL-5, 20 ng/ml IL-7, 20 ng/ml IL-10, 20 ng/ml IL-12, 20 ng/ml IL-15, 10 ng/ml IL-21 or no added cytokine). After 8 to 12 days Alamar Blue (Accumed, Chicago, Ill.) was added at 20 microliters/well. Plates were further incubated at 37 °C, 5% CO₂, for 24 hours. Plates were read on the FmaxTM plate reader (Molecular Devices Sunnyvale, Calif.) using the SoftMaxTM Pro program, at wavelengths 544 (Excitation) and 590 (Emission). Alamar Blue gives a fluourometric readout based on the metabolic activity of cells, and is thus a direct measurement of cell proliferation in comparison to a negative control.

[282] IFN- α 2a caused a significant inhibition of bone marrow expansion under all conditions tested. In contrast, IL-29 had no significant effect on expansion of bone marrow cells in

the presence of IL-3, IL-4, IL-5, IL-7, IL-10, IL-12, IL-21 or no added cytokine. A small inhibition of bone marrow cell expansion was seen in the presence of IL-2 or IL-15.

Example 19

Inhibition of IL-28 and IL-29 signaling with soluble receptor (zcytoR19/CRF2-4)

[283] *Signal Transduction Reporter Assay*

[284] A signal transduction reporter assay can be used to show the inhibitor properties of zcytoR19-Fc4 homodimeric and zcytoR19-Fc/CRF2-4-Fc heterodimeric soluble receptors on zcyto20, zcyto21 and zcyto24 signaling. Human embryonal kidney (HEK) cells overexpressing the zcytoR19 receptor are transfected with a reporter plasmid containing an interferon-stimulated response element (ISRE) driving transcription of a luciferase reporter gene. Luciferase activity following stimulation of transfected cells with ligands (including zcyto20 (SEQ ID NO:2), zcyto21 (SEQ ID NO:15), zcyto24 (SEQ ID NO:8)) reflects the interaction of the ligand with soluble receptor.

[285] *Cell Transfections*

[286] 293 HEK cells overexpressing zcytoR19 were transfected as follows: 700,000 293 cells/well (6 well plates) were plated approximately 18h prior to transfection in 2 milliliters DMEM + 10% fetal bovine serum. Per well, 1 microgram pISRE-Luciferase DNA (Stratagene) and 1 microgram pIRES2-EGFP DNA (Clontech,) were added to 6 microliters Fugene 6 reagent (Roche Biochemicals) in a total of 100 microliters DMEM. This transfection mix was added 30 minutes later to the pre-plated 293 cells. Twenty-four hours later the transfected cells were removed from the plate using trypsin-EDTA and replated at approximately 25,000 cells/well in 96 well microtiter plates. Approximately 18 h prior to ligand stimulation, media was changed to DMEM + 0.5%FBS.

[287] *Signal Transduction Reporter Assays*

[288] The signal transduction reporter assays were done as follows: Following an 18h incubation at 37°C in DMEM + 0.5%FBS, transfected cells were stimulated with 10 ng/ml zcyto20, zcyto21 or zcyto24 and 10 micrograms/ml of the following soluble receptors; human zcytoR19-Fc homodimer, human zcytoR19-Fc/human CRF2-4-Fc heterodimer, human CRF2-4-Fc homodimer, murine zcytoR19-Ig homodimer. Following a 4-hour incubation at 37°C, the cells were lysed, and the relative light units (RLU) were measured on a luminometer after addition of a luciferase substrate. The results obtained are shown as the percent inhibition of ligand-induced signaling in the presence of soluble receptor relative to the signaling in the presence of PBS alone. Table 16 shows that the human zcytoR19-Fc/human CRF2-4 heterodimeric soluble receptor is able to inhibit zcyto20, zcyto21 and zcyto24-induced signaling between 16 and 45% of control. The human zcytoR19-Fc homodimeric

soluble receptor is also able to inhibit zcyto21-induced signaling by 45%. No significant effects were seen with huCRF2-4-Fc or muzcytor19-Ig homodimeric soluble receptors.

Table 16: Percent Inhibition of Ligand-induced Interferon Stimulated Response Element (ISRE) Signaling by Soluble Receptors

Ligand	Huzcytor19-Fc/huCRF2-4-Fc	Huzcytor19-Fc	HuCRF2-4-Fc	Muzcytor19-Ig
Zcyto20	16%	92%	80%	91%
Zcyto21	16%	45%	79%	103%
Zcyto24	47%	90%	82%	89%

Example 20

Induction of Interferon Stimulated Genes by IL-28 and IL-29

[289] *Human Peripheral Blood Mononuclear Cells*

[290] Freshly isolated human peripheral blood mononuclear cells were grown in the presence of IL-29 (20 ng/mL), IFN α 2a (2 ng/ml) (PBL Biomedical Labs, Piscataway, NJ), or in medium alone. Cells were incubated for 6, 24, 48, or 72 hours, and then total RNA was isolated and treated with RNase-free DNase. 100 ng total RNA was used as a template for One-Step Semi-Quantitative RT-PCR® using Taqman One-Step RT-PCR Master Mix® Reagents and gene specific primers as suggested by the manufacturer. (Applied Biosystems, Branchburg, NJ) Results were normalized to HPRT and are shown as the fold induction over the medium alone control for each time-point. Table 17 shows that IL-29 induces Interferon Stimulated Gene Expression in human peripheral blood mononuclear cells at all time-points tested.

Table 17

	MxA Fold induction	Pkr Fold Induction	OAS Fold Induction
6 hr IL29	3.1	2.1	2.5
6 hr IFN α 2a	17.2	9.6	16.2
24 hr IL29	19.2	5.0	8.8
24 hr IFN α 2a	57.2	9.4	22.3
48 hr IL29	7.9	3.5	3.3
48hr IFN α 2a	18.1	5.0	17.3
72 hr IL29	9.4	3.7	9.6
72 hr IFN α 2a	29.9	6.4	47.3

[291] *Activated Human T Cells*

[292] Human T cells were isolated by negative selection from freshly harvested peripheral blood mononuclear cells using the Pan T-cell Isolation® kit according to manufacturer's instructions (Miltenyi, Auburn, CA). T cells were then activated and expanded for 5 days with plate-bound anti-CD3, soluble anti-CD28 (0.5ug/ml), (Pharmingen, San Diego, CA) and Interleukin 2 (IL-2; 100 U/ml) (R&D Systems, Minneapolis, MN), washed and then expanded for a further 5 days with IL-2. Following activation and expansion, cells were stimulated with IL-28A (20 ng/ml), IL-29 (20 ng/ml), or medium alone for 3, 6, or 18 hours. Total RNA was isolated and treated with RNase-Free DNase. One-Step Semi-Quantitative RT-PCR® was performed as described in the example above. Results were normalized to HPRT and are shown as the fold induction over the medium alone control for each time-point. Table 18 shows that IL-28 and IL-29 induce Interferon Stimulated Gene expression in activated human T cells at all time-points tested.

Table 18

	MxA Fold Induction	Pkr Fold Induction	OAS Fold Induction
Donor #1 3 hr IL28	5.2	2.8	4.8
Donor #1 3 hr IL29	5.0	3.5	6.0
Donor #1 6 hr IL28	5.5	2.2	3.0
Donor #1 6 hr IL29	6.4	2.2	3.7
Donor #1 18 hr IL28	4.6	4.8	4.0
Donor #1 18 hr IL29	5.0	3.8	4.1
Donor #2 3 hr IL28	5.7	2.2	3.5
Donor #2 3 hr IL29	6.2	2.8	4.7
Donor #2 6 hr IL28	7.3	1.9	4.4
Donor #2 6 hr IL29	8.7	2.6	4.9
Donor #2 18 hr IL28	4.7	2.3	3.6
Donor #2 18 hr IL29	4.9	2.1	3.8

[293] *Primary Human Hepatocytes*

[294] Freshly isolated human hepatocytes from two separate donors (Cambrex, Baltimore, MD and CellzDirect, Tucson, AZ) were stimulated with IL-28A (50 ng/ml), IL-29 (50 ng/ml), IFN α 2a (50 ng/ml), or medium alone for 24 hours. Following stimulation, total RNA was isolated and treated with RNase-Free DNase. One-step semi-quantitative RT-PCR was performed as described previously in the example above. Results were normalized to HPRT and are shown as the fold induction over the medium alone control for each time-point. Table 19 shows that IL-28 and IL-29 induce Interferon Stimulated Gene expression in primary human hepatocytes following 24-hour stimulation.

Table 19

	MxA Fold Induction	Pkr Fold Induction	OAS Fold Induction
Donor #1 IL28	31.4	6.4	30.4
Donor #1 IL29	31.8	5.2	27.8
Donor #1 IFN- α 2a	63.4	8.2	66.7
Donor #2 IL28	41.7	4.2	24.3
Donor #2 IL29	44.8	5.2	25.2
Donor #2 IFN- α 2a	53.2	4.8	38.3

[295] *HepG2 and HuH7: Human Liver Hepatoma Cell Lines*

[296] HepG2 and HuH7 cells (ATCC NOS. 8065, Manassas, VA) were stimulated with IL-28A (10 ng/ml), IL-29 (10 ng/ml), IFN α 2a (10 ng/ml), IFN β (1 ng/ml) (PBL Biomedical, Piscataway, NJ), or medium alone for 24 or 48 hours. In a separate culture, HepG2 cells were stimulated as described above with 20 ng/ml of MetIL-29C172S-PEG or MetIL-29-PEG. Total RNA was isolated and treated with RNase-Free DNase. 100 ng Total RNA was used as a template for one-step semi-quantitative RT-PCR as described previously. Results were normalized to HPRT and are shown as the fold induction over the medium alone control for each time-point. Table 20 shows that IL-28 and IL-29 induce ISG expression in HepG2 and HuH7 liver hepatoma cell lines after 24 and 48 hours.

Table 20

	MxA Fold Induction	Pkr Fold Induction	OAS Fold Induction
HepG2 24 hr IL28	12.4	0.7	3.3
HepG2 24 hr IL29	36.6	2.2	6.4
HepG2 24 hr IFN α 2a	12.2	1.9	3.2
HepG2 24 hr IFN β	93.6	3.9	19.0
HepG2 48hr IL28	2.7	0.9	1.1
HepG2 48hr IL29	27.2	2.1	5.3
HepG2 48 hr IFN α 2a	2.5	0.9	1.2
HepG2 48hr IFN β	15.9	1.8	3.3
HuH7 24 hr IL28	132.5	5.4	52.6
HuH7 24 hr IL29	220.2	7.0	116.6
HuH7 24 hr IFN α 2a	157.0	5.7	67.0
HuH7 24 hr IFN β	279.8	5.6	151.8
HuH7 48hr IL28	25.6	3.4	10.3
HuH7 48hr IL29	143.5	7.4	60.3
HuH7 48 hr IFN α 2a	91.3	5.8	32.3
HuH7 48hr IFN β	65.0	4.2	35.7

Table 21

	MxA Fold Induction	OAS Fold Induction	Pkr Fold Induction
MetIL-29-PEG	36.7	6.9	2.2
MetIL-29C172S-PEG	46.1	8.9	2.8

[297] Data shown is for 20 ng/ml metIL-29-PEG and metIL-29C172S-PEG versions of IL-29 after culture for 24 hours.

[298] Data shown is normalized to HPRT and shown as fold induction over unstimulated cells.

Example 21

IL-28, IL-29, metIL-29-PEG and metIL-29C172S-PEG Stimulate ISG induction in the Mouse Liver Cell line AML-12

[299] Interferon stimulated genes (ISGs) are genes that are induced by type I interferons (IFNs) and also by the IL-28 and IL-29 family molecules, suggesting that IFN and IL-28 and IL-29 induce similar pathways leading to antiviral activity. Human type I IFNs (IFN α 1-4 and IFN β) have little or no activity on mouse cells, which is thought to be caused by lack of species cross-reactivity. To test if human IL-28 and IL-29 have effects on mouse cells, ISG induction by human IL-28 and IL-29 was evaluated by real-time PCR on the mouse liver derived cell line AML-12.

[300] AML-12 cells were plated in 6-well plates in complete DMEM media at a concentration of 2×10^6 cells/well. Twenty-four hours after plating cells, human IL-28 and IL-29 were added to the culture at a concentration of 20 ng/ml. As a control, cells were either stimulated with mouse IFN α (positive control) or unstimulated (negative). Cells were harvested at 8, 24, 48 and 72 hours after addition of CHO-derived human IL-28A (SEQ ID NO:2) or IL-29 (SEQ ID NO:15). RNA was isolated from cell pellets using RNeasy-kit® (Qiagen, Valencia, CA). RNA was treated with DNase (Millipore, Billerica, MA) to clean RNA of any contaminating DNA. cDNA was generated using Perkin-Elmer RT mix. ISG gene induction was evaluated by real-time PCR using primers and probes specific for mouse OAS, Pkr and Mx1. To obtain quantitative data, HPRT real-time PCR was duplexed with ISG PCR. A standard curve was obtained using known amounts of RNA from IFN-stimulated mouse PBLs. All data are shown as expression relative to internal HPRT expression.

[301] Human IL-28A and IL-29 stimulated ISG induction in the mouse hepatocyte cell line AML-12 and demonstrated that unlike type I IFNs, the IL-28/29 family proteins showed cross-species reactivity.

Table 22

<i>Stimulation</i>	OAS	PkR	Mx1
None	0.001	0.001	0.001
Human IL-28	0.04	0.02	0.06
Human IL-29	0.04	0.02	0.07
Mouse IL-28	0.04	0.02	0.08
Mouse IFN α	0.02	0.02	0.01

[302] All data shown were expressed as fold relative to HPRT gene expression ng of OAS mRNA = normalized value of OAS mRNA amount relative to internal

[303] ng of HPRT mRNA housekeeping gene, HPRT

[304] As an example, the data for the 48 hour time point is shown.

Table 23

AML12's

	Mx1 Fold Induction	OAS Fold Induction	Pkr Fold Induction
MetIL-29-PEG	728	614	8
MetIL-29C172S-PEG	761	657	8

[305] Cells were stimulated with 20 ng/ml metIL-29-PEG or metIL-29C172S-PEG for 24 hours.

[306] Data shown is normalized to HPRT and shown as fold induction over unstimulated cells.

Example 22

ISGs are Efficiently Induced in Spleens of Transgenic Mice Expressing Human IL-29

[307] Transgenic (Tg) mice were generated expressing human IL-29 under the control of the Eu-lck promoter. To study if human IL-29 has biological activity *in vivo* in mice, expression of ISGs was analyzed by real-time PCR in the spleens of Eu-lck IL-29 transgenic mice.

[308] Transgenic mice (C3H/C57BL/6) were generated using a construct that expressed the human IL-29 gene under the control of the Eu-lck promoter. This promoter is active in T cells and B cells. Transgenic mice and their non-transgenic littermates (n=2/gp) were sacrificed at about 10 weeks of age. Spleens of mice were isolated. RNA was isolated from cell pellets using RNeasy-kit® (Qiagen). RNA was treated with DNase to clean RNA of any contaminating DNA. cDNA was generated using Perkin-Elmer RT® mix. ISG gene induction was evaluated by real-time PCR using primers and probes (5' FAM, 3' NFQ) specific for mouse OAS, Pkr and Mx1. To obtain quantitative data, HPRT real-time PCR was duplexed with ISG PCR. Furthermore, a standard curve was obtained

using known amounts of IFN stimulated mouse PBLs. All data are shown as expression relative to internal HPRT expression.

[309] Spleens isolated from IL-29 Tg mice showed high induction of ISGs OAS, Pkr and Mx1 compared to their non-Tg littermate controls suggesting that human IL-29 is biologically active *in vivo* in mice.

Table 24

<i>Mice</i>	OAS	PkR	Mx1
Non-Tg	4.5	4.5	3.5
IL-29 Tg	12	8	21

[310] All data shown are fold expression relative to HPRT gene expression. The average expression in two mice is shown

Example 23

Human IL-28 and IL-29 Protein Induce ISG Gene Expression In Liver, Spleen and Blood of Mice

[311] To determine whether human IL-28 and IL-29 induce interferon stimulated genes *in vivo*, CHO-derived human IL-28A and IL-29 protein were injected into mice. In addition, *E. coli* derived IL-29 was also tested in *in vivo* assays as described above using MetIL-29C172S-PEG and MetIL-29-PEG. At various time points and at different doses, ISG gene induction was measured in the blood, spleen and livers of the mice.

[312] C57BL/6 mice were injected i.p or i.v with a range of doses (10 µg – 250 µg) of CHO-derived human IL-28A and IL-29 or MetIL-29C172S-PEG and MetIL-29C16-C113-PEG. Mice were sacrificed at various time points (1hr – 48hr). Spleens and livers were isolated from mice, and RNA was isolated. RNA was also isolated from the blood cells. The cells were pelleted and RNA isolated from pellets using RNeasy®-kit (Qiagen). RNA was treated with DNase (Amicon) to rid RNA of any contaminating DNA. cDNA was generated using Perkin-Elmer RT mix (Perkin-Elmer). ISG gene induction was measured by real-time PCR using primers and probes specific for mouse OAS, Pkr and Mx1. To obtain quantitative data, HPRT real-time PCR was duplexed with ISG PCR. A standard curve was calculated using known amounts of IFN-stimulated mouse PBLs. All data are shown as expression relative to internal HPRT expression.

[313] Human IL-29 induced ISG gene expression (OAS, Pkr, Mx1) in the livers, spleen and blood of mice in a dose dependent manner. Expression of ISGs peaked between 1-6 hours after injection and showed sustained expression above control mice upto 48 hours. In this experiment, human IL-28A did not induce ISG gene expression.

Table 25

Injection	OAS- 1hr	OAS-6hr	OAS-24hr	OAS-48hr
None - liver	1.6	1.6	1.6	1.6
IL-29 liver	2.5	4	2.5	2.8
None - spleen	1.8	1.8	1.8	1.8
IL-29 - spleen	4	6	3.2	3.2
None - blood	5	5	5	5
IL-29 blood	12	18	11	10

[314] Results shown are fold expression relative to HPRT gene expression. A sample data set for IL-29 induced OAS in liver at a single injection of 250 μ g i.v. is shown. The data shown is the average expression from 5 different animals/group.

