

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau



(10) International Publication Number

WO 2014/136114 A1

(43) International Publication Date
12 September 2014 (12.09.2014)

WIPO | PCT

(51) International Patent Classification:
C07K 14/525 (2006.01) *C12N 15/82* (2006.01)

(21) International Application Number:
PCT/IL2014/050228

(22) International Filing Date:
6 March 2014 (06.03.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/773,431 6 March 2013 (06.03.2013) US
61/773,401 6 March 2013 (06.03.2013) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

— with sequence listing part of description (Rule 5.2(a))

(54) Title: TNF alpha INHIBITOR POLYPEPTIDES, POLYNUCLEOTIDES ENCODING SAME, CELLS EXPRESSING SAME AND METHODS OF PRODUCING SAME

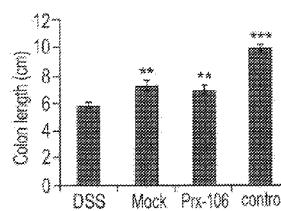


FIG. 14A

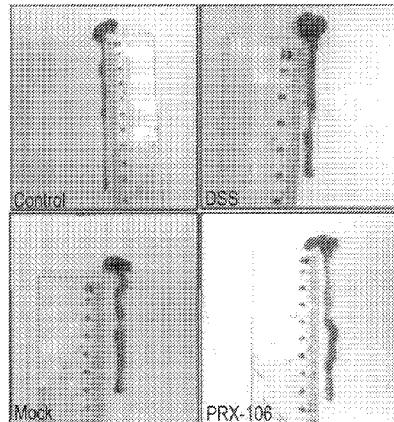


FIG. 14B

(57) Abstract: A plant produced TNF alpha polypeptide inhibitor is provided. Also provided are methods of generating and using same.

TNF alpha INHIBITOR POLYPEPTIDES, POLYNUCLEOTIDES ENCODING
SAME, CELLS EXPRESSING SAME AND METHODS OF PRODUCING SAME

FIELD AND BACKGROUND OF THE INVENTION

5 The present invention, in some embodiments thereof, relates to TNF alpha inhibitor polypeptides, polynucleotides encoding same, cells expressing same and methods of producing same.

10 Tumor necrosis factor alpha (TNF α) is an important, pro-inflammatory cytokine mediating the regulation of diverse inflammatory, infectious and immune-related processes and diseases, TNF α being considered the most important mediator responsible for inflammatory pathology.

15 TNF-alpha is a 17 kD molecular weight protein, initially synthesized as a transmembrane protein arranged in stable trimers, then cleaved by metalloprotease-TNF alpha converting enzyme (TACE) to form the homotrimeric soluble TNF (sTNF) which engages to its cognate receptors (TNFR1, p55 and TNFR2, p75), expressed ubiquitously. The ubiquitous TNF receptors provide the basis for the wide variety of TNF-alpha mediated cellular responses.

20 TNF-alpha induces a wide variety of cellular responses, many of which result in deleterious consequences, such as cachexia (loss of fat and whole body protein depletion, leading to anorexia, common in cancer and AIDS patients) and septic shock. Elevated secretion of TNF-alpha has been implicated in a variety of human diseases including diabetes, allograft rejection, sepsis, inflammatory bowel diseases, osteoporosis, in many autoimmune diseases such as multiple sclerosis, rheumatoid 25 arthritis, psoriasis, psoriatic arthritis, hypersensitivity, immune complex diseases, and even in malaria, cancer and lung fibrosis.

25 The biological effect of TNF α is mediated by the two distinct receptors. TNF-alpha receptors, when shed from mononuclear cells, lower the TNF-alpha levels by “mopping up” and acting as natural inhibitors. Neutralization of TNF α by specific antibodies and decoy receptors has become a common strategy for regulation of TNF α mediated toxicity.

30 To date, five protein-based TNF α antagonists have been approved by the US FDA for clinical use: Cimzia (Certolizumab pegol), a TNFmAb Fab' fragment-PEG

conjugate; Remicade (Infliximab), a TNF rmAB; Humira (Adalimumab, a TNF rmAB, Simponi™ (Golimumab), an anti-TNF and etanercept, a fusion protein of soluble 75 kDa TNF α receptors fused to the Fc fragment of human IgG (registered as Enbrel™).