Table 26

Injection	OAS (24hr)
None	1.8
IL-29 10 μ g	3.7
IL-29 50 μ g	4.2
IL-29 250 μ g	6

Table 27

MetIL-29-PEG					MetIL-29C172S-PEG			Naive	
	3hr	6hr	12hr	24hr	3hr	6hr	12hr	24hr	24hr
PKR	18.24	13.93	4.99	3.77	5.29	5.65	3.79	3.55	3.70
OAS	91.29	65.93	54.04	20.81	13.42	13.02	10.54	8.72	6.60
Mx1	537.51	124.99	33.58	35.82	27.89	29.34	16.61	0.00	10.98

[315] Mice were injected with 100 μ g of proteins i.v. Data shown is fold expression over HPRT expression from livers of mice. Similar data was obtained from blood and spleens of mice.

Example 24

IL-28 and IL-29 Induce ISG Protein In Mice

[316] To analyze of the effect of human IL-28 and IL-29 on induction of ISG protein (OAS), serum and plasma from IL-28 and IL-29 treated mice were tested for OAS activity.

[317] C57BL/6 mice were injected i.v with PBS or a range of concentrations (10 μ g-250 μ g) of human IL-28 or IL-29. Serum and plasma were isolated from mice at varying time points, and OAS activity was measured using the OAS radioimmunoassay (RIA) kit from Eiken Chemicals (Tokyo, Japan).

[318] IL-28 and IL-29 induced OAS activity in the serum and plasma of mice showing that these proteins are biologically active *in vivo*.

Table 28

<i>Injection</i>	OAS-1hr	OAS-6hr	OAS-24hr	OAS-48hr
None	80	80	80	80
IL-29	80	80	180	200

[319] OAS activity is shown at pmol/dL of plasma for a single concentration (250 µg) of human IL-29.

Example 25

Signal Transduction Reporter Assay

[320] A signal transduction reporter assay can be used to determine the functional interaction of human and mouse IL-28 and IL-29 with the IL-28 receptor. Human embryonal kidney (HEK) cells are transfected with a reporter plasmid containing an interferon-stimulated response element (ISRE) driving transcription of a luciferase reporter gene in the presence or absence of pZP7 expression vectors containing cDNAs for class II cytokine receptors (including human DIRS1, IFNαR1, IFNαR2 and IL-28 receptor). Luciferase activity following stimulation of transfected cells with class II ligands (including IL-28A (SEQ ID NO: 2), IL-29 (SEQ ID NO: 4), IL-28B (SEQ ID NO: 6), zcyto10, huIL10 and huIFNα-2a) reflects the interaction of the ligand with transfected and native cytokine receptors on the cell surface. The results and methods are described below.

[321] *Cell Transfections*

[322] 293 HEK cells were transfected as follows: 700,000 293 cells/well (6 well plates) were plated approximately 18h prior to transfection in 2 milliliters DMEM + 10% fetal bovine serum. Per well, 1 microgram pISRE-Luciferase DNA (Stratagene), 1 microgram cytokine receptor DNA and 1 microgram pIRES2-EGFP DNA (Clontech,) were added to 9 microliters Fugene 6 reagent (Roche Biochemicals) in a total of 100 microliters DMEM. Two micrograms pIRES2-EGFP DNA was used when cytokine receptor DNA was not included. This transfection mix was added 30 minutes later to the pre-plated 293 cells. Twenty-four hours later the transfected cells were removed from the plate using trypsin-EDTA and replated at approximately 25,000 cells/well in 96 well microtiter plates. Approximately 18 h prior to ligand stimulation, media was changed to DMEM + 0.5%FBS.

[323] *Signal Transduction Reporter Assays*

[324] The signal transduction reporter assays were done as follows: Following an 18h incubation at 37°C in DMEM + 0.5%FBS, transfected cells were stimulated with dilutions (in DMEM + 0.5%FBS) of the following class II ligands; IL-28A, IL-29, IL-28B, zcyto10, huIL10 and huIFNα-2a. Following a 4-hour incubation at 37°C, the cells were lysed, and the relative light units (RLU)

were measured on a luminometer after addition of a luciferase substrate. The results obtained are shown as the fold induction of the RLU of the experimental samples over the medium alone control (RLU of experimental samples/RLU of medium alone = fold induction). Table 29 shows that IL-28A, IL-29, and IL-28B induce ISRE signaling in 293 cells transfected with ISRE-luciferase giving a 15 to 17-fold induction in luciferase activity over medium alone. The addition of IL-28 receptor alpha subunit DNA (SEQ ID NO:11), using the endogenous CRF2-4 (SEQ ID NO:71) to the transfection mix results in a 6 to 8-fold further induction in ISRE signaling by IL-28A, IL-29, and IL-28B giving a 104 to 125-fold total induction. None of the other transfected class II cytokine receptor DNAs resulted in increased ISRE signaling. These results indicate that IL-28A, IL-29, and IL-28B functionally interact with the IL-28 cytokine receptor. Table 29 also shows that huIFNa-2a can induce ISRE signaling in ISRE-luciferase transfected 293 cells giving a 205-fold induction of luciferase activity compared to medium alone. However, the addition of IL-28 receptor DNA to the transfection leads to an 11-fold reduction in ISRE-signaling (compared to ISRE-luciferase DNA alone), suggesting that IL-28 receptor over-expression negatively effects interferon signaling, in contrast to the positive effects of IL-28 receptor over-expression on IL-28A, IL-29, and IL-28B signaling.

Table 29

Interferon Stimulated Response Element (ISRE) Signaling of Transfected 293 Cells Following Class
II Cytokine Stimulation (Fold Induction)

Ligand	ISRE-Luc.	ISRE-Luc./IL-28R
IL-28A (125ng/ml)	15	125
IL-29 (125ng/ml)	17	108
IL-28B (125ng/ml)	17	104
HuIFNa-2a (100ng/ml)	205	18
Zcyto10 (125ng/ml)	1.3	1
HuIL10 (100ng/ml)	1	0.5

Example 26Signal Transduction Assays with IL-29 Cysteine mutants**[325]** *Cell Transfections*

[326] To produce 293 HEK cells stably overexpressing human IL-28 receptor, 293 cells were transfected as follows: 300,000 293 cells/well (6 well plates) were plated approximately 6h prior to transfection in 2 milliliters DMEM + 10% fetal bovine serum. Per well, 2 micrograms of a pZP7 expression vector containing the cDNA of human IL-28 receptor alpha subunit (SEQ ID NO: 11) was added to 6 microliters Fugene 6 reagent (Roche Biochemicals) in a total of 100 microliters DMEM. This transfection mix was added 30 minutes later to the pre-plated 293 cells. Forty-eight hours later the transfected cells were placed under 2 microgram/milliliter puromycin selection. Puromycin resistant cells were carried as a population of cells.

[327] The 293 HEK cells overexpressing human IL-28 receptor were transfected as follows: 700,000 293 cells/well (6 well plates) were plated approximately 18h prior to transfection in 2 milliliters DMEM + 10% fetal bovine serum. Per well, 1 microgram KZ157 containing an interferon-stimulated response element (ISRE) driving transcription of a luciferase reporter gene were added to 3 microliters Fugene 6 reagent (Roche Biochemicals) in a total of 100 microliters DMEM. This transfection mix was added 30 minutes later to the pre-plated 293HEK cells. Forty-eight hours later the transfected cells were removed from the plate using trypsin-EDTA and replated in 500 micrograms/ml G418 (Geneticin, Life Technologies). Puromycin and G418 resistant cells were carried as a population of cells.

[328] *Signal Transduction Reporter Assays*

[329] The signal transduction reporter assays were done as follows: 293HEK cells overexpressing human IL-28 receptor and containing KZ157 were treated with trypsin-EDTA and

replated at approximately 25,000 cells/well in 96 well microtiter plates. Approximately 18 h prior to ligand stimulation, media was changed to DMEM + 0.5%FBS.

[330] Following an 18h incubation at 37°C in DMEM + 0.5%FBS, transfected cells were stimulated with dilutions (in DMEM + 0.5%FBS) of the different forms of *E.coli*-derived zcyto21 containing different cysteine binding patterns. Following a 4-hour incubation at 37°C, the cells were lysed, and the relative light units (RLU) were measured on a luminometer after addition of a luciferase substrate. The results obtained are shown as the fold induction of the RLU of the experimental samples over the medium alone control (RLU of experimental samples/RLU of medium alone = fold induction).

[331] Table 30 shows that C1-C3 form (C16-C113) of wild-type *E. coli*-derived IL-29 is better able to induce ISRE signaling than wild-type C3-C5 form (C113-C172) or a mixture of wild-type C1-C3 form and C3-C5 form (C16-C113, C113-C172), all referring to SEQ ID NO:15.

[332] Table 31 shows that C1-C3 (C16-C113) of wild-type *E. coli*-derived IL-29 and C1-C3 (C16-C113; SEQ ID NO:15) of Cysteine mutant (C172S) *E. coli*-derived IL-29 (SEQ ID NO:29) are equally able to induce ISRE signaling in 293HEK cells overexpressing human IL-28 receptor.

Table 30

ISRE Signaling by different forms of *E.coli*-derived IL-29 (Fold Induction)

Cytokine Concentration (ng/ml)	C1-C3 form (C16-C113)	C3-C5 form (C113-C172)	Mixture of C1-C3 and C3-C5
100	36	29	34
10	38	25	35
1	32	12	24
0.1	10	2	5
0.01	3	1	1
0.001	1	1	1

Table 31

ISRE Signaling by different forms of E.coli-derived IL-29 (Fold Induction)

Cytokine Concentration (ng/ml)	Wild-type C1-C3	Cysteine mutant C172S C1-C3
1000	9.9	8.9
100	9.3	8.7
10	9.3	8.1
1	7.8	7
0.1	4.6	3.3
0.01	1.9	1.5
0.001	1.3	0.9

Example 27Human IL-29 Effect on B-cells and IL-29 Toxic Saporin Fusion

[333] The effects of human IL-29 are tested on the following human B-cell lines: and human Burkitt's lymphoma cell lines Raji (ATCC No.CCL-86), and Ramos (ATCC No. CRL-1596); human EBV B-cell lymphoma cell line RPMI 1788 (ATCC No. CRL-156); human myeloma/plasmacytoma cell line IM-9 (ATCC No. CRL159); and human EBV transformed B-cell line DAKIKI (ATCC No. TIB-206), and HS Sultan cells (ATCC No. CRL-1484). Following about 2-5 days treatment with IL-29, changes in surface marker expression on the cells shows that these cells can respond to IL-29. Human B-cell lines treated with IL-29 grow much more slowly than untreated cells when replated in cell culture dishes. These cells also have an increased expression of FAS ligand, as assessed by flow cytometry (Example 27D and Example 27E), and moderately increased sensitivity to an activating FAS antibody (Example 27A). These results indicate that IL-29 could control some types of B-cell neoplasms by inducing them to differentiate to a less proliferative and or more FAS ligand sensitive state. Furthermore, IL-28 receptor is expressed on the surface of several B and T cell lines (Example 16). Thus, IL-29 and the human IL-29-saporin immunotoxin conjugate (Example 27B, below), or other IL-29-toxin fusion could be therapeutically used in B-cell leukemias and lymphomas.

[334] The effect of human IL-29 on B-cell lines

[335] IM-9 cells are seeded at about 50,000 cells per ml +/- 50 µg/ml purified human IL-29. After 3 days growth the cells are harvested, washed and counted then re-plated at about 2500 cells/ml in 96 well plates in to wells with 0, 0.033, 0.1 or 0.33 µg/ml anti-FAS antibody (R&D Systems,

Minneapolis). After 2 days an Alamar blue fluorescence assay is performed (See U.S. Patent No. 6,307,024) to assess proliferation of the cells.

[336] The growth of IL-29 treated IM-9 cells is inhibited relative to the growth of untreated cells in the absence of anti-FAS antibody. In the presence of 0.33 $\mu\text{g/ml}$ anti-FAS antibody, the IL-29-treated cells are even further inhibited.

[337] *The effect of human IL-29-saporin immunotoxin on B-cell lines*

[338] The human IL-29-saporin immunotoxin conjugate (IL-29-sap) construction and purification is described in Example 28. The human IL-29-sap was far more potent than the saporin alone in inhibiting cell growth. When the treated cell are re-plated after a three or four day treatment the human IL-29-sap treated cells grow very poorly.

[339] IM-9, Ramos and K562 (ATCC No. CCL-243) cells are seeded at about 2500 cells/well in 96 well plates with zero to 250 ng/ml human $\alpha\text{IL-29-sap}$ conjugate or 0-250 ng/ml saporin (Stirpe et al., *Biotechnology* 10:405-412, 1992) only as a control. The plates are incubated 4 days then an Alamar Blue proliferation assay is performed (U.S. Patent No. 6,307,024). At the maximal concentration of human IL-29-sap conjugate, the growth of cells is inhibited. Cells lines low/negative by flow for expression of the IL-28 receptor are not affected by the IL-29-sap, thus showing the specificity of the conjugate's effect.

[340] IM-9 cells are seeded a 50,000 cells/ml into 6 well plates at zero and 50 ng/ml human $\alpha\text{IL-29-sap}$ conjugate. After 3 days the cells are harvested and counted then re-plated from 100 to 0.8 cells per well in 2 fold serial dilutions, and 12 wells per cell dilution without the human IL-29-saporin immunotoxin. After 6 days the number of wells with growth at each cell dilution is scored according to the results of an Alamar blue proliferation assay.

[341] When cell number is assessed by Alamar blue assay the growth of the surviving treated IM-9 cells is markedly impaired even after the removal, by re-plating, of the IL-29-sap immunotoxin.

[342] The limited tissue distribution of the human IL-28 receptor, and the specificity of action of the IL-29-sap to receptor-expressing cell lines suggest that this conjugate may be tolerated *in vivo*.

[343] *The effect of human IL-29-saporin immunotoxin on B-cell line viability*

[344] HS Sultan cells (ATCC No. CRL-1484) are seeded at about 40,000 cells per ml into 12 well plates and grown for five days with either no added cytokines or 40 ng/ml purified human IL-29 or 25 ng/ml human IL-29-sap conjugate (Example 28, below) or with 20 ng/ml IFN-alpha (RDI) or IL-29 and IFN-alpha. IL-29 and IFN-alpha inhibit the outgrowth of the cells indicating that the growth inhibitory effects of human IL-29 and IFN-alpha may be additive.

[345] The results above support the possible use of IL-29 or human IL-29-sap in the treatment of malignancies or other diseases that express the IL-28 receptor, particularly those of B-cell origin. The combination of IL-29 with IFN-alpha is specifically suggested by their additive effect in the inhibition of HS Sultan cells. Some other types of lymphoid malignancies and diseases may also express the IL-28 receptor, as activated T-cells also express the receptor mRNA and some of these diseases may also be responsive to IL-29 or IL-29-toxic fusion therapy.

[346] *FAS (CD95) Expression on Human B-cell Lines is Increased by human IL-29 Stimulation*

[347] Human B-cell lines HS Sultan (ATCC No. CRL-1484), IM-9 (ATCC No. CRL159), RPMI 8226 (ATCC No. CCL-155), RAMOS (ATCC No. CRL-1596), DAKIKI (ATCC No. TIB-206), and RPMI 1788 (ATCC No. CRL-156), are all treated with or without purified 10 to 50 ng/ml human IL-29 for 2 to 8 days. The cells are then stained with anti-CD95 PE-conjugated antibody (PharMingen, San Diego, CA), per manufacturer's protocol, and analyzed on a FACScalibur (Becton Dickinson, San Jose, CA). In all cell lines, anti-CD95 (FAS or APO-1) staining is increased upon treatment with human IL-29.

[348] *FAS (CD95) Expression on Primary Mouse Spleen B-cells is Increased by Human IL-29 Stimulation*

[349] Primary mouse splenocytes are obtained by chopping up spleens from 8 to 12 week old C57/BL6 mice. Erythrocytes are lysed by treating the preparation for 5 seconds with water then put through a 70 micron sieve. The remaining splenocytes are washed and plated in RPMI (JRH Bioscience) plus 10% HIA-FBS (Hyclone, Logan, UT). IL-2 (R & D Systems) with or without human IL-29, as described above. They were then incubated at 37°C, in 5% CO₂ for 5 days. The splenocytes were harvested and stained with anti-CD95 PE conjugated antibody (PharMingen) and anti-CD19 FITC conjugated antibody (PharMingen) per manufacturer's protocol. The cells are analyzed by flow cytometry on a FACScalibur (Becton Dickinson).

Example 28

Construction and Purification of IL-29 Toxic Fusion

[350] Ten mg human IL-29 is conjugated to the plant toxin saporin (Stirpe et al., *Biotechnology* 10,:405-412, 1992). The resulting 1.3 mg of a protein conjugate is comprised of 1.1 molecules saporin per molecule of human IL-29, formulated at a concentration of 1.14 mg/ml in 20 mM Sodium phosphate, 300 mM sodium chloride, pH 7.2.

Example 29

IL-29 Toxic Fusion *in vivo***[351]** *Testing IL-29-saporin conjugate in mice*

[352] IL-29-saporin conjugate (Example 27) is administered to C57BL6 mice (female, 12 weeks of age, purchased from Taconic) at two different dosages: 0.5 and 0.05 mg/kg. Injections are given i.v. in vehicle consisting of 0.1% BSA (ICN, Costa Mesa, CA). Three injections are given over a period of one week (day 0, 2, and 7). Blood samples are taken from the mice on day 0 (pre-injection) and on days 2 and 8 (post-injection). Blood is collected into heparinized tubes (Bectin Dickenson, Franklin Lakes, NJ), and cell counts are determined using an automated hematology analyzer (Abbot Cell-Dyn model No. CD-3500CS, Abbot Park, IL). Animals are euthanized and necropsied on day 8 following blood collection. Spleen, thymus, liver, kidney and bone marrow are collected for histopathology. Spleen and thymus are weighed, and additional blood sample is collected in serum separator tubes. Serum is tested in a standard chemistry panel. Samples are also collected for flow cytometric analysis as described herein.

[353] *Testing IL-29 toxic saporin fusion on B-cell derived tumors in vivo*

[354] The effects of human IL-29 and the human IL-29 toxic saporin fusion (Example 28) on human tumor cells are tested *in vivo* using a mouse tumor xenograft model described herein. The xenograft models are initially tested using cell lines selected on the basis of *in vitro* experiments, such as those described in Example 27. These cell lines include, but are not limited to: human Burkitt's lymphoma cell lines Raji (ATCC No. CCL-86), and Ramos (ATCC No. CRL-1596); human cell line RPMI 1788 (ATCC No. CRL-156); human myeloma/plasmacytoma cell line IM-9 (ATCC No. CRL159); human cell line DAKIKI (ATCC No. TIB-206), and HS Sultan cells (ATCC No. CRL-1484). Cells derived directly from human tumors can also be used in this type of model. In this way, screening of patient samples for sensitivity to treatment with IL-29 or with a IL-29 toxic saporin fusion can be used to select optimal indications for use of $\alpha 11$ in anti-cancer therapy.

[355] After selection of the appropriate xenograft *in vivo* model, described above, IL-29-induced activity of natural killer cells and/or IL-29 effects on B-cell derived tumors is assessed *in vivo*. Human IL-29 is tested for its ability to generate cytotoxic effector cells (e.g., NK cells) with activity against B-cell derived tumors using mouse tumor xenograft models described herein. Moreover, direct effects of human IL-29 on tumors can be assessed. The xenograft models to be carried out are selected as described above. A protocol using IL-29 stimulated human cells is developed and tested for efficacy in depleting tumor cells and promoting survival in mice inoculated with cell lines or primary tumors.

Example 30IL-29 Effect on B-cell Derived Tumors *in vivo*

[356] *Infusion of IL-29 using mini-osmotic pumps*

[357] Administration of IL-29 by constant infusion via mini-osmotic pumps results in steady state serum concentrations proportional to the concentration of the IL-29 contained in the pump. 0.22 ml of human IL-29 contained in phosphate buffered saline (pH 6.0) at a concentration of 2 mg/ml or 0.2 mg/ml is loaded under sterile conditions into Alzet mini-osmotic pumps (model 2004; Alza corporation Palo Alto, CA). Pumps are implanted subcutaneously in mice through a 1 cm incision in the dorsal skin, and the skin is closed with sterile wound closures. These pumps are designed to deliver their contents at a rate of 0.25 μ l per hour over a period of 28 days. This method of administration results in significant increase in survival in mice injected with tumor cells (below).

[358] *IL-29 effect on B-cell derived tumors in vivo*

[359] The effects of human IL-29 are tested *in vivo* using a mouse tumor xenograft model described herein. The xenograft model to be tested is human lymphoblastoid cell line IM-9 (ATCC No. CRL159). C.B-17 SCID mice (female C.B-17/IcrHsd-scid; Harlan, Indianapolis, Indiana) are divided into 4 groups. On day 0, IM-9 cells (ATCC No. CRL159) are harvested from culture and injected intravenously, via the tail vein, to all mice (about 1,000,000 cells per mouse). On day 1, mini-osmotic pumps containing test article or control article are implanted subcutaneously in the mice. Mice in groups 1-3 (n=9 per group) are treated with increasing concentrations of IL-29: group 1 contains 2.0 mg/mL of human IL-29 and is delivered 12 μ g per day; group 2 contains 0.20 mg/mL of human IL-29 and is delivered 1.2 μ g per day; group 3 contained 0.02 mg/mL of human IL-29 and is delivered 0.12 μ g per day. Mice in group 4 (n = 9) are a control and are treated with vehicle (PBS pH 6.0).

[360] Mice treated with either 12 μ g/day or 1.2 μ g/day IL-29 infusion have increased survival compared to vehicle treated mice ($p < .0001$ and $p < .005$ for 12 μ g/day or 1.2 μ g/day vs. vehicle, respectively, using log rank tests of the survival function). These results show that IL-29 significantly reduced the effects of the B-cell tumor cells *in vivo*, significantly resulting in increased survival.

Example 31

In vivo Anti-tumor Effects of IL-29 in B16-F10 Melanoma and EG.7 Thymoma Models

[361] *Murine IL-29 effect on B16-F10 melanoma metastasis growth in vivo*

[362] Mice (female, C57Bl6, 9 weeks old; Charles River Labs, Kingston, NY) are divided into three groups. On day 0, B16-F10 melanoma cells (ATCC No. CRL-6475) are harvested from culture and injected intravenously, via the tail vein, to all mice (about 100,000 cells per mouse). Mice are then treated with the test article or associated vehicle by intraperitoneal injection of 0.1 ml of the indicated solution. Mice in the first group (n = 24) are treated with vehicle (PBS pH 6.0), which is

injected on day 0, 2, 4, 6, and 8. Mice in the second group ($n = 24$) are treated with zcyto24 or zcyto25, which is injected at a dose of $75 \mu\text{g}$ on day 0, 2, 4, 6, and 8. Mice in the third group ($n = 12$) are treated with zcyto24 or zcyto25, which is injected at a dose of $75 \mu\text{g}$ daily from day 0 through day 9. All of the mice are sacrificed on day 18, and lungs are collected for quantitation of tumor. Foci of tumor growth greater than 0.5 mm in diameter are counted on all surfaces of each lung lobe. In both groups of mice treated with zcyto24 or zcyto25, the average number of tumor foci present on lungs is significantly reduced, compared to mice treated with vehicle. Mice treated more frequently (i.e. daily) have fewer tumor foci than mice treated on alternate days.

[363] These results indicated that treatment with zcyto24 or zcyto25 either slowed the growth of the B16 melanoma tumors or enhanced the ability of the immune system to destroy the tumor cells. The effects of the treatment on tumor cells are likely mediated through cells of the immune system which do possess receptors for IL-29.

[364] *Murine IL-29 effect on EG.7 thymoma growth in vivo*

[365] Mice (female, C57Bl6, 9 weeks old; Charles River Labs, Kingston, NY) are divided into three groups. On day 0, EG.7 cells (ATCC No. CRL-2113) are harvested from culture and 1,000,000 cells are injected intraperitoneal in all mice. Mice are then treated with the test article or associated vehicle by intraperitoneal injection of 0.1 mL of the indicated solution. Mice in the first group ($n = 6$) are treated with vehicle (PBS pH 6.0), which is injected on day 0, 2, 4, and 6. Mice in the second group ($n = 6$) are treated with zcyto24 or zcyto25, which is injected at a dose of $10 \mu\text{g}$ on day 0, 2, 4, and 6. Mice in the third group ($n = 6$) are treated with zcyto24 or zcyto25, which is injected at a dose of $75 \mu\text{g}$ on day 0, 2, 4, and 6. In both groups of mice treated with zcyto24 or zcyto25, time of survival is significantly increased, compared to mice treated with vehicle. These results indicate that treatment with zcyto24 or zcyto25 either slowed the growth of the EG.7 tumors or enhanced the ability of the immune system to destroy the tumor cells.

Example 32

Flow Cytometric Analysis IL-28 Receptor Expression.

[366] The expression of IL-28 receptors on neoplastic B cells derived from non-Hodgkin's lymphoma (NHL) specimens is assessed. Multiple MAbs are used to identify neoplastic B cells and to co-localize IL-28 receptors. The immunofluorescent staining by anti-IL-28 receptor MAb or by biotin-IL-29 is recorded as mean peak fluorescence. The qualitative scores are assessed based on the shift in mean peak fluorescence relative to an isotype matched control MAb.

[367] Anti-IL-28 receptor MAb or biotin-IL-29 is used to detect IL-28 receptor on the neoplastic B cells by immunofluorescent staining. The intensity of the staining signal correlates to the

levels of IL-28 receptor. These data suggests that IL-28 receptors represent a therapeutic target for non Hodgkin's lymphoma.

Example 33

In vivo Effects of IL-29 on B-cell lymphomas

[368] Human B-lymphoma cell lines are maintained *in vitro* by passage in growth medium. The cells are washed thoroughly in PBS to remove culture components.

[369] SCID Mice are injected with (typically) one million human lymphoma cells via the tail vein in a 100 microliter volume. The optimal number of cell injected is determined empirically in a pilot study to yield tumor take consistently with desired kinetics. IL-29 treatment is begun the next day by either subcutaneous implantation of an ALZET® osmotic mini-pump (ALZET, Cupertino, CA) or by daily i.p. injection of IL-29 or vehicle. Mice are monitored for survival and significant morbidity. Mice that lose greater than 20% of their initial body weight are sacrificed, as well as mice that exhibit substantial morbidity such as hind limb paralysis. Depending on the lymphoma cell line employed, the untreated mice typically die in 3 to 6 weeks. For B cell lymphomas that secrete IgG or IgM, the disease progression can also be monitored by weekly blood sampling and measuring serum human Immunoglobulin levels by ELISA.

[370] IL-29 Dose response/ IM-9 model

[371] Mice are injected with 1×10^6 IM-9 cells, and 28 day osmotic mini pumps implanted the following day. The pumps are loaded with the following concentrations of IL-29 to deliver: 0, 0.12, 1.2 or 12 micrograms per day with 8 mice per dose group. IL-29 exhibits a clear dose dependent effect in protecting mice from the tumor cell line. The effects of IL-29 are dose dependent. Surviving mice at the end of the experiment have no signs of disease and no detectable human IgG in their serum.

[372] These data demonstrate that the efficacy of IL-29 in SCID mouse lymphoma models correlates with the ability to inhibit the growth of the lymphoma cell lines *in vivo*.

Example 34

The Effects of IL-29 in a Mouse Syngeneic Ovarian Carcinoma Model

[373] The effect of IL-29 is tested for efficacy in ovarian carcinoma using a mouse syngeneic model as described in Zhang et al., Am. J. of Pathol. 161:2295-2309, 2002. Briefly, using retroviral transfection and fluorescence-activated cell sorting a C57BL6 murine ID8 ovarian carcinoma cell line is generated that stably overexpresses the murine VEGF164 isoform and the enhanced green fluorescence protein (GFP). The retroviral construct containing VEGF164 and GFP

cDNAs was transfected into BOSC23 cells. The cells are analyzed by FACS cell sorting and GFP high positive cells are identified.

[374] The ID8 VEGF164/GFP transfected cells are cultured to subconfluence and prepared in a single-cell suspension in phosphate buffer saline (PBS) and cold MATRIGEL (BD Biosciences, Bedford, MA). Six to eight week old femal C57BL6 mice are injected subcutaneously in the flank at 5×10^6 cells or untransfected control cells. Alternatively, the mice can be injected intraperitoneally at 7×10^6 cells or control cells. Animals are either followed for survival or sacrificed eight weeks after inoculation and evaluated for tumor growth. Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be administered on a daily basis for 5-14 days, and may be continued thereafter if no evidence of neutralizing antibody formation is seen.

Example 35

The Effects of IL-29 in a Mouse RENCA Model

[375] The efficacy of IL-29 in a renal cell carcinoma model is evaluated using BALB/c mice that have been injected with RENCA cells, a mouse renal adenocarcinoma of spontaneous origin, essentially as described in Wigginton et al., *J. Nat. Cancer Instit.* 88:38-43, 1996.

[376] Briefly, BALB/c mice between eight and ten weeks are injected with RENCA cells 1×10^5 cells into the kidney capsule of the mice. Twelve days after tumor cell implantation, the mice are nephrectomized to remove primary tumors. The mice are allowed to recover from surgery, prior to administration of IL-29. Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be administered on a daily basis for 5-14 days, and may be continued thereafter if no evidence of neutralizing antibody formation is seen. Alternatively, RENCA cells may be introduced by subcutaneous (5×10^5 cells) or intravenous (1×10^5 cells) injection.

[377] The mice are evaluated for tumor response as compared to untreated mice. Survival is compared using a Kaplan-Meier method, as well as tumor volume being evaluated.

Example 36

The Effects of IL-29 in a Mouse Colorectal Tumor Model

[378] The effects of IL-29 in a colorectal mouse model are tested as described in Yao et al., *Cancer Res.* 63:586-592, 2003. In this model, MC-26 mouse colon tumor cells are implanted into the splenic subcapsul of BALB/c mice. After 14 days, the treated mice are administered IL-29. Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be

administered on a daily basis for 5-14 days, and may be continued thereafter if no evidence of neutralizing antibody formation is seen.

[379] The efficacy of IL-29 in prolonging survival or promoting a tumor response is evaluated using standard techniques described herein.

Example 37

The Effect of IL-29 in a Mouse Pancreatic Cancer Model

[380] The efficacy of IL-29 in a mouse pancreatic cancer model is evaluated using the protocol developed by Mukherjee et al., *J. Immunol.* **165**:3451-3460, 2000. Briefly, MUC1 transgenic (MUC1.Tg) mice are bred with oncogene-expressing mice that spontaneously develop tumors of the pancreas (ET mice) designated as MET. MUC1.Tg mice. ET mice express the first 127 aa of SV40 large T Ag under the control of the rat elastase promoter. Fifty percent of the animals develop life-threatening pancreatic tumors by about 21 wk of age. Cells are routinely tested by flow cytometry for the presence of MUC1. All mice are on the C57BL/6 background. Animals are sacrificed and characterized at 3-wk intervals from 3 to 24 wk. Mice are carefully observed for signs of ill-health, including lethargy, abdominal distention, failure to eat or drink, marked weight loss, pale feces, and hunched posture.

[381] The entire pancreas is dissected free of fat and lymph nodes, weighed, and spread on bibulus paper for photography. Nodules are counted, and the pancreas is fixed in methacarn, processed for microscopy by conventional methods, step sectioned at 5 μ m (about 10 sections per mouse pancreas), stained with hematoxylin and eosin, and examined by light microscopy. Tumors are obtained from MET mice at various time points during tumor progression, fixed in methacarn (60% methanol, 30% chloroform, 10% glacial acetic acid), embedded in paraffin, and sectioned for immunohistochemical analysis. MUC1 antibodies used are CT1, a rabbit polyclonal Ab that recognizes mouse and human cytoplasmic tail region of MUC1, HMFG-2, BC2, and SM-3, which have epitopes in the TR domain of MUC1.

[382] Determination of CTL activity is performed using a standard ^{51}Cr release method after a 6-day in vitro peptide stimulation without additional added cytokines. Splenocytes from individual MET mice are harvested by passing through a nylon mesh followed by lysis of RBC.

[383] Single cells from spleens of MET mice are analyzed by two-color immunofluorescence for alterations in lymphocyte subpopulations: CD3, CD4, CD8, Fas, FasL, CD11c, and MHC class I and II. Intracellular cytokine levels were determined after cells are stimulated with MUC1 peptide (10 μ g/ml for 6 days) and treated with brefeldin-A (also called Golgi-Stop; PharMingen) as directed by the manufacturer's recommendation (4 μ l/1.2 $\times 10^7$ cells/6 ml for 3 h at 37°C before staining). Cells are permeabilized using the PharMingen permeabilization kit and stained for intracellular IFN- γ , IL-2, IL-4, and IL-5 as described by PharMingen. All fluorescently

labeled Abs are purchased from PharMingen. Flow cytometric analysis is done on Becton Dickinson FACScan using the CellQuest program (Becton Dickinson, Mountain View, CA).

[384] Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be administered on a daily basis for 5-14 days, and may be continued thereafter if no evidence of neutralizing antibody formation is seen.

Example 38

The Effects of IL-29 in a Murine Breast Cancer Model

[385] The efficacy of IL-29 in a murine model for breast cancer is made using a syngeneic model as described in Colombo et al., Cancer Research 62:941-946, 2002. Briefly, TS/A cells which are a spontaneous mammary carcinoma for BALB/C mice. The cells are cultured for approximately one week to select for clones. The selected TS/A cells are grown and used to challenge CD-1 *nu/nu* BR mice (Charles River Laboratories) by injected 2×10^2 TS/A cells subcutaneously into the flank of the mouse.

[386] Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be administered on a daily basis for 5-14 days, and may be continued thereafter if no evidence of neutralizing antibody formation is seen. The tumors are excised after sacrificing the animals and analyzed for volume and using histochemistry and immunohistochemistry.

Example 39

The Effects of IL-29 in a Murine Prostate Cancer Model

[387] The effects of IL-29 on tumor response are evaluated in murine prostate cancer model, using a model similar to that described in Kwon et al., PNAS 96:15074-15079, 1999. In this model, there is a metastatic outgrowth of transgenic adenocarcinoma of mouse prostate (TRAMP) derived prostate cancer cell line TRAMP-C2, which are implanted in C57BL/6 mice. Metastatic relapse is reliable, occurring primarily in the draining lymph nodes in close proximity to the primary tumor.

[388] Briefly, the C2 cell line used is an early passage line derived from the TRAMP mouse that spontaneously develops autochthonous tumors attributable to prostate-restricted SV40 antigen expression. The cells are cultured and injected subcutaneously into the C57BL/6 mice at $2.5-5 \times 10^6$ cells/0.1 ml media. Mice are treated with recombinant zcyto24 or zcyto25 beginning 3-14 days following tumor implantation, or when tumor engraftment and growth rate is established. Treatment levels of 0.5 - 5 mg/kg will be administered on a daily basis for 5-14 days, and may be continued

thereafter if no evidence of neutralizing antibody formation is seen. The tumors are excised after sacrificing the animals and analyzed for volume and using histochemistry and immunohistochemistry.

Example 40

The Effects of IL-28 and IL-29 in the Murine Experimental Allergic Encephalomyelitis (EAE) Model

[389] Experimental allergic encephalomyelitis (EAE) is a mouse model for human Multiple Sclerosis (MS) (Gold et al., *Mol. Med. Today*, 6:88-91, 2000; Anderton et al., *Immunol. Rev.*, 169:123-137, 1999). There are multiple ways of inducing disease in mice. One such method is to immunize mice with a peptide of the myelin protein myelin oligodendrocyte glycoprotein (MOG). This protein is present on the outside of the myelin sheath and acts as a protective layer for myelin. Mice were immunized sub-cutaneously with MOG peptide (MOG35-55) emulsified in RIBI adjuvant on day 0. Mice were then injected intravenously with pertussis toxin (PT) on day 2. The mice started showing symptoms of paralysis starting with a limp tail, wobbly motion, followed by hind limb and forelimb paralysis, which were scored according to several different parameters that measured the timing, extent and severity of disease. Delay in onset of disease indicates that the drug is modifying the disease process in mice. Decrease in incidence indicates that the drug is having an effect on the number of mice that are getting sick. Decrease in clinical score indicates that the drug has an effect on the severity of disease. Groups of mice were given PBS or either mouse IL28 (SEQ ID NO:8) or human IL29C172S (SEQ ID NO:29)-PEG. The onset of symptoms, incidence of disease scores and severity of disease scores in IL-28/29 treated mice indicates the effect of IL-28/29 on these parameters in this model. Mice (n=13/gp) were immunized s.c with 100ug MOG35-55 in RIBI adjuvant on d0. All mice received 200ng pertussis toxin i.v on d2. Groups of mice were treated i.p with PBS, 25ug human IL29C172S every other day (EOD) on days 1-18 or with PBS, BSA or mouse IL28. As specified above, mice were scored for clinical signs and weight loss daily from d0-d30. IL29 C172S(SEQ ID NO:29)-PEG or mouse IL28 (SEQ ID NO:8) treated mice showed a delay in the onset of disease compared to PBS treated animals.