Etanercept is indicated for rheumatoid arthritis (RA) and other arthritic indications such as juvenile idiopathic arthritis (JIA), psoriasis and Ankylosing Spondylitis (AS). Rheumatoid arthritis (RA) is a chronic disease that affects approximately five million people World Wide. Nearly 500,000 patients worldwide across indications are treated with Enbrel. Enbrel sales in 2010 were 7.8 billion dollars and the total anti-TNF market amounted to 24.04 Billion dollars. Clinical trials of Enbrel therapy, current or completed, include such diverse indications as adult respiratory distress syndrome, pemphigus, Alzheimer's disease, Behcet's syndrome, HIV, myocardial infarct, knee joint synovitis, lupus nephritis, lichen planus, systemic amyloidosis, sciatica, vitiligo, chronic fatigue syndrome, anorexia, TMJ, asthma, bronchitis, diabetes, myelodysplastic disease and others.

Enbrel is currently produced in mammalian cells. The safety of biopharmaceuticals has recently come to the forefront for both patients and health care providers due to outbreaks of emerging pathogens, most notably HIV, HCV, Cruezfeld-Jacob's Disease, West Nile Virus and SARS, in multiple regions of the world, emphasizing the risk of pathogen transmission through the use of human- or animal-derived raw materials, such as blood-derived products (serum, plasma cell medium components, etc) in the manufacture of biopharmaceuticals. For example, approximately half (!) of the hemophilia population contracted HIV until identification and screening for the virus became widespread.

Screening and testing have improved recently, reducing the threat of pathogen transmission, but risks still remain from plasma-derived additives during recombinant manufacturing processes. In particular, the risk from unknown pathogens is significant, as these agents may appear in the blood supply in the future and could have a significant impact on safety of mammalian-cell-based biopharmaceuticals. Of particular concern are biopharmaceutical drugs which require repeated, regular administrations, specifically via injection, increasing the cumulative risk to the patient.

However, eliminating animal-derived components from media can significantly alter culture performance as well as post-translational protein modifications. The

glycosylation pattern of an antibody molecule can affect its structural integrity, thus influencing its biological function, physicochemical properties and pharmacokinetics, altering both efficacy and safety, particularly immunogenicity. Although no major outbreaks have occurred in recent years, it is still critical to reduce dependence on blood and plasma components in the manufacture of biopharmaceuticals. Conversely, recombinant protein production in mammalian cell culture is unsafe due to xeno contaminations. In 2009 Genzyme was forced to temporarily close its main factory because of viral contamination. It did not restore full supplies of the drugs until 2011. Due to the shortage in the only approved drug for Fabry patients in the US, some people with Fabry disease have suffered heart or kidney problems and one or more may have even died because of the shortage.

Non-mammalian cells, for example plant cell culture is one promising development.

Biopharmaceuticals, including modified human proteins, can be produced in transgenic plants in order to address problems of safety, viral infections, immune reactions, production yield and cost. US Patent No. 6,391,638 and PCT WO2008/135991 teach bioreactor devices for commercial-scale production of recombinant polypeptides from plant cell culture. US Patent No. 7,951,557, US Patent Application Nos. 10/554,387 and 11/790,991 teach construction and expression of nucleic acid vectors for recombinant expression of human proteins in plant cells. PCT WO2007/010533 teaches the expression of recombinant human polypeptides in plant cells, for enteral administration.

Additional background art includes: US Patent NO. 7,915,225 to Finck et al, US Patent Applications Nos. 13/021,545 and 10/853,479 to Finck et al, US Patent Application No. 11/906,600 to Li et al, US Patent Application No. 10/115,625 to Warren et al and US Patent Application No. 11/784,538 to Gombotz et al.

SUMMARY OF THE INVENTION

According to an aspect of some embodiments of the present invention there is provided a plant produced TNF α polypeptide inhibitor.

According to some embodiments of the invention, the TNF α polypeptide inhibitor is an anti-TNF α antibody.

According to some embodiments of the invention, the anti-TNF α antibody the anti-TNF α antibody is selected from the group consisting of infliximab, adalimumab, certolizumab pegol and golimumab.