Table 32

Treatment groups D0-18 (EOD)	Mean Day of Onset (MDO)	P value (vs PBS group) Mantel-Cox test
PBS	21.1 ± 4.7	-
25ug human IL29 C172S- PEG	28.8 ± 4.5	0.0006

Table 33

Treatment groups Days 1-21 EOD	Mean Day of Onset (MDO)	P value (vs PBS group) Mantel-Cox test
PBS	8.6 ± 1.6	-
130ug BSA	8.6 ± 1.3	NS
130ug mIL28	12.2 ± 3.3	P=0.0009 (PBS) P=0.001 (BSA)

Table 34

Treatment groups Days 1-11 EOD	Mean Day of Onset (MDO)	P value (vs PBS group) Mantel-Cox test
PBS	9.5 ± 2.5	-
50ug mIL28	12.4 ± 3.8	P=0.0354
200ug mIL28	13.5 ± 3.2	P=0.0007

[390] IL-29 delays onset of disease in a mouse model for multiple sclerosis

[391] *Summary*

[392] To test if human IL-29 had any effects on multiple sclerosis, the ability of IL-29 to inhibit experimental autoimmune encephalomyelitis (EAE), a mouse model for MS was tested. The well characterized myelin oligodendrocyte glycoprotein (MOG) 35-55 peptide immunization model in C57BL/6 mice was used. The experiment was run to determine that IL-29 could delay and/or inhibit disease scores in EAE. IL-29 delayed onset of disease in the EAE model, suggesting that use of IL-29 may be beneficial in MS.

[393] *Study design*

[394] Experimental autoimmune encephalomyelitis (EAE) is a mouse model for MS. In one such model, C57BL/6 mice are immunized with 100 µg MOG peptide (MOG35-55) emulsified in RIBI adjuvant. Two milliliters of a 0.5 mg/ml preparation of the MOG35-55 in PBS was added to a vial of RIBI and vortexed vigorously to emulsify the solution. The backs of mice were shaved and 100 µg MOG/RIBI was injected s.c in the backs of mice. Weights of mice were taken 2 days before and every day after the immunization. Mice were then injected on day 2 i.v with 200 µl pertussis toxin (PT), a final concentration of 200 ng/mouse. Mice were monitored daily for clinical scores. Groups of mice were injected i.p. with 200 µl PBS, or 25ug IL-29 C172S(SEQ ID NO:29)-PEG in a 200 µl volume EOD from days 0-18. The weights of mice, clinical scores and incidence were evaluated and plotted for analysis.

[395] *Results and conclusion*

[396] Administration of IL-29 EOD from days 0-18 delayed onset of disease in this model. This delay was significant compared to PBS treated mice ($p=0.0006$, Mantel-Cox test).

[397] IL-28 delays onset of disease in a mouse model for multiple sclerosis

[398] *Summary*

[399] To test if mouse IL-28 had any effects on multiple sclerosis, the ability of IL-28 to inhibit experimental autoimmune encephalomyelitis (EAE), a mouse model for MS was tested. The well characterized myelin oligodendrocyte glycoprotein (MOG) 35-55 peptide immunization model in C57BL/6 mice was used. The experiment was run to determine that IL-28 could delay and/or inhibit disease scores in EAE. IL-28 delayed onset of disease in the EAE model, suggesting that use of IL-28 may be beneficial in treatment of MS.

[400] *Study design*

[401] Experimental autoimmune encephalomyelitis (EAE) is a mouse model for MS. In one such model, C57BL/6 mice are immunized with 100 μ g MOG peptide (MOG35-55) emulsified in RIBI adjuvant. Two milliliters of a 0.5 mg/ml preparation of the MOG35-55 in PBS was added to a vial of RIBI and vortexed vigorously to emulsify the solution. The backs of mice were shaved and 100 μ g MOG/RIBI was injected s.c in the backs of mice. Weights of mice were taken 2 days before and every day after the immunization. Mice were then injected on day 2 i.v with 200 μ l pertussis toxin (PT), a final concentration of 200 ng/mouse. Mice were monitored daily for clinical scores. In one experiment groups of mice were injected i.p. with 200 μ l PBS, 50ug mL28 or 200ug mL28 (SEQ ID NO:8) in a 200 μ l volume EOD from days 1-11. In a second experiment groups of mice were injected i.p. with 200 μ l PBS, 130ug BSA or 130ug mL28 (SEQ ID NO:8) in a 200 μ l volume EOD from days 1-21. The weights of mice, clinical scores and incidence were evaluated and plotted for analysis.

[402] *Results and conclusion*

[403] Administration of IL-28 EOD delayed onset of disease in this model in a dose dependent manner. This delay was significant compared to PBS or BSA treated mice.

Example 41

IL-29 and IFN α 2a MicroArray Comparison in Hepatoma Cell Line HepG2

[404] *Introduction*

[405] Type 1 interferons (IFNs) are induced following viral infection as part of the body's immune response to the virus. These proteins inhibit viral replication through the induction of interferon-stimulated genes (ISGs) that act to directly inhibit viral replication, increase the lytic potential of NK cells (Biron, C. A. 1998. Role of early cytokines, including alpha and beta interferons (IFN-alpha/beta), in innate and adaptive immune responses to viral infections. *Semin Immunol* 10:383-90) and modulate the adaptive immune response by increasing MHC class I expression to promote antigen presentation (Fellous, M., Nir, U., Wallach, D., Merlin, G., Rubinstein, M., and Revel, M. 1982. Interferon-dependent induction of mRNA for the major histocompatibility antigens in human fibroblasts and lymphoblastoid cells. *Proc Natl Acad Sci U S A* 79:3082-6), promoting T cell survival (Marrack, P., Kappler, J., and Mitchell, T. 1999. Type I interferons keep activated T cells alive. *J Exp Med* 189:521-30) and stimulating dendritic cell maturation (Buelens, C., Bartholome, E. J., Amraoui, Z., Boutriaux, M., Salmon, I., Thielemans, K., Willems, F., and Goldman, M. 2002. Interleukin-3 and interferon beta cooperate to induce differentiation of monocytes into dendritic cells with potent helper T-cell stimulatory properties. *Blood* 99:993-8). Because of this profound effect on the viral lifecycle, IFN α 2a has proved to be a valuable therapeutic agent for the treatment of Hepatitis C.

[406] In addition to the type I interferons, viral infection induces the production of IL-28 and IL-29 (IFN λ 1-3), a recently discovered family of novel class II cytokines distantly related to IFN α and IL-10. Like the Type 1 IFNs IL28/29 have antiviral activity against a number of viruses (Sheppard, P. et al., 2003. IL-28, IL-29 and their class II cytokine receptor IL-28R. *Nat Immunol* 4:63-8; Kotenko, S. V. et al., 2003. IFN-lambdas mediate antiviral protection through a distinct class II cytokine receptor complex. *Nat Immunol* 4:69-77; and Robek, M. D. et al., 2005. Lambda interferon inhibits hepatitis B and C virus replication. *J Virol* 79:3851-4). We and others have previously shown that IL-29 induces the ISGs Mx1, PRKR and OAS in primary human hepatocytes as well as human hepatoma cell lines such as HuH7 and HepG2. Therefore IL28/29 may regulate biology similar to IFN α 2a and have therapeutic value against chronic viral hepatitis in human patients. However, IL-29 and IFN α utilize distinct receptors making it possible that these two cytokines could potentially regulate other cytokine-specific genes subsets and biological processes. It was therefore of interest to compare the gene regulation profiles of these two cytokines on a global scale. Accordingly, HepG2 cells were treated with IL-29 and IFN α 2a for varying times prior to isolation of total RNA and analysis of gene regulation using DNA microarray analysis.

[407] Study Design

[408] To identify genes regulated by IL-29 and IFN α 2a in hepatocytes, microarray experiments were performed on the hepatoma cell line HepG2. For these studies triplicate cultures of HepG2 cells were treated with media as a negative control, 50 μ g/ml human IL-29 (SEQ ID NO:4) or

5 µg/ml human IFNα2a for one, six or twenty-four hours. Following stimulation, total RNA was extracted using the RNeasy Mini kit from QIAGEN and RNA quality and quantity were assessed on an Agilent 2100 Bioanalyzer using the RNA 6000 Nano Assay (Agilent) according to the manufacturers instructions. Briefly, biotin-labeled cRNAs were synthesized using the GeneChip® One-Cycle Target Labeling and Control Reagents from Affymetrix. Fragmented cRNA for each sample was hybridized to Affymetrix Human Genome Focus Arrays and stained according to the manufacturer's instructions. Arrays were then scanned on an Affymetrix GeneChip® Scanner 3000 and raw data generated using Affymetrix GeneChip® Operating Software (GCOS) data mining software. Raw data was then loaded into the GeneSpring 7.0 microarray analysis program (Silicon Genetics) for data analysis purposes. Values of less than 0.01 were transformed to a value of 0.01. The intensity of each array was normalized to the 50th percentile for all arrays using all values not absent and having a raw value of 50 or greater. Values on a per gene basis were normalized to the median calculated for values with a raw value of 50 or greater on all arrays. Scatter plots were generated using unfiltered data. Genes regulated by IL-29 were identified as having a 1-way analysis of variance (ANOVA) *p*-value of less than or equal to 0.05, a raw intensity in IL-29-treated samples of 600 (three times the background) or greater and a fold change of 2 or greater as compared to the media-treated sample at the corresponding time point. The most profound induction of genes was observed at the six-hour time point.

[409] *Results and Discussion*

[410] Upon analyzing the microarray results it was apparent that gene regulation by both IL-29 and IFNα2a in HepG2 cells was transient, peaking at six hours followed by a gradual decline. After comparing the data from the IL-29-treated sample to the data from the IFNα2a-treated sample all genes were found to be regulated similarly by the two cytokines indicating that IL-29 and IFNα2a regulate identical gene subsets in hepatocytes. However, the degree of induction by IFNα2a in HepG2 cells was more profound than that elicited by IL-29. The list of all genes identified as upregulated by IL-29 as determined by the criteria listed in the Study Design is listed below in Table 35. These genes were found to consist exclusively of known interferon-stimulated genes (ISGs) coding for proteins involved in antiviral responses (OAS genes, MX genes and PRKR, ADAR), regulation of proliferation (IFITM1, IFITM3, CEB1), apoptosis (TNFSF10) and signal transduction (NMI, STAT1, IRF9). These data suggest that IL-29 mediates biology identical to that regulated by the type 1 interferons in cells such as hepatocytes that express the IL-28 receptor.

Table 35

Gene Name	Description	Unigene ID	IFN Fold Change	IL-29 Fold Change
IFI1	interferon-induced protein with tetratricopeptide repeats 1	Hs.20315	384.1	198.1
IFI27	interferon, alpha-inducible protein 27	Hs.532634	221.5	91.96
OAS2	2'-5' oligoadenylate synthetase 2	Hs.414332	92.73	40.91
MX1	myxovirus (influenza virus) resistance 1	Hs.517307	81.47	42.44
G1P3	interferon, alpha-inducible protein (clone IFI-6-16)	Hs.523847	38.48	32.87
CEB1	cyclin-E binding protein 1	Hs.26663	34.09	4.526
IFIT3	interferon-induced protein with tetratricopeptide repeats 3	Hs.47338	33.06	12.58
OAS1	2',5'-oligoadenylate synthetase 1	Hs.524760	26.78	13.1
OASL	2'-5'-oligoadenylate synthetase-like	Hs.118633	25.87	8.516
OAS3	2'-5'-oligoadenylate synthetase 3	Hs.528634	23.15	10.83
MDA5	melanoma differentiation associated protein-5	Hs.163173	22.7	7.423
G1P2	interferon, alpha-inducible protein (clone IFI-15K)	Hs.458485	22.49	13.6
DDX58	DEAD (Asp-Glu-Ala-Asp) box polypeptide 58	Hs.190622	21.63	8.265
APOL6	apolipoprotein L, 6	Hs.257352	18.16	7.865
HSXIAPAF1	XIAP associated factor-1	Hs.441975	15.2	7.96
NMI	N-myc (and STAT) interactor	Hs.54483	13.85	3.855
PLSCR1	phospholipid scramblase 1	Hs.130759	11.64	6.899
UBE2L6	ubiquitin-conjugating enzyme E2L 6	Hs.425777	11.21	4.463
SP110	SP110 nuclear body protein	Hs.145150	10.94	4.551
USP18	ubiquitin specific protease 18	Hs.38260	10.83	4.357
ISGF3G	interferon regulatory factor 9	Hs.1706	10.44	7.496
STAT1	signal transducer and activator of transcription 1, 91kDa	Hs.470943	9.701	5.565
SP100	Nuclear antigen Sp100	Hs.369056	9.328	3.567
PSMB9	proteasome (prosome, macropain) subunit, beta type, 9	Hs.381081	9.227	3.128
TNFSF10	tumor necrosis factor superfamily, member 10 (TRAIL)	Hs.478275	8.819	3.003
MX2	myxovirus (influenza virus) resistance 2	Hs.926	7.847	3.368
IFIT5	interferon-induced protein with tetratricopeptide repeats 5	Hs.252839	7.208	4.143
ISG20	interferon stimulated gene 20kDa	Hs.459265	7.188	2.489
PRKR	interferon-inducible double stranded RNA dependent protein kinase	Hs.131431	7.025	4.924
IFITM1	interferon induced transmembrane protein 1 (9-27)	Hs.458414	6.288	3.144
LY6E	lymphocyte antigen 6 complex, locus E (Sca-2)	Hs.521903	4.047	2.282
BST2	bone marrow stromal cell antigen 2	Hs.118110	3.737	2.127
IFITM3	interferon induced transmembrane protein 3 (1-8U)	Hs.374650	3.057	2.25

Example 42Mouse IL28 plasmid inhibits growth of renal cell carcinoma RENCA tumors in mice**[411]** *Summary*

[412] To determine whether IL28/IL29 has an effect on tumor growth in mice, groups of mice were injected s.c with the RENCA tumor on Day 0. Mice were then injected with 50ug control vector plasmid or mIL28 plasmid (SEQ ID NO:7) by hydrodynamic delivery (HDD) on Days 5 and 12. Tumor volume was monitored 3X/week for 5 weeks. Mouse IL28 protein level in serum was measured by ELISA. Mice injected with mIL28 plasmid showed significantly smaller tumors compared to control plasmid injected mice, suggesting that mouse IL28 has anti-tumor activity.

[413] *Study design*

[414] Ten-week old female BALB/c mice (Charles River Laboratories) were injected s.c. on the right flank with 0.1×10^6 RENCA cells on Day 0. On days 5 and 12, groups of mice (n=10/group) were injected i.v. with 50ug of either empty pZP-7 plasmid or pZP-7/mIL28 using the hydrodynamic push method (inject plasmid resuspended in 1.6ml of physiological saline via tail vein in 5-8 seconds). Mice were bled 24hrs after plasmid injections (Days 6 and 13) to assess serum mIL28 levels by ELISA. Tumor growth was monitored 3X/week for 5 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³).

[415] *Results and conclusion*

[416] Injection of mIL28 plasmid resulted in protein expression between 50-200ng/ml 24 hours after plasmid delivery. Injection of mIL-28 plasmid inhibited tumor growth in the RENCA model. The differences in tumor volume between control plasmid and IL28 plasmid injected mice was statistically significant ($p = 0.0125$ compared to controls on Day 36) (Figure 1). These data suggest that IL28 has anti-tumor activity and is a possible therapeutic for cancer.

Example 43Mouse IL28 plasmid and human IL29 C172S-PEG protein inhibit growth of RENCA tumors in mice**[417]** *Summary*

[418] To determine if IL28/IL29 has an effect on tumor growth in mice, groups of mice were injected s.c with the RENCA tumor on Day 0. Mice were then injected with 50ug control vector plasmid, mIL28 plasmid (SEQ ID NO:7) or mIFN α plasmid by hydrodynamic delivery (HDD) on Days 5 and 12. A separate group of tumor bearing mice received 25ug human IL29 C172S (SEQ ID NO:29)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) protein by i.p. injection every other day (EOD) from Days 5-21. Tumor volume was monitored 3X/week for 4 weeks. Mouse IL28 and IFN α protein levels in serum were measured by ELISA. Mice injected

with mIL28 or mIFN α plasmid showed significantly smaller tumors compared to control plasmid injected mice, suggesting that mouse IL28 has anti-tumor activity. Furthermore, mice injected with IL29 C172S-PEG protein also showed decreased tumor volume compared to controls. These data suggest that both IL28 and IL29 have anti-tumor activity.

[419] *Study design*

[420] Ten-week old female BALB/c mice (Charles River Laboratories) were injected s.c. on the right flank with 0.1×10^6 RENCA cells on Day 0. On days 5 and 12, groups of mice (n=10/group) were injected i.v. with 50ug of either empty pZP-7 plasmid, pZP-7/mIL28 or pORF/mIFN α using the hydrodynamic push method (inject plasmid resuspended in 1.6ml of physiological saline via tail vein in 5-8 seconds). A separate group of mice (n=10) were injected i.p. with 25ug human IL29 C172S-PEG EOD from days 5-21. Intra-peritoneal injections were given in a total volume of 200ul. Mice were bled 24hrs after plasmid injections (Days 6 and 13) to assess serum mIL28 and mIFN α levels by ELISA. Tumor growth was monitored 3X/week for 4 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³).

[421] *Results and conclusion*

[422] Administration of mIL-28 or mIFN α plasmid significantly inhibited tumor growth in this RENCA model (p< 0.001 for all 3 groups compared to control group on Day 28) (Figure 2). Human IL-29 C172S-PEG protein injection also significantly inhibited tumor growth compared to controls. These data suggest that mIL28 and human IL29 have anti-tumor activity and are possible therapeutics for cancer.

Example 44

Low doses of 2 different forms of human IL29 protein show anti-tumor activity in the RENCA model

[423] *Summary*

[424] To determine if anti-tumor activity of IL29 can be achieved at lower doses than described above, groups of mice were injected s.c with the RENCA tumor on Day 0. Groups (n=10/group) of tumor bearing mice received 1ug, 5ug, 25ug human IL29 C172S (SEQ ID NO:29)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) or human IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) protein by i.p. injection every other day (EOD) from Days 5-23. Tumor volume was monitored 3X/week for 4 weeks. Mice injected with 1, 5 or 25ug IL29 C172S-PEG protein showed decreased tumor volume compared to controls. Furthermore, mice injected with 1, 5 or 25ug human IL29 C172S d2-7-PEG protein also showed significantly decreased tumor growth compared to

controls. These data suggest that low doses of 2 different forms of human IL29 protein have anti-tumor activity in mice.