According to some embodiments of the invention, the TNF α polypeptide inhibitor is a soluble TNFR fragment, which specifically binds TNF α .

According to some embodiments of the invention, the soluble TNFR fragment is part of a chimeric polypeptide.

According to some embodiments of the invention, the TNF α polypeptide inhibitor, wherein the chimeric polypeptide comprises:

- 10 (i) a first domain which comprises a TNF α binding domain of a TNF receptor; and
- (ii) a second domain which comprises an Fc domain of an immunoglobulin; wherein the first domain and the second domain are N-terminally to C-terminally respectively sequentially translationally fused and wherein the chimeric polypeptide specifically binds TNF α .

15 According to some embodiments of the invention, the chimeric polypeptide further comprises a third domain which comprises an endoplasmic reticulum retention signal, wherein the first domain, second domain and third domain are N-terminally to C-terminally respectively sequentially translationally fused.

According to some embodiments of the invention, the TNF α polypeptide inhibitor comprises an additional domain encoding an endoplasmic reticulum signal peptide translationally fused N-terminally to the first domain.

According to some embodiments of the invention, the signal peptide is a plant signal peptide.

According to some embodiments of the invention, the plant signal peptide is as set forth in SEQ ID NO: 4.

According to some embodiments of the invention, the first domain is 200-250 amino acids long.

According to some embodiments of the invention, the first domain comprises the amino acid sequence LCAP (SEQ ID NO: 11) and VFCT (SEQ ID NO: 12).

30 According to some embodiments of the invention, the first domain further comprises the amino acid sequence LPAQVAFXPYAPEPGSTC (SEQ ID NO: 13).

According to some embodiments of the invention, the first domain is as set forth in SEQ ID NO: 2.

According to some embodiments of the invention, the immunoglobulin is IgG₁.

According to some embodiments of the invention, the second domain is as set forth in SEQ ID NO: 9.

According to some embodiments of the invention, the chimeric polypeptide is as set forth in SEQ ID NO: 6.

According to some embodiments of the invention, the chimeric polypeptide is as set forth in SEQ ID NO: 7, 204 OR 205 or 214.

According to some embodiments of the invention, the chimeric polypeptide is capable of inhibiting TNF α -induced apoptosis.

According to some embodiments of the invention, the TNF α polypeptide inhibitor comprises a plant-specific glycan.

According to some embodiments of the invention, the plant-specific glycan is selected from the group consisting of a core xylose and a core α -(1,3) fucose.

According to some embodiments of the invention, the polypeptide is purified to at least 98 % homogeneity.

According to some embodiments of the invention, the TNF α polypeptide inhibitor is capable of inhibiting TNF α -induced apoptosis.

According to an aspect of some embodiments of the present invention there is provided an isolated polynucleotide comprising a nucleic acid sequence encoding the TNF α polypeptide inhibitor.

According to some embodiments of the invention, a codon usage of the nucleic acid sequence is optimized for *Nicotinia tabaccum*.

According to some embodiments of the invention, the isolated polynucleotide is as set forth in SEQ ID NO: 5.

According to an aspect of some embodiments of the present invention there is provided a nucleic acid expression construct comprising a nucleic acid sequence encoding the polynucleotide and a cis-acting regulatory element active in a plant cell.

According to some embodiments of the invention, the cis-acting regulatory element is a promoter.

According to an aspect of some embodiments of the present invention there is provided a plant cell comprising the nucleic acid construct.

According to some embodiments of the invention, the plant cell is of a *Nicotiana tabacum* plant.

5 According to some embodiments of the invention, the *Nicotiana tabacum* L. cv plant cell is a Bright Yellow (BY-2) cell.

According to some embodiments of the invention, the plant cell is lyophilized.

According to an aspect of some embodiments of the present invention there is provided a plant cell suspension culture comprising the plant cell.

10 According to an aspect of some embodiments of the present invention there is provided a pharmaceutical composition comprising as an active ingredient the polypeptide and a pharmaceutically acceptable carrier.

15 According to an aspect of some embodiments of the present invention there is provided a pharmaceutical composition comprising as an active ingredient the plant cell and a pharmaceutically acceptable carrier.

According to an aspect of some embodiments of the present invention there is provided a method of treating a TNF α -associated medical condition in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of the polypeptide, thereby treating the TNF α -associated medical condition in 20 the subject.

According to an aspect of some embodiments of the present invention there is provided a method of treating a TNF α -associated medical condition in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of the plant cells, thereby treating the TNF α -associated medical condition in the 25 subject.

According to some embodiments of the invention, the polypeptide is for use in treating a TNF α -associated medical condition in a subject.

According to some embodiments of the invention, the plant cells are for use in treating a TNF α -associated medical condition in a subject.

30 According to an aspect of some embodiments of the present invention there is provided use of the polypeptide in treating a TNF α -associated medical condition in a subject.

According to an aspect of some embodiments of the present invention there is provided use of the plant cells in treating a TNF α -associated medical condition in a subject.

According to some embodiments of the invention, the medical condition is an inflammatory disease.

According to some embodiments of the invention, the medical condition is an autoimmune disease.

According to some embodiments of the invention, the medical condition is selected from the group consisting of rheumatoid arthritis, ankylosing spondyloarthritis, plaque psoriasis and juvenile idiopathic arthritis.

According to some embodiments of the invention, the medical condition is an inflammatory bowel disease.

According to some embodiments of the invention, the inflammatory bowel disease is selected from the group consisting of colitis and Crohn's disease.

According to some embodiments of the invention, the polypeptide is formulated for paraenteral administration.

According to some embodiments of the invention, the polypeptide is formulated for oral administration.

According to some embodiments of the invention, the medical condition is selected from the group consisting of rheumatoid arthritis, inflammatory bowel disease, sepsis, endotoxic shock, AIDS, endometriosis, psoriasis, cardiovascular disease, cancer, vitiligo, arthritis, rheumatoid polyarthritis, psoriatic rheumatism, ankylosing spondyloarthritis, plaque psoriasis, juvenile idiopathic arthritis, polyarticular juvenile idiopathic arthritis, psoriasis arthritis, Wegener's disease (granulomatosis), Crohn's disease, short bowel syndrome, ulcerative colitis, chronic obstructive pulmonary disease (COPD), Hepatitis C, asthma, cachexia, atopic dermatitis, Alzheimer's disease, hepatic encephalopathy, ADHD, chronic fatigue syndrome dermatitis herpetiformis (Duhring's disease), contact dermatitis, urticaria (including chronic idiopathic urticaria), autoimmune blistering diseases, including pemphigus vulgaris, bullous pemphigoid, myasthenia gravis, sarcoidosis, including pulmonary sarcoidosis, scleroderma, reactive arthritis, hyper IgE syndrome, multiple sclerosis and idiopathic hypereosinophil syndrome, and allergy.

According to some embodiments of the invention, the polypeptide is formulated for parenteral administration.

According to some embodiments of the invention, the plant cells are formulated for enteral administration and wherein the medical condition is not a obesity, metabolic syndrome, diabetes and a liver disease or disorder.

According to an aspect of some embodiments of the present invention there is provided a method of producing the polypeptide, comprising:

- providing a cell as described; and
- culturing the cell so as to produce the polypeptide.

According to some embodiments of the invention, the method further comprises isolating the polypeptide from the cell.

According to some embodiments of the invention, the cell is an isolated cell cultured in a plant cell culture medium.

According to some embodiments of the invention, the culturing is performed in a disposable bioreactor.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1 is a schematic illustration of the amino acid sequence of plant recombinant human (prh) TNFR2:Fc (also termed herein PRX-106, SEQ ID NO:6). prh TNFR2:Fc cDNA for expression in BY2 cells was assembled with a signal peptide for targeting the fusion polypeptide composed of the TNF-binding moiety of the TNF receptor and FC protein to the secretory pathway. Colour code for the amino acids sequence: the signal peptide is coloured in yellow; the TNF receptor portion is coloured in black (green); the Fc portion of IgG1 is in blue; ER retention signal in red.

FIGs. 2A-B show comparison of PRH TNFR2:FC and Commercial Enbrel by Western-blot. Prh TNFR2:Fc (lane 1) and commercial Enbrel (lane 2) were analyzed under reducing conditions (panel A) and non-reducing conditions (panel B) by 12 % and 8 % Tris-Glycine SDS-PAGE, respectively. Membranes were blotted with an anti FC antibody (upper panel) and with an anti TNFR2 antibody (lower panel). Molecular weight marker is shown in right lanes. Lane 1:PRH TNFR2:FC; Lane 2: commercial Enbrel.