[425] *Study design*

[426] Ten-week old female BALB/c mice (Charles River Laboratories) were injected s.c. on the right flank with 0.1×10^6 RENCA cells on Day 0. Groups of mice (n=10/group) were injected i.p. with 1ug, 5ug, or 25ug human IL29 C172S-PEG or human IL29 C172S d2-7-PEG EOD from days 5-23. Intra-peritoneal injections were given in a total volume of 200ul. Tumor growth was monitored 3X/week for 4 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³).

[427] *Results and conclusion*

[428] Administration of 1ug, 5ug or 25ug human IL29 C172S-PEG protein significantly inhibited tumor growth. Furthermore, 1ug, 5ug or 25ug IL29 C172S d2-7-PEG protein injection also inhibited tumor growth compared to vehicle treated mice (Figure 3). These data provide evidence that human IL29 protein has anti-tumor activity and is a potential therapeutic for various tumors.

Example 45

Therapeutic treatment with Pegylated human IL29 shows potent anti-tumor activity in the RENCA model

[429] *Summary*

[430] To determine if therapeutic treatment with IL29 can induce anti-tumor activity groups of mice were injected s.c with the RENCA tumor on Day 0. When tumor volume of 100mm³ was reached, mice received vehicle, 5ug or 25ug human IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) protein every other day (EOD) for 10 injections or 5ug human IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) protein every day (ED) for 20 injections. As a control, one group of mice was treated prophylactically with 5ug human IL29 C172S d2-7-PEG EOD for 20 days starting on day 5 of tumor injection (Day 5-23). Each individual mouse received injections only after its tumor volume reached 100mm³. All injections of protein were by i.p. administration. Tumor volume was monitored 3X/week for 4 weeks. Mice injected with 5ug or 25ug EOD or 5ug ED showed significantly less tumor growth compared to controls. Consistent with previous results, mice given prophylactic treatment with 5ug IL29 also showed decreased tumor growth compared to controls. These data suggest that therapeutic treatment with human IL29 protein have anti-tumor activity in mice.

[431] *Study design*

[432] Ten-week old female BALB/c mice (Charles River Laboratories) were injected s.c. on the right flank with 0.1×10^6 RENCA cells on Day 0. Groups of mice (n=10/group) were injected i.p. with vehicle, 5ug or 25ug human IL29 C172S d2-7-PEG EOD for 20 days or 5ug human IL29 C172S d2-7-PEG ED for 20 days starting with a tumor volume of approximately 100mm^3 . A separate group of mice received 5ug human IL29 C172S d2-7-PEG EOD for 20 days starting d5 of experiment (prophylactic treatment). Intra-peritoneal injections were given in a total volume of 200ul. Tumor growth was monitored 3X/week for 4 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm^3).

[433] *Results and conclusion*

[434] Mice injected with 5ug or 25ug EOD or 5ug ED showed significantly less tumor growth compared to controls. Consistent with previous results, mice given prophylactic treatment with 5ug IL29 also showed decreased tumor growth compared to controls (Figure 4). These data provide evidence that human IL29 protein has anti-tumor activity and is a potential therapeutic for various tumors.

Example 46

Prophylactic treatment with Pegylated human IL29 inhibits tumor growth in the E.G7 thymoma model

[435] *Summary*

[436] To determine if IL29 can induce anti-tumor activity in other tumors, groups of mice were injected s.c with the E.G7 tumor on Day 0. Groups of mice received vehicle or 25ug human IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) protein every other day (EOD) for 10 injections (days 0-18). All injections of protein were by i.p. administration. Tumor volume was monitored 3X/week for 4 weeks. Mice injected with 25ug EOD showed significantly less tumor growth compared to controls. These data suggest that treatment with human IL29 protein have anti-tumor activity in mice.

[437] *Study design*

[438] Ten-week old female C57BL/6 mice (Charles River Laboratories) were injected s.c. on the right flank with 0.4×10^6 E.G7 cells on Day 0. Groups of mice (n=10/group) were injected i.p. with vehicle or 25ug human IL29 C172S d2-7-PEG EOD for 20 days. Intra-peritoneal injections were given in a total volume of 200ul. Tumor growth was monitored 3X/week for 4 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm^3).

[439] *Results and conclusion*

[440] Mice injected with 25ug EOD showed significantly less tumor growth compared to controls and also prolonged survival of mice compared to control animals (Figure 5A and 5B). These data provide evidence that human IL29 protein has anti-tumor activity and is a potential therapeutic for various tumors.

Example 47

PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B inhibit growth of human hepatocellular carcinoma cells C3A and HuH7 *in vivo*

[441] Summary

[442] To test if anti-tumor activity of PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B can be achieved against human hepatocellular carcinoma cells *in vivo*, groups of BALB/c *nude* mice are injected with either HuH7 or C3A hepatocellular carcinoma cells on Day 0. Groups (n=10/group) of tumor bearing mice receive 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein by i.p. or peritumoral injection every other day (EOD) from Days 5-33. Tumor volume is monitored 3X/week for 6 weeks. Inhibition of tumor growth by either PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein(s) has inhibitory effects on human hepatocellular carcinoma *in vivo*.

[443] Study design

[444] Eight-week old female BALB/c *nude* mice (Charles River Laboratories) are injected s.c. on the right flank with 6×10^6 HuH7 or C3A cells on Day 0. Groups of mice (n=10/group) are injected i.p. or peritumorally with 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein from days 5-33. Injections are given in a total volume of 200ul. Tumor growth is monitored 3X/week for 6 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³).

[445] Results and conclusion

[446] Inhibition of tumor growth by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein(s) has inhibitory effects on human hepatocellular carcinoma *in vivo*.

Example 48

PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B inhibit growth of human prostate carcinoma cells PC-3 and DU145 *in vivo*

[447] Summary

[448] To test if anti-tumor activity of PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B can be achieved against human prostate carcinoma cells *in vivo*, groups of BALB/c *nude* mice are injected with either PC-3 or DU-145 prostate carcinoma cells on Day 0. Groups (n=10/group) of tumor bearing mice receive 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein by i.p. or peritumoral injection every other day (EOD) from Days 5-33. Tumor volume is monitored 3X/week for 6 weeks. Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that respective protein has inhibitory effects on human prostate carcinoma *in vivo*.

[449] Study design

[450] Eight-week old female BALB/c *nude* mice (Charles River Laboratories) are injected s.c. on the right flank or orthotopically in the prostate lobe with 10×10^6 PC-3 or 6×10^6 DU-145 cells on Day 0. Groups of mice (n=10/group) are injected i.p. or peritumorally (s.c model only) with 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein from days 5-33. Injections are given in a total volume of 200ul. For s.c tumors, tumor growth is monitored 3X/week for 6 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³). For orthotopic tumors, mice are terminated at the end of the study and tumor weighed to enable tumor load assessment.

[451] Results and conclusion

[452] Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein(s) has inhibitory effects on human prostate carcinoma *in vivo*.

Example 49

PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B inhibit growth of human colon carcinoma cells DLD-1 and HCT-116 *in vivo*

[453] Summary

[454] To test if anti-tumor activity of PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B can be achieved against human colon carcinoma cells *in vivo*, groups of BALB/c

nude mice are injected with either DLD-1 or HCT-116 colon carcinoma cells on Day 0. Groups (n=10/group) of tumor bearing mice receive 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein by i.p. or peritumoral injection every other day (EOD) from Days 5-33. Tumor volume is monitored 3X/week for 6 weeks. Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein has inhibitory effects on human colon carcinoma *in vivo*.

[455] Study design

[456] Eight-week old female BALB/c *nude* mice (Charles River Laboratories) are injected s.c. on the right flank or orthotopically in the colonic wall with 6×10^6 DLD-1 or HCT-116 cells on Day 0. Groups of mice (n=10/group) are injected i.p. or peritumorally (for s.c model only) with 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein from days 5-33. Injections are given in a total volume of 200ul. For s.c tumors, tumor growth is monitored 3X/week for 6 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³). For orthotopic tumors, mice are terminated at the end of the study and tumor weighed to enable tumor load assessment.

[457] Results and conclusion

[458] Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein(s) has inhibitory effects on human colon carcinoma *in vivo*.

Example 50

PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B inhibit growth of human pancreatic carcinoma cells BxPC-3 and HPAF-II *in vivo*

[459] Summary

[460] To test if anti-tumor activity of PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B can be achieved against human pancreatic carcinoma cells *in vivo*, groups of BALB/c *nude* mice are injected with either BxPC-3 or HPAF-II pancreatic carcinoma cells on Day 0. Groups (n=10/group) of tumor bearing mice receive 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein by i.p. or peritumoral injection every other day (EOD) from Days 5-33. Tumor volume is monitored 3X/week for 6 weeks. Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B

protein suggests that the respective protein has inhibitory effects on human pancreatic carcinoma *in vivo*.

[461] Study design

[462] Eight-week old female BALB/c *nude* mice (Charles River Laboratories) are injected s.c. on the right flank or orthotopically in the pancreatic lobe with 6×10^6 BxPC-3 or HCT-116 cells on Day 0. Groups of mice (n=10/group) are injected i.p. or peritumorally (for s.c model only) with 5ug-75ug human PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein from days 5-33. Injections are given in a total volume of 200ul. For s.c tumors, tumor growth is monitored 3X/week for 6 weeks using caliper measurements. Tumor volume was calculated using the formula $\frac{1}{2} \times (B)^2 \times L$ (mm³). For orthotopic tumors, mice are terminated at the end of the study and tumor weighed to enable tumor load assessment.

[463] Results and conclusion

[464] Inhibition of tumor growth (volume or weight) by PEG-rIL-29, rIL-29, PEG-rIL-28A, rIL-28A, PEG-rIL-28B, or rIL-28B protein suggests that the respective protein(s) has inhibitory effects on human pancreatic carcinoma *in vivo*.

Example 51

IL-29 in EAE Mouse Models for Multiple Sclerosis (MS)

[465] Experimental allergic encephalomyelitis (EAE) is a mouse model for human MS (Gold et al., Mol. Med. Today, 6:88-91, 2000; Anderton et al., Immunol. Rev., 169:123-137, 1999). MS in humans can be broadly classified into chronic progressive and relapsing remitting disease phenotypes. These disease phenotypes can be modeled in mice using multiple methods. One such method of inducing chronic progressive MS in mice is to immunize mice with a peptide of the myelin protein MOG (myelin oligodendrocyte glycoprotein). This protein is present on the outside of the myelin sheath and acts as a protective layer for myelin. Mice are immunized sub-cutaneously with MOG peptide (MOG35-55) emulsified in RIBI adjuvant on day 0. Mice are then injected intravenously with pertussis toxin (PT) on day 2. The mice start showing symptoms of paralysis starting with a limp tail, wobbly motion, followed by hind limb and forelimb paralysis, which are scored according to several different parameters that measure the timing, extent and severity of disease. Delay in onset of disease indicates that the drug is modifying the disease process in mice. Decrease in incidence indicates that the drug is having an effect on the number of mice that are getting sick. Decrease in clinical score indicates that the drug has an effect on the severity of disease. Groups of mice are given PBS or either mouse IL28 or human IL29C172S-PEG. The onset of symptoms, incidence of disease scores and severity of disease scores in IL-28/29 treated mice

indicates the effect of IL-28/29 on these parameters in this model. Mice (n=13/gp) are immunized s.c with 100ug MOG35-55 in RIBI adjuvant on d0. All mice receive 200ng pertussis toxin i.v on d2. Groups of mice are treated i.p with PBS, 25ug human IL29C172S every other day (EOD) on days 1-18 or with PBS, BSA or mouse IL28. As specified above, mice are scored for clinical signs and weight loss daily from d0-d30. IL29 C172S-PEG or mouse IL28 treated mice show a delay in the onset of disease compared to PBS treated animals.

[466] To model relapsing remitting disease, mice (SJL) are immunized with a peptide derived from the proteolipid protein (PLP). Mice are immunized in the back s.c with PLP139-151 peptide emulsified in complete Freund's adjuvant (CFA). The mice start showing symptoms of paralysis starting with a limp tail, wobbly motion, followed by hind limb and forelimb paralysis, which are scored according to several different parameters that measure the timing, extent and severity of disease. In the RR-EAE model, during the course of disease, mice will spontaneously have a remission for a short period after which mice will again relapse spontaneously. Mice might have these relapsing-remitting cycles multiple times during the course of the disease. Delay in onset of disease indicates that the drug is modifying the disease process in mice. Decrease in incidence indicates that the drug is having an effect on the number of mice that are getting sick. Decrease in clinical score indicates that the drug has an effect on the severity of disease. In this model, decreases in numbers of relapses, decrease in maximum clinical score achieved at a relapse and to maintain mice in complete remission are all indications of a therapeutic drug. Groups of immunized mice are given either prophylactic (starting Day 3 after immunization) or therapeutic (starting on first day of clinical score) PEG-rIL-29 or PEG-mIL-28 at different doses. Decrease in relapses, disease severity and incidence or induction of complete remission indicate that PEG-rIL-29 or PEG-mIL-28 can inhibit RR-EAE and could be a therapeutic for RR-MS in humans.

Prophylactic administration of PEG-mIL-28 or PEG-rIL-29 inhibits severity of disease and disease incidence in the RR-EAE model in SJL mice

[467] Summary

[468] To test if mouse IL-28 or human IL-29 had any effects on relapsing-remitting multiple sclerosis, the ability of PEG-mIL-28 or PEG-rIL-29 to inhibit experimental autoimmune encephalomyelitis (EAE), a mouse model for RR-MS was tested. The well characterized proteolipid protein PLP 139-151 peptide immunization model in SJL mice was used. The experiment was run to determine that IL-28 or IL-29 could delay and /or inhibit disease scores in RR-EAE. Prophylactic administration of either PEG-rIL-29 and PEG-mIL-28 delayed onset of disease and reduced incidence of disease in the RR-EAE model, suggesting that use of IL-28 or IL-29 may be beneficial in MS.

[469] Study design

[470] Experimental autoimmune encephalomyelitis (EAE) is a mouse model for MS. In one such model, SJL mice are immunized with 100 µg PLP peptide (PLP139-151) emulsified in CFA adjuvant (1:1 ratio). A 1 mg/mL preparation of the PLP139-151 peptide in PBS was prepared. CFA (Sigma Aldrich Ltd) containing 1mg/mL heat inactivated mycobacterium tuberculosis (Mtb) was fortified with further 1mg/mL of Mtb (Difco Laboratories) to make a final concentration of 2mg/mL Mtb. A 1:1 emulsion of this CFA and PLP peptide solution was generated using emulsifying syringes. The backs of mice were shaved and 100 µg PLP/CFA (200uL of emulsion) was injected s.c in the backs of mice. Weights of mice were taken 2 days before and every day after the immunization. Mice were monitored daily for clinical scores. Groups of mice were injected i.p. with 100 µl PBS, or 5-75ug PEG-mIL-28 (mouse IL-28 (SEQ ID NO:8)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) or 25ug PEG-rIL-29 (IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) in a 100uL volume EOD from days 3-23. In some experiments, 25ug Novantrone was administered i.p. on Days 4, 8, 12 and 16. The weights of mice, clinical scores and incidence were evaluated and plotted for analysis.

[471] Results and conclusion

[472] Prophylactic administration of 5ug, 25ug or 75ug PEG-mIL-28 significantly inhibited disease incidence, and delayed disease onset in the RR-EAE model (See Figure 6 and 7, $p < 0.0001$ for all PEG-mIL-28 groups vs Vehicle – Kaplein-Meier test). Prophylactic administration of 25ug PEG-rIL-29 significantly inhibited disease incidence and delayed disease onset in the RR-EAE model (Figure 8 and 9, $p < 0.0001$ compared to vehicle, Kaplein Meier test)

Therapeutic administration of PEG-mIL-28 inhibits severity of disease and relapse of disease in the RR-EAE model in SJL mice

[473] Summary

[474] To test if therapeutic administration of mouse IL-28 had any effects on relapsing-remitting multiple sclerosis, the ability of PEG-mIL-28 to inhibit experimental autoimmune encephalomyelitis (EAE), a mouse model for RR-MS was tested. The well characterized proteolipid protein PLP 139-151 peptide immunization model in SJL mice was used. The experiment was run to determine that IL-28 could inhibit disease scores and prevent relapses when given therapeutically (after first clinical sign of disease) in RR-EAE. Therapeutic administration of PEG-mIL-28 inhibited disease severity and reduced relapses in the RR-EAE model, suggesting that use of IL-28 may be beneficial in MS.

[475] Study design

[476] Experimental autoimmune encephalomyelitis (EAE) is a mouse model for MS. In one such model, SJL mice were immunized with 100 µg PLP peptide (PLP139-151) emulsified in

CFA adjuvant (1.1 ratio). A 1 mg/mL preparation of the PLP139-151 peptide in PBS was prepared. CFA (Sigma Aldrich Ltd) containing 1mg/mL heat inactivated mycobacterium tuberculosis (Mtb) was fortified with further 1mg/mL of Mtb (Difco Laboratories) to make a final concentration of 2mg/mL Mtb. A 1:1 emulsion of this CFA and PLP peptide solution was generated using emulsifying syringes. The backs of mice were shaved and 100 µg PLP/CFA (200uL of emulsion) was injected s.c in the backs of mice. Weights of mice were taken 2 days before and every day after the immunization. Mice were monitored daily for clinical scores. Groups of mice were injected i.p. with 100 µl PBS, or 25ug or 50ug PEG-mIL-28 (mouse IL-28 (SEQ ID NO:8)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) in a 100uL volume every day (ED) for 30 days starting from Day 1 of first clinical score in each individual mice. The weights of mice, clinical scores and incidence were evaluated and plotted for analysis.

[477] Results and conclusion

[478] Therapeutic administration of 25ug or 50ug PEG-mIL-28 significantly inhibited disease severity, in the RR-EAE model (Figure 10 and 11). PEG-mIL-28 also reduced relapses and sustained remission in RR-EAE mice (Figure 12)

Therapeutic administration of PEG-rIL-29 inhibits severity of disease and relapse of disease in the RR-EAE model in SJL mice

[479] Summary

[480] To test if therapeutic administration of human IL-29 had any effects on relapsing-remitting multiple sclerosis, the ability of PEG-rIL-29 to inhibit experimental autoimmune encephalomyelitis (EAE), a mouse model for RR-MS was tested. The well characterized proteolipid protein PLP 139-151 peptide immunization model in SJL mice was used. The experiment was run to determine that IL-29 could inhibit disease scores and prevent relapses when given therapeutically (after first clinical sign of disease) in RR-EAE. Inhibition of disease severity and prevention of relapses in RR-EAE model by PEG-rIL-29 suggest the clinical use of this protein in human MS.

[481] Study design

[482] Experimental autoimmune encephalomyelitis (EAE) is a mouse model for MS. In one such model, SJL mice are immunized with 100 µg PLP peptide (PLP139-151) emulsified in CFA adjuvant (1.1 ratio). A 1 mg/mL preparation of the PLP139-151 peptide in PBS was prepared. CFA (Sigma Aldrich Ltd) containing 1mg/mL heat inactivated mycobacterium tuberculosis (Mtb) was fortified with further 1mg/mL of Mtb (Difco Laboratories) to make a final concentration of 2mg/mL Mtb. A 1:1 emulsion of this CFA and PLP peptide solution was generated using emulsifying syringes. The backs of mice were shaved and 100 µg PLP/CFA (200uL of emulsion) was injected s.c in the backs of mice. Weights of mice were taken 2 days before and every day after the immunization. Mice were monitored daily for clinical scores. Groups of mice were injected i.p. with

100 μ l PBS, or 5ug-75ug PEG-rIL-29 (IL29 C172S d2-7 (SEQ ID NO:159)-PEG (20kD N-terminally conjugated methoxy-polyethylene glycol propionaldehyde) in a 100uL volume every day (ED) or every other day (EOD) for 30 days starting from Day 1 of first clinical score in each individual mice. The weights of mice, clinical scores and incidence were evaluated and plotted for analysis.

[483] Results and conclusion

[484] After therapeutic administration of PEG-rIL-29, the disease severity and prevention of relapses in RR-EAE model was inhibited. This suggests clinical use of this protein in human MS.

[485] The complete disclosure of all patents, patent applications, and publications, and electronically available material (e.g., GenBank amino acid and nucleotide sequence submissions) cited herein are incorporated by reference. The foregoing detailed description and examples have been given for clarity of understanding only. No unnecessary limitations are to be understood therefrom. The invention is not limited to the exact details shown and described, for variations obvious to one skilled in the art will be included within the invention defined by the claims.

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CLAIMS

What is claimed is:

1. A method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.
2. The method of claim 1 wherein the polypeptide further comprises polyethylene glycol.
3. The method of claim 2 wherein the polyethylene glycol is covalently linked amino-terminally to the polypeptide.
4. The method of claim 2 wherein the polyethylene glycol is about 20kD, 30kD, or 40 kD.
5. The method of claim 2 wherein the polyethylene glycol is linear or branched.
6. The method of claim 2 wherein the polyethylene glycol is monomethoxy-PEG propionaldehyde.
7. The method of claim 1 wherein the patient is a mammal.
8. The method of claim 7 wherein the patient is a human.
9. A method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer,

melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

10. A method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:
a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175; and
a pharmaceutically acceptable vehicle; and
wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

11. A method of treating cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:
a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;
a second polypeptide;
a pharmaceutically acceptable vehicle; and
wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

12. The method of claim 11 wherein the second polypeptide is an Interferon.

13. The method of claim 12 wherein the second polypeptide is Interferon-alpha, Interferon-beta, or Interferon-gamma.

14. A method of inhibiting the progressive of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95%

sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

15. A method of inhibiting the progression of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide;

a pharmaceutically acceptable vehicle; and

wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

16. A method of delaying the onset of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

17. A method of delaying the onset of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide;

a pharmaceutically acceptable vehicle; and

wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

18. A method of reducing the severity of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

19. A method of reducing the severity of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:
a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;
a second polypeptide;
a pharmaceutically acceptable vehicle; and
wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

20. A method of inhibiting at least one of the conditions or symptoms of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's

lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

21. A method of inhibiting at least one of the conditions or symptoms of cancer comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide;

a pharmaceutically acceptable vehicle; and

wherein the cancer is selected from the group of B-cell lymphomas, chronic lymphocytic leukemia, acute lymphocytic leukemia, Non-Hodgkin's lymphomas, multiple myeloma, acute myelocytic leukemia, chronic myelocytic leukemia, renal cell carcinoma, hepatocellular carcinoma, cervical cancer, melanoma, thyroid carcinoma, malignant gliomas, breast cancer, colon cancer, lung cancer, pancreatic cancer, prostate cancer, stomach cancer, ovarian cancer, testicular cancer, Kaposi's sarcoma, and bone cancer.

22. A method of inhibiting at least one of the conditions or symptoms of non-Hodgkin's lymphoma comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of painless swelling of a lymph node in the neck, armpit or groin, night sweats, unexplained fever, weight loss, and excessive tiredness.

23. A method of inhibiting at least one of the conditions or symptoms of non-Hodgkin's lymphoma comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide; and

a pharmaceutically acceptable vehicle;

wherein the at least one of the conditions or symptoms is selected from the group of painless swelling of a lymph node in the neck, armpit or groin, night sweats, unexplained fever, weight loss, and excessive tiredness.

24. A method of inhibiting at least one of the conditions or symptoms of multiple myeloma comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of back pain, loss of height, anaemia, kidney damage, repeated respiratory infections, and hypercalcaemia.

25. A method of inhibiting at least one of the conditions or symptoms of multiple myeloma comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide; and

a pharmaceutically acceptable vehicle;

wherein the at least one of the conditions or symptoms is selected from the group of back pain, loss of height, anaemia, kidney damage, repeated respiratory infections, and hypercalcaemia.

26. A method of inhibiting at least one of the conditions or symptoms of head and neck tumours comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the at least one of the conditions or symptoms is selected from the group of an ulcer or sore area in the head or neck that does not heal within a few weeks, difficulty in swallowing, trouble with breathing or speaking, a numb feeling in the mouth, nose bleeds, persistent earache, difficulty in hearing, and swelling or lump in the mouth or neck.

27. A method of inhibiting at least one of the conditions or symptoms of head and neck tumours comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a second polypeptide; and

a pharmaceutically acceptable vehicle;

wherein the at least one of the conditions or symptoms is selected from the group of an ulcer or sore area in the head or neck that does not heal within a few weeks, difficulty in swallowing, trouble with breathing or speaking, a numb feeling in the mouth, nose bleeds, persistent earache, difficulty in hearing, and swelling or lump in the mouth or neck.

28. A method of treating an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the autoimmune disorder is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

29. A method of treating an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175, wherein the autoimmune disorder is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

30. A method of an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

- a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;
- a second polypeptide;
- a pharmaceutically acceptable vehicle; and

wherein the cancer is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

31. A method of inhibiting the progression of an autoimmune disorder comprising administering to a patient in need thereof a therapeutically effective amount of a formulation comprising:

- a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;
- a second polypeptide;
- a pharmaceutically acceptable vehicle; and

wherein the cancer is selected from the group of multiple sclerosis, arthritis, rheumatoid arthritis, ulcerative colitis, Crohn's disease, systemic lupus erythematosus, and psoriasis.

32. A method of delaying a multiple sclerosis relapse in a patient comprising administering to the patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a pharmaceutically acceptable vehicle.

33. A method of reducing the severity of a multiple sclerosis relapse in a patient comprising administering to the patient in need thereof a therapeutically effective amount of a formulation comprising:

a polypeptide having at least 95% sequence identity with a sequence selected from the group of SEQ ID NOs:163, 165, 167, 169, 171, 173 and 175;

a pharmaceutically acceptable vehicle.

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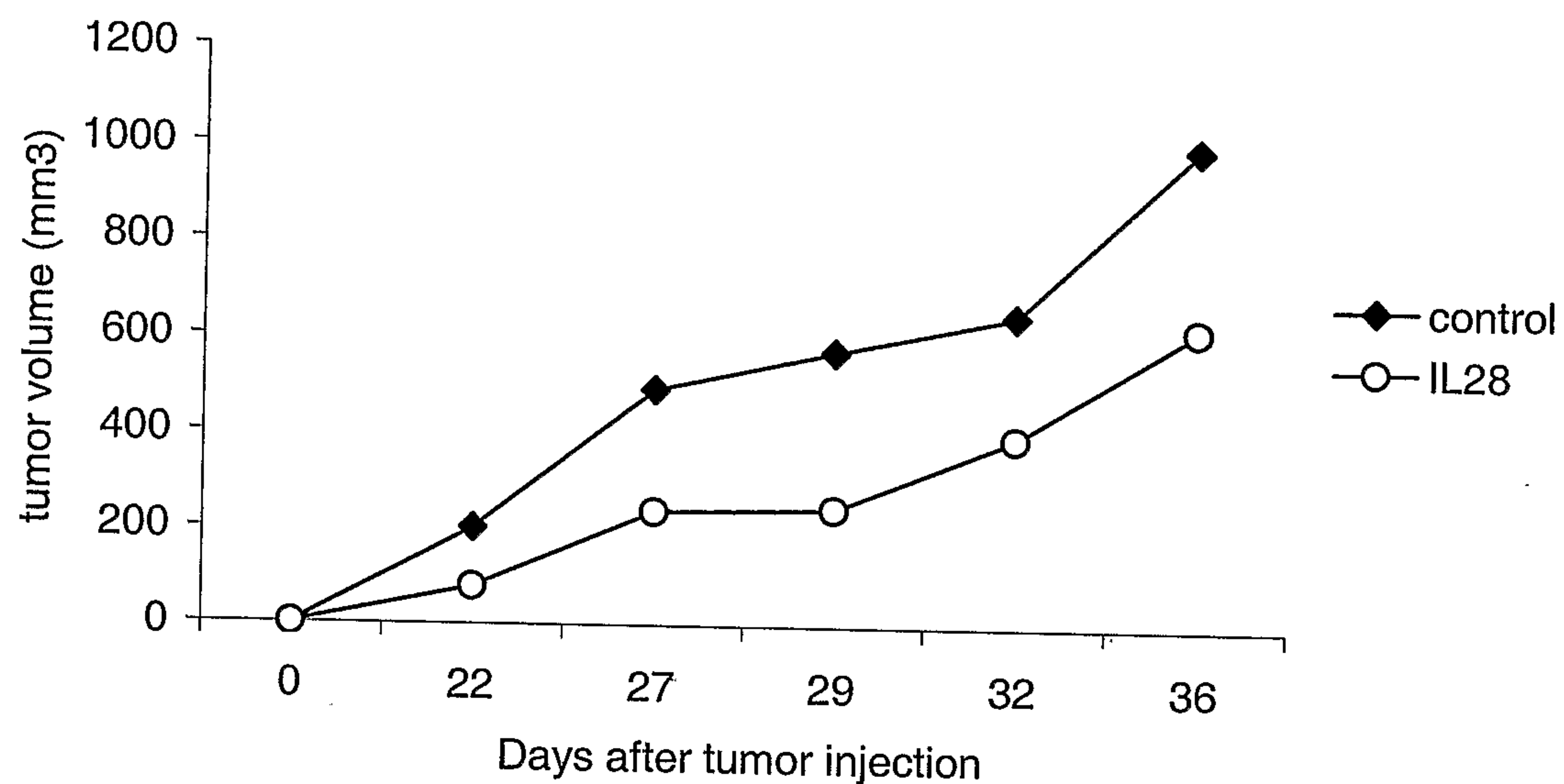


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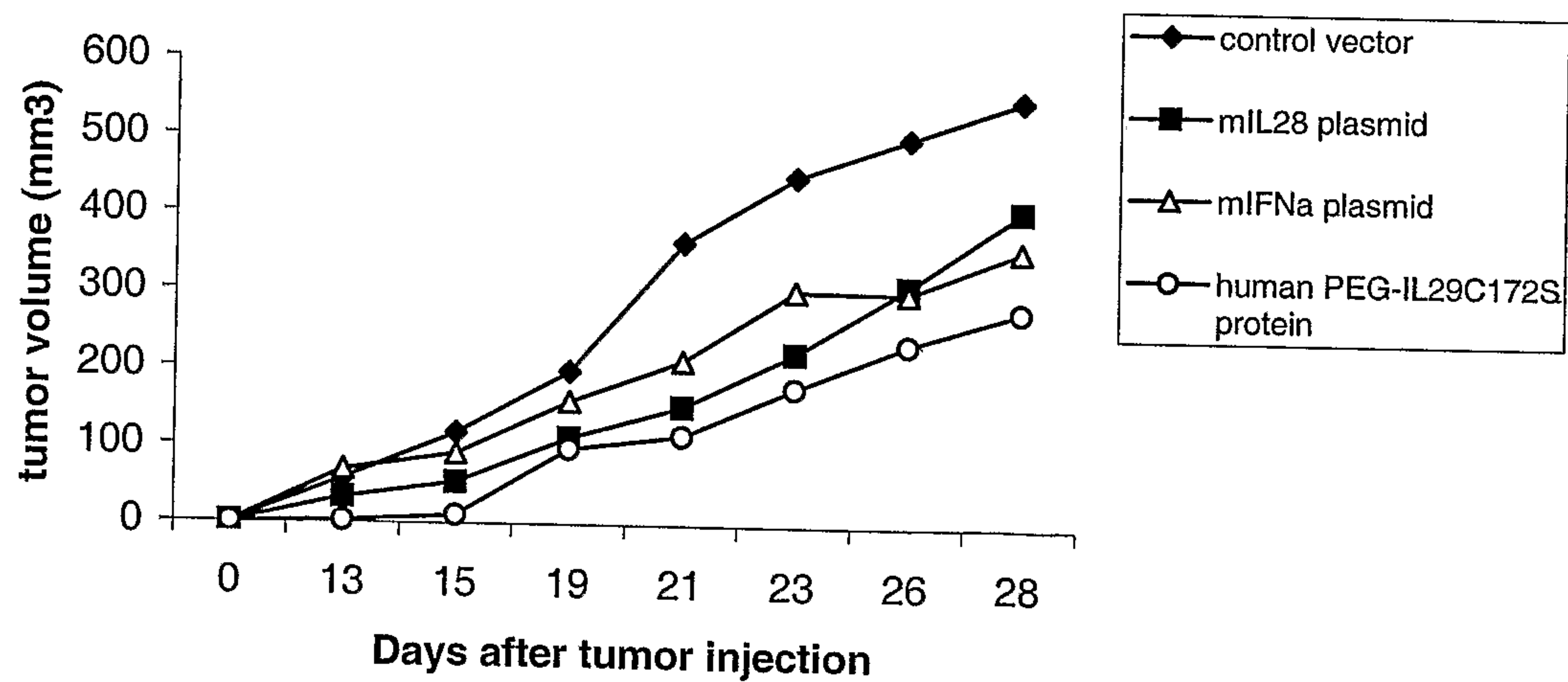


Figure 2

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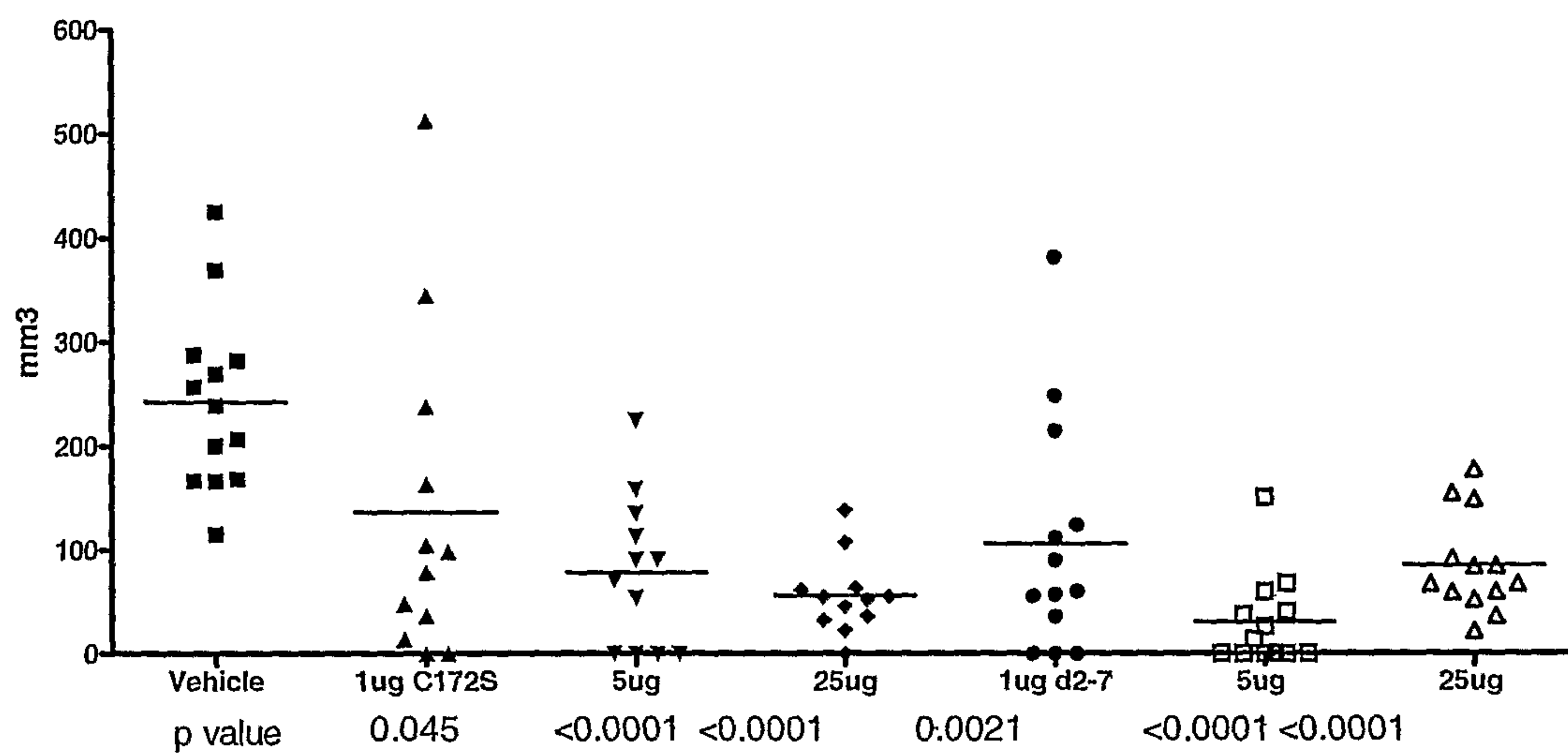


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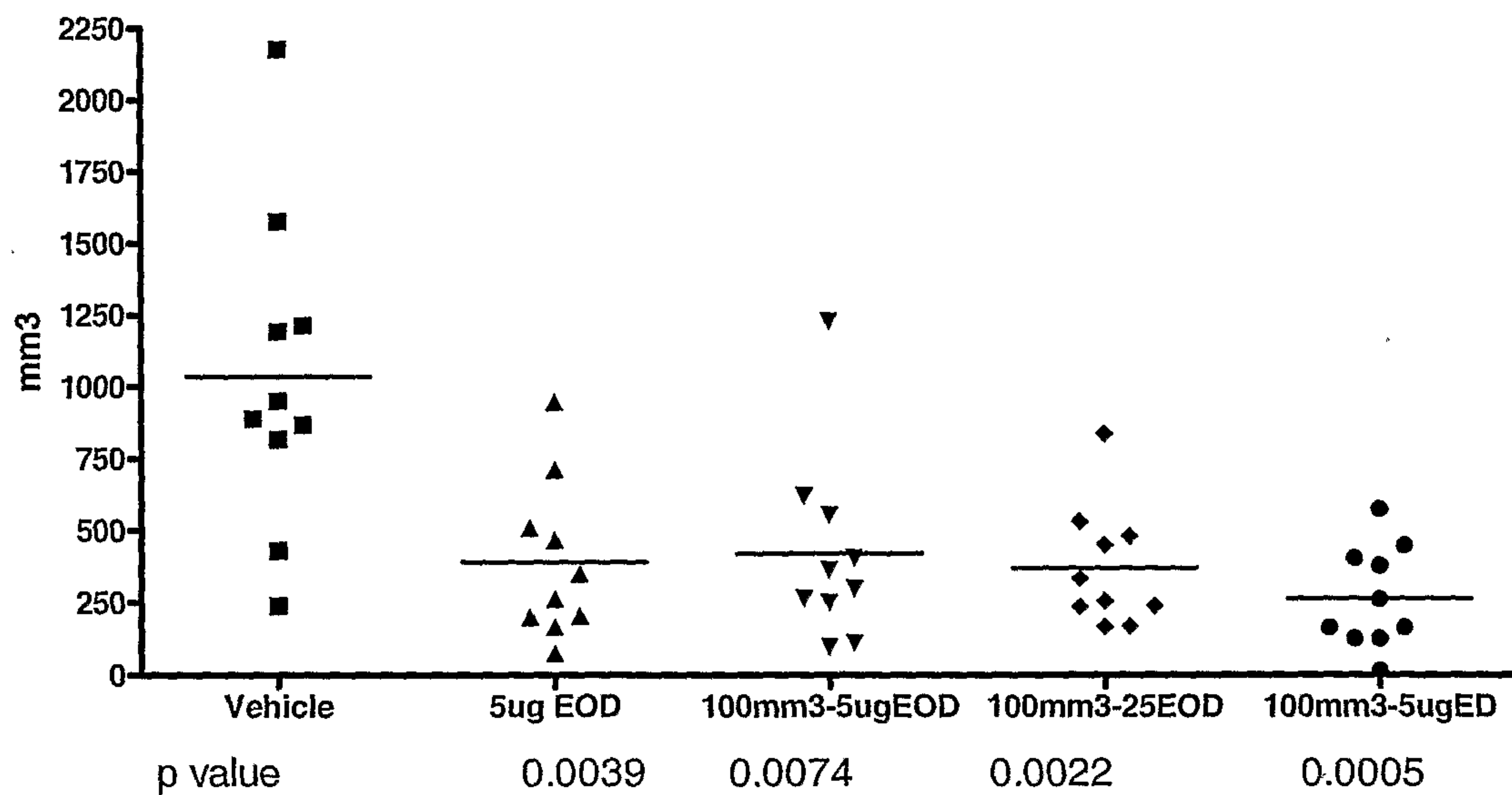


Figure 4

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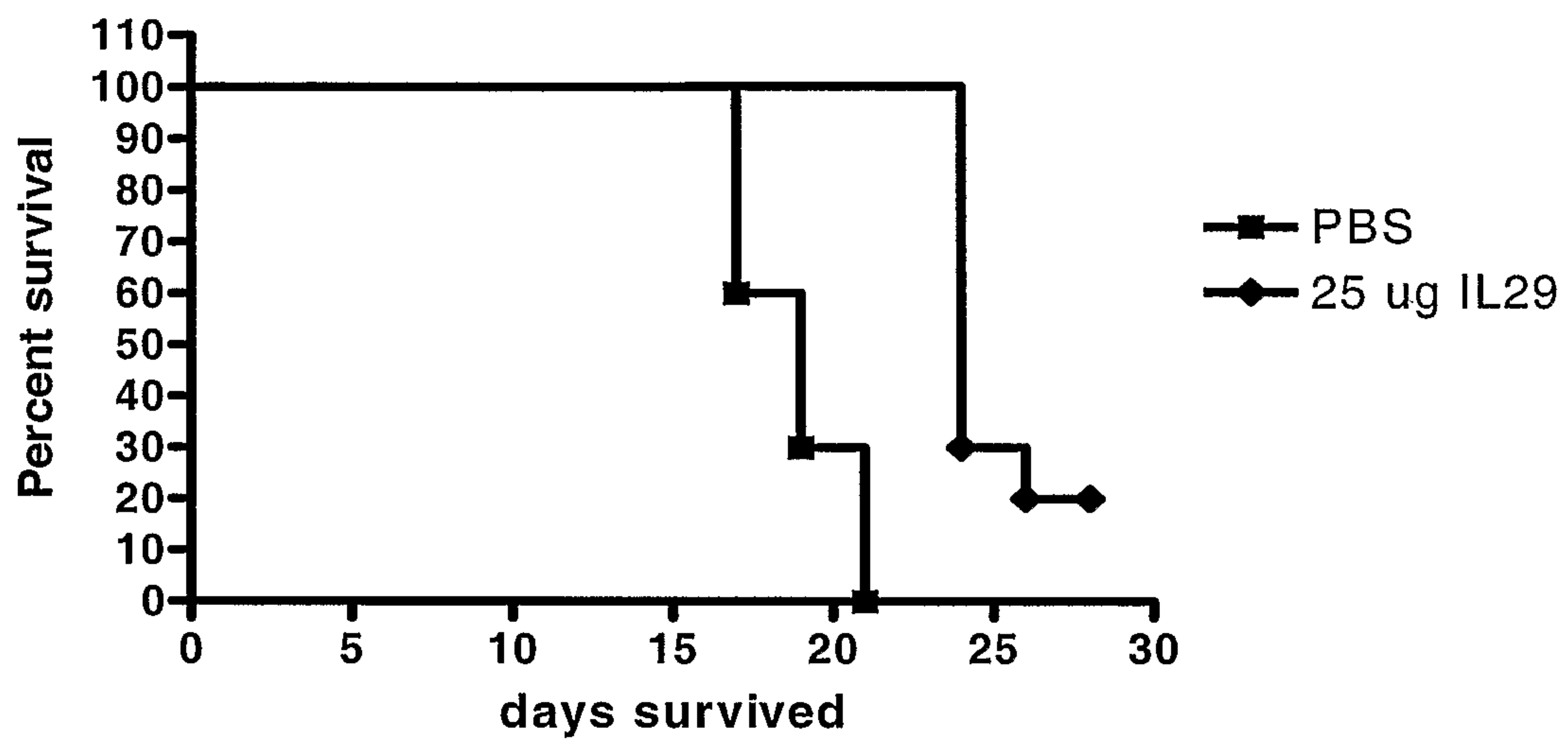


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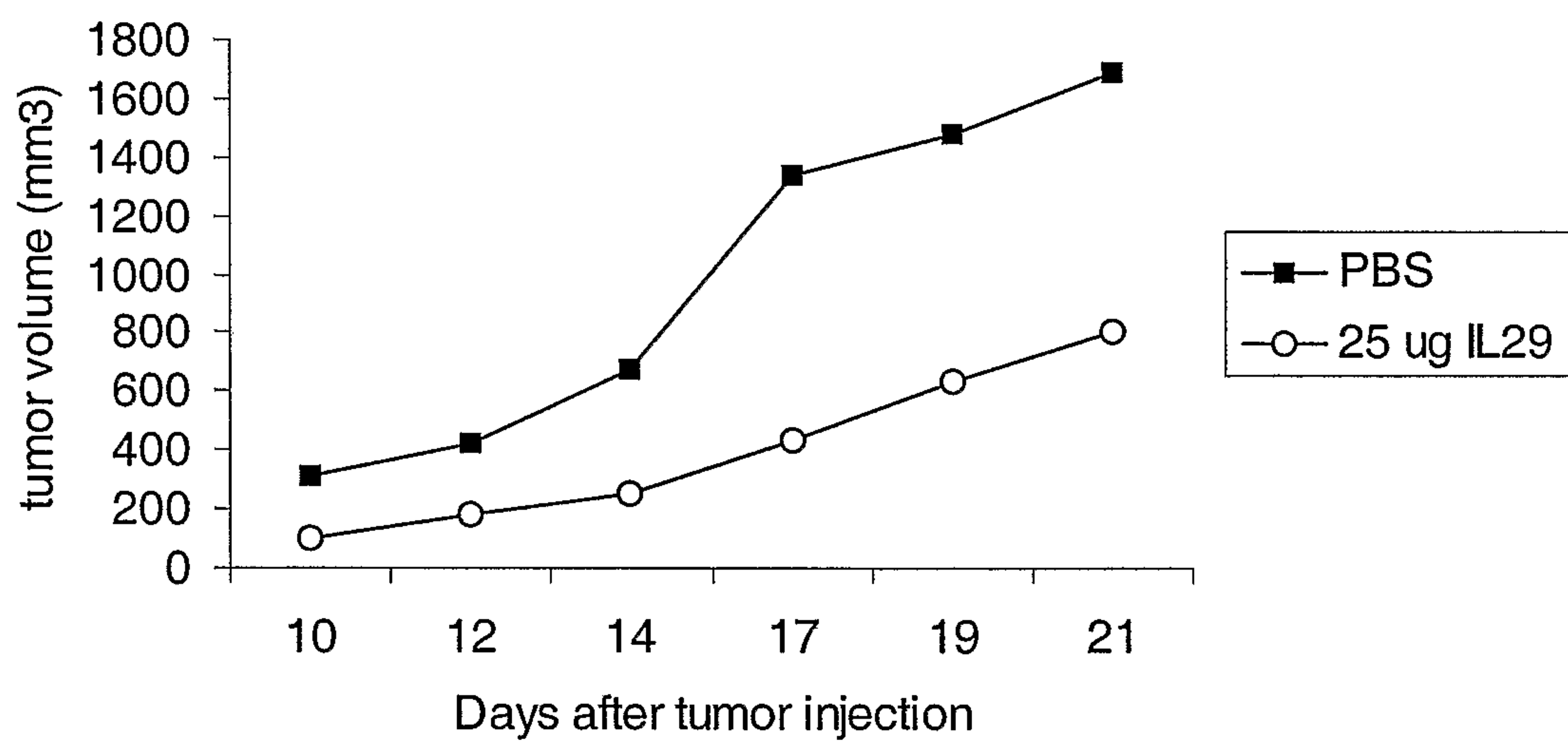


Figure 5B

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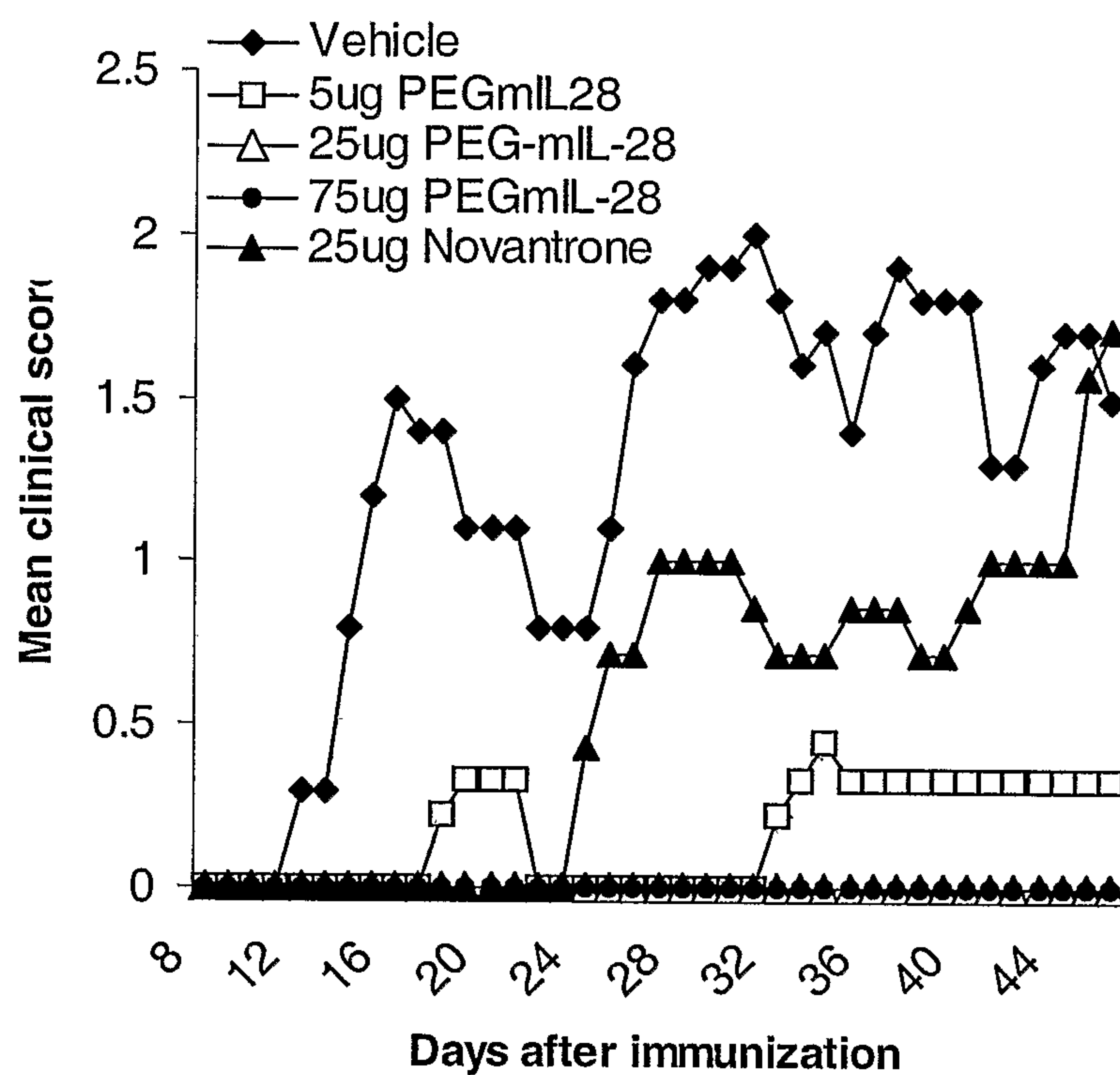


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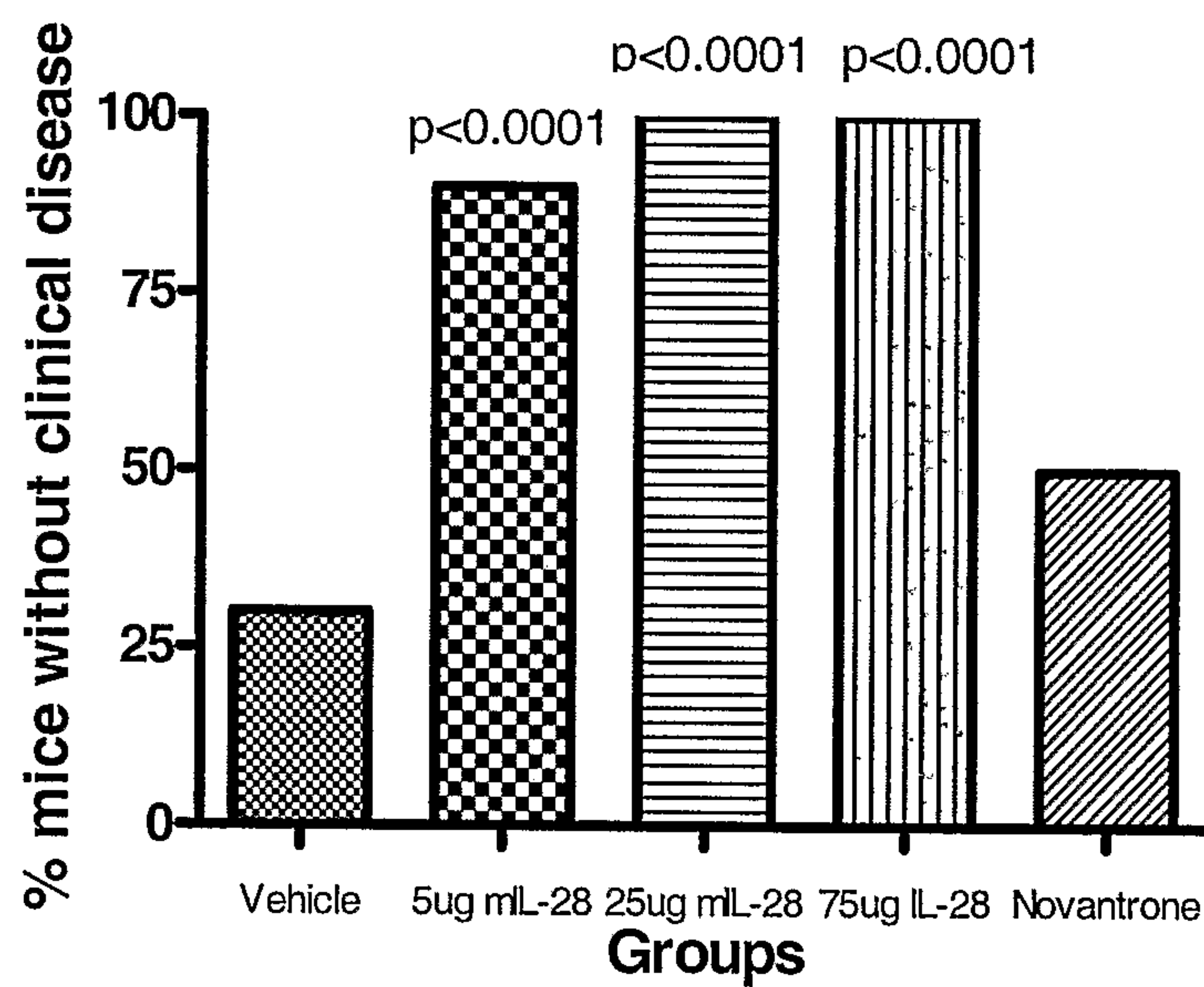


Figure 7

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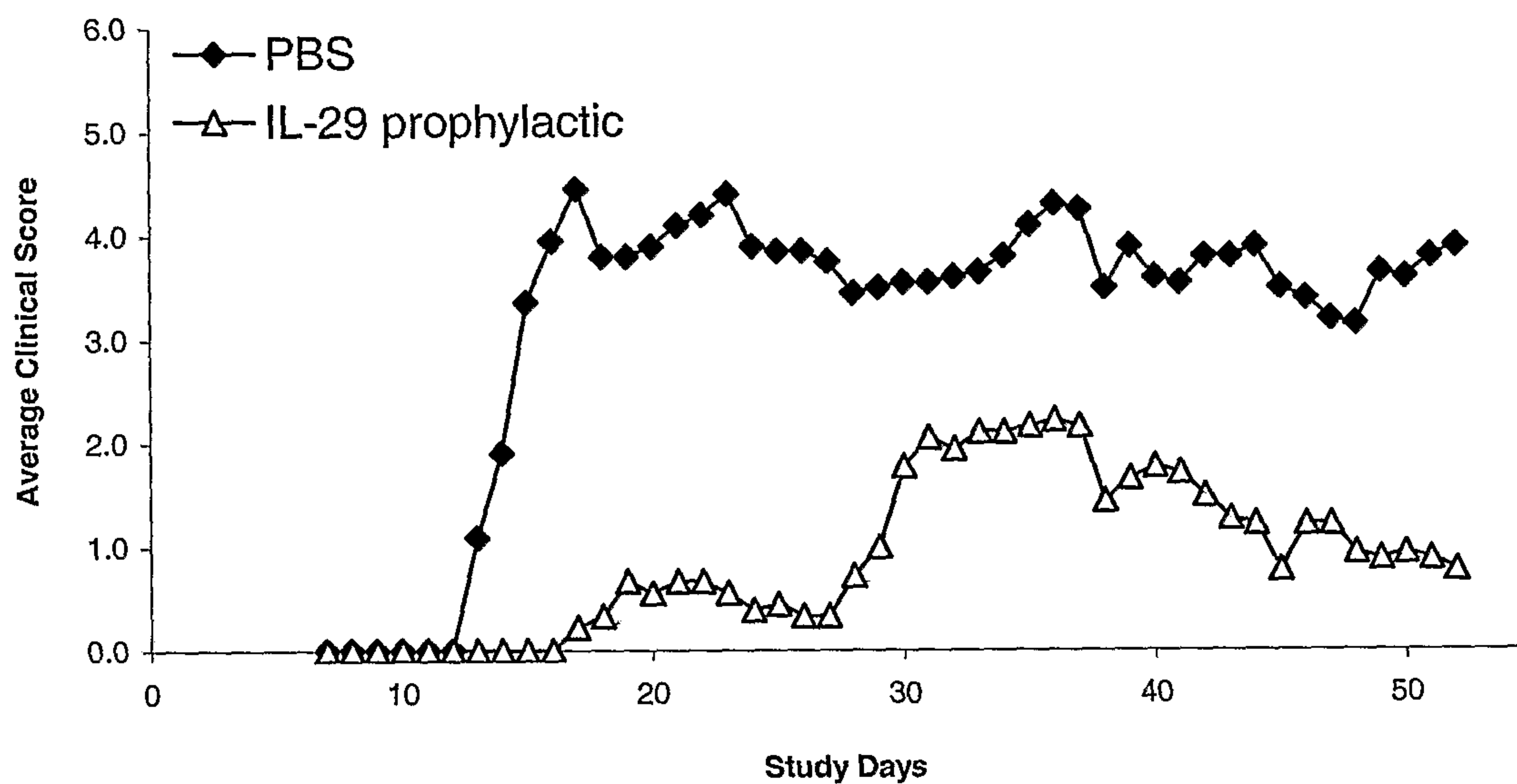


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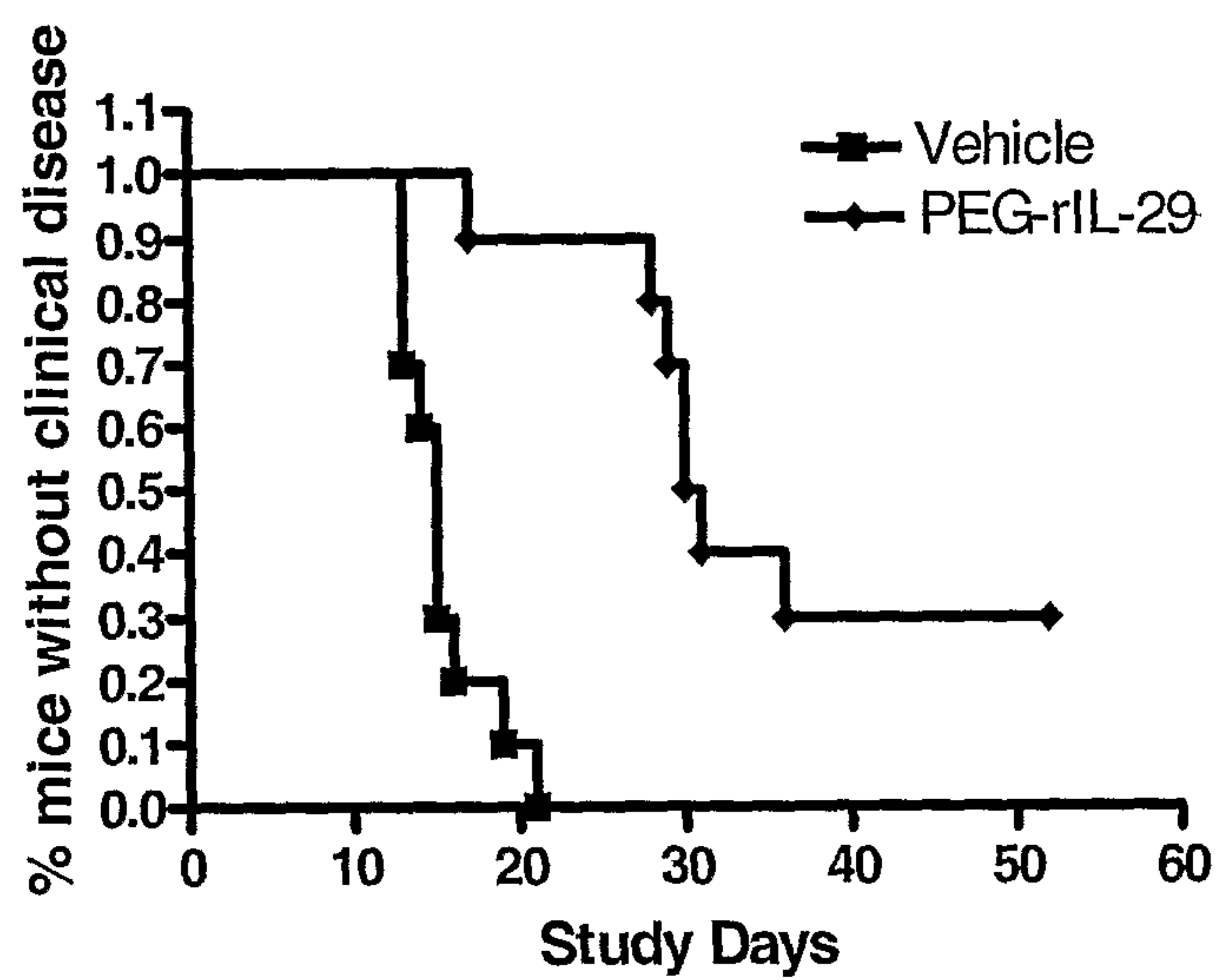


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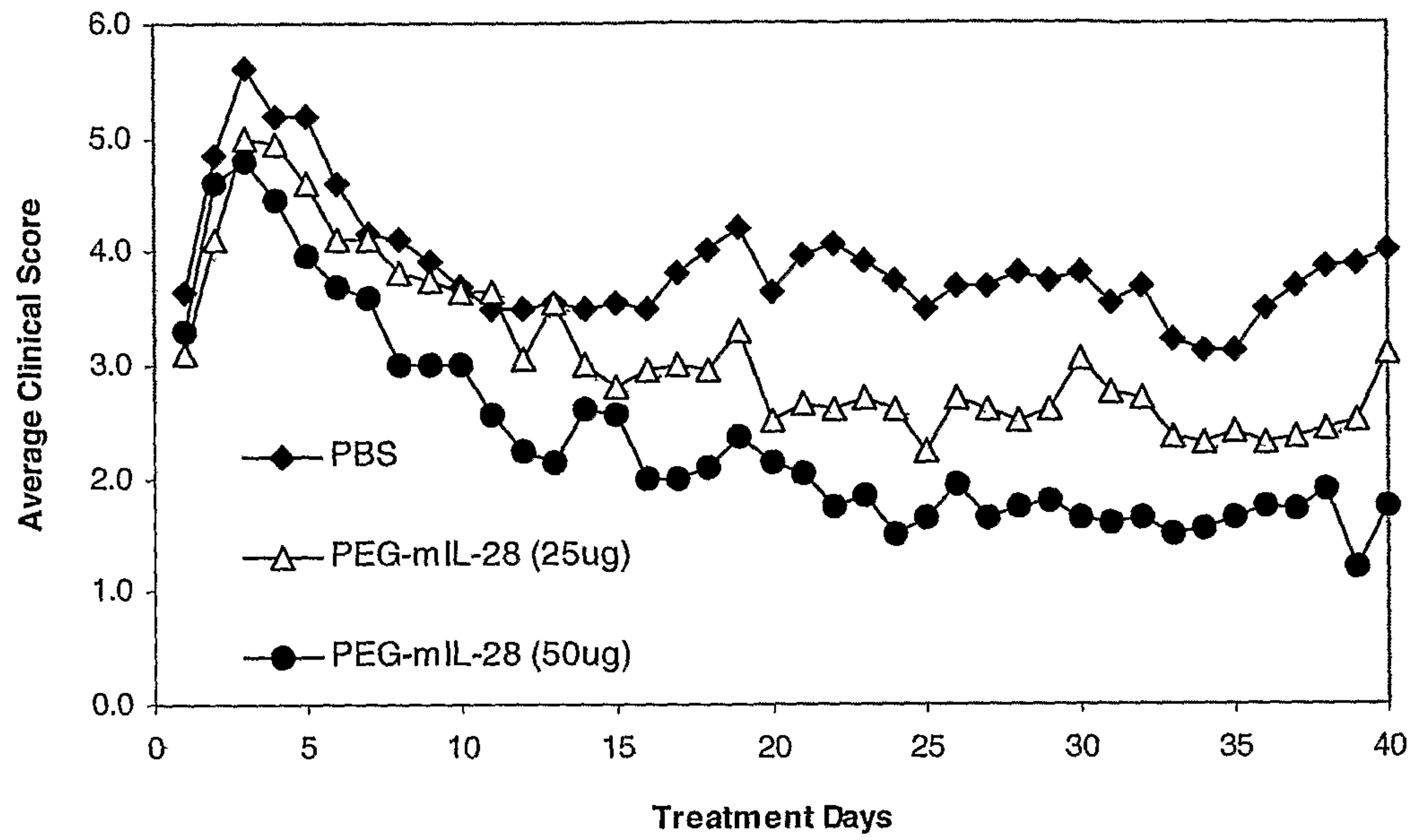


Figure 10

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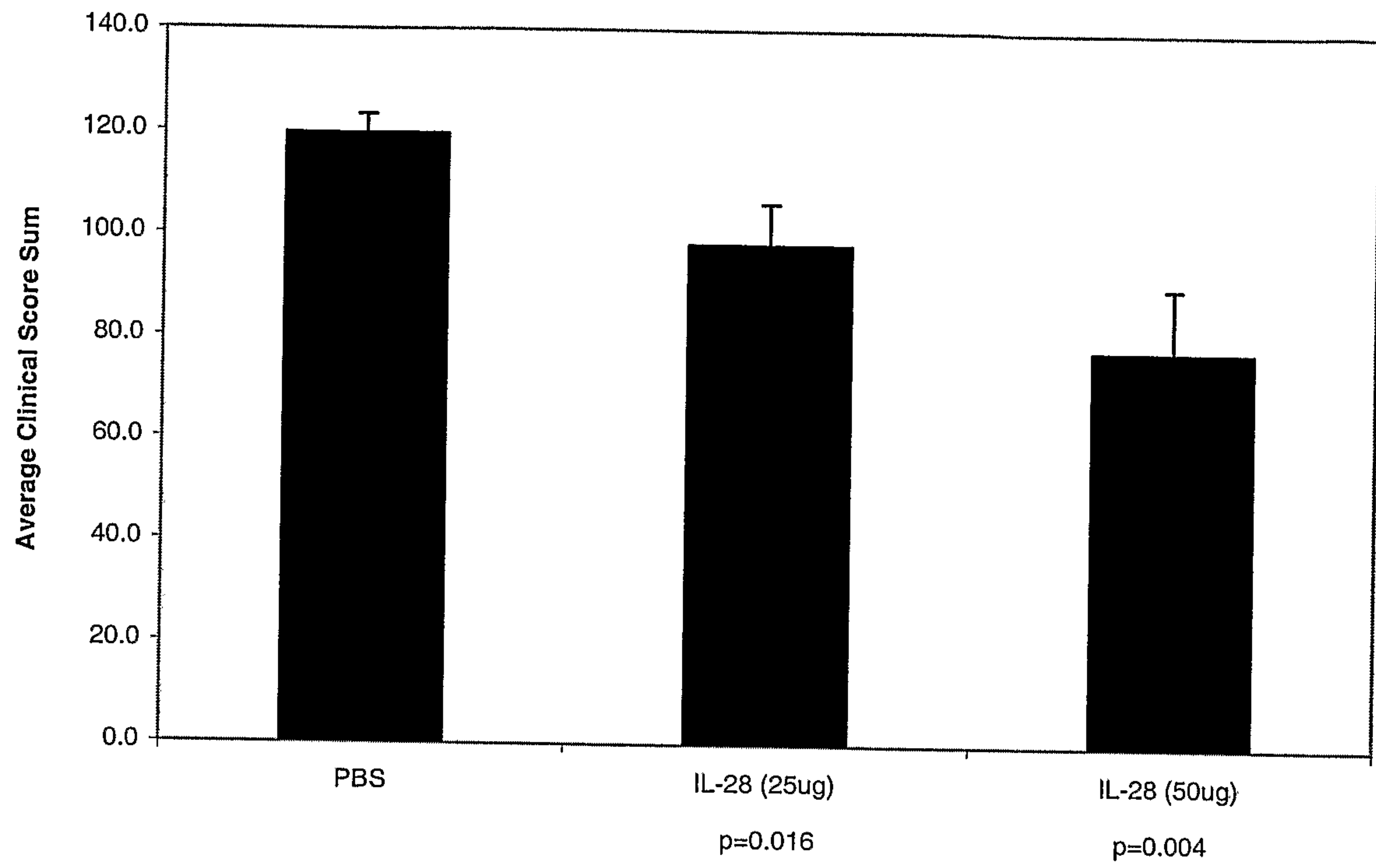


Figure 11

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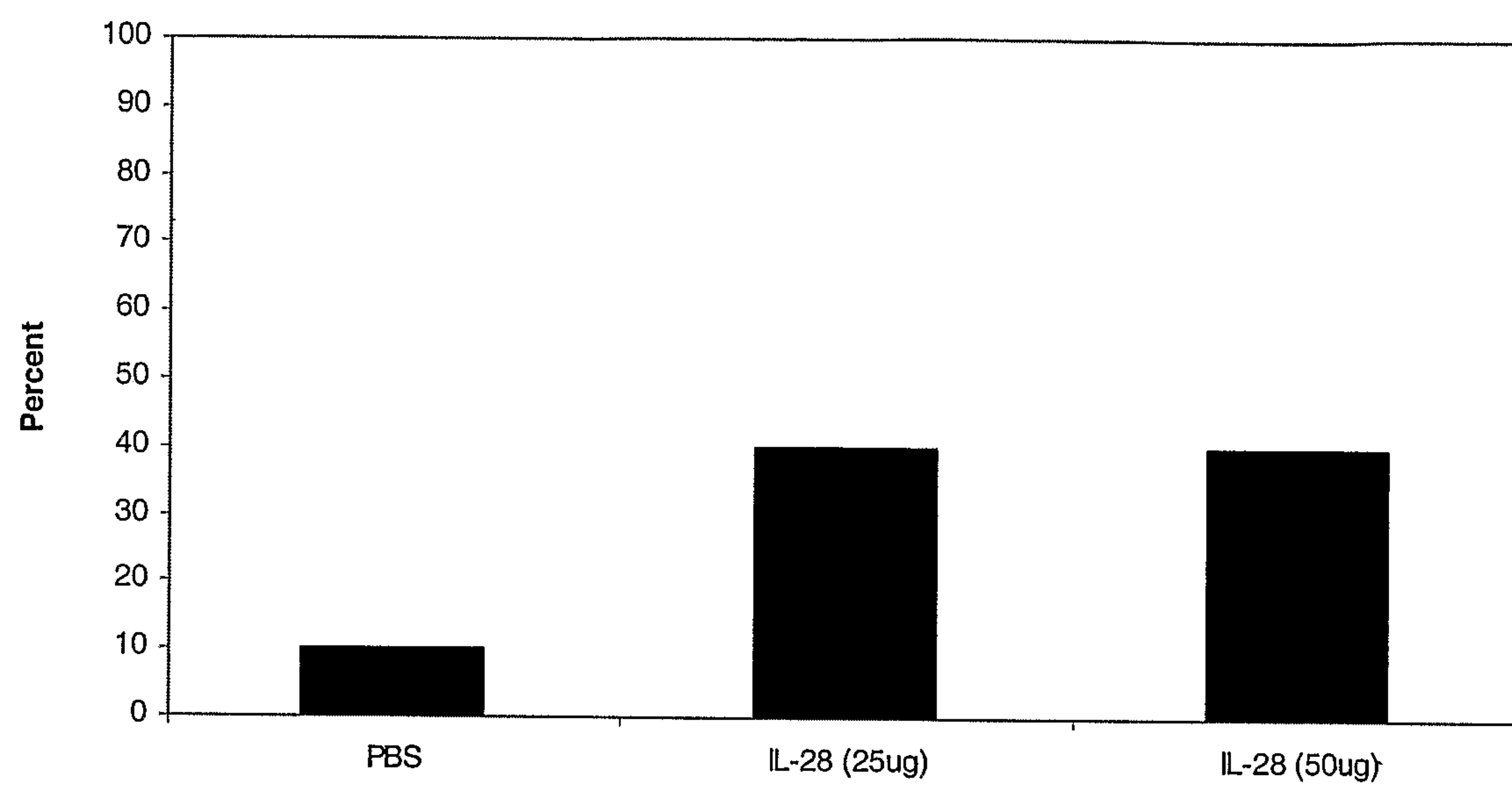


Figure 12