FIG. 3 is a graph showing TNF α binding by prh TNFR2:Fc and commercial Enbrel by quantitative non radioactive assay for prh TNFR2:Fc binding activity and molecular integrity. An ELISA plate pre-coated with antibodies against TNF α , was incubated with TNF α followed by exposure to commercial Enbrel and supernatant from BY2 cells expressing prh TNFR2:Fc. Serial dilutions of both tested items are shown in the X axis. Fc portion of the molecule was detected with Goat anti human IgG Fc HRP.

FIG. 4 is an image showing screening of individual cell lines for expression of prh TNFR2:Fc by Western blot analysis.

FIGs. 5A-F are images showing TNF α cytotoxicity in A375 cells in the presence of prh TNFR2:Fc or commercial Enbrel by MTT viability assay. FIG. 5A-untreated Cultured A375 cells; FIG. 5B-treated with TNF α ; FIG. 5C- TNF α exposed cells treated with prh TNFR2:Fc (3.125 ng/ml) ; FIG. 5D- TNF α exposed cells treated with commercial Enbrel (3.125 ng/ml); FIG. 5E- TNF α exposed cells treated with prh TNFR2:Fc (100 ng/ml); FIG. 5F- TNF α exposed cells treated with commercial Enbrel (100 ng/ml).

FIG. 5G is a bar graph showing showing TNF α cytotoxicity in A375 cells in the presence of prh TNFR2:Fc or commercial Enbrel by MTT viability assay.

FIGs. 6A-F are images showing TNF α cytotoxicity in L929 cells in the presence of prh TNFR2:Fc or commercial Enbrel by MTT viability assay. FIG. 6A-untreated Cultured L929 cells; FIG. 6B-treated with TNF α ; FIG. 6C- TNF α exposed cells treated with prh TNFR2:Fc (3.125 ng/ml); FIG. 6D- TNF α exposed cells treated with commercial Enbrel (3.125 ng/ml); FIG. 6E- TNF α exposed cells treated with prh TNFR2:Fc (100 ng/ml) ; FIG. 6F- TNF α exposed cells treated with commercial Enbrel (100 ng/ml).

FIG. 6G is a bar graph showing are images showing TNF α cytotoxicity in L929 cells in the presence of prh TNFR2:Fc or commercial Enbrel by MTT viability assay.

FIGs. 7A-B are graphs showing body weight changes following TNBS challenge. Mice were orally administered with prh TNFR2:Fc 6 hours after TNBS induction, For four consecutive days body weights were determined daily (means \pm SE). FIG. 7A - Average weight loss at day four following treatment with TNBS, presented in % loss from original weight. column 1-saline control (n=15); column 2-Mock -host plant control cells (BY2-; n=15); column 3-PRX-106- plant cells expressing recombinant TNFR2:Fc (doseI) (n=15); column 4-PRX-106- plant cells expressing recombinant TNFR2:Fc (dose II) (n=7); column 5- Dexametason treated mice (n=10); column 6-control mice (n=5). FIG. 7B- Average weight loss during four days following treatment with TNBS, presented in % loss from original weight. Note oral treatment with plant cells expressing recombinant TNFR2:Fc attenuated body weight reduction.

FIG. 8 is a bar graph showing that oral administration of plant cells expressing TNFR2:Fc inhibits TNBS-induced colonic shorting. The mice with colitis were orally administered with plant cells expressing TNFR2:Fc for four consecutive days after TNBS induction and the colon lengths were determined at day 4 (means \pm SE). From left to right : Column 1- control mice (n=5); column 2- saline control (n=15); column 3-Mock -host plant control cells (BY2-; n=15); column 4- PRX-106- plant cells expressing recombinant TNFR2:Fc (doseI) (n=15); column 5- PRX-106- plant cells expressing recombinant TNFR2:Fc (dose II) (n=7); column 6 - Dexametason treated mice (n=10)

FIG. 9 is a bar graph showing that oral administration of plant cells expressing TNFR2:Fc improved the macroscopic futures of TNBS-induced colitis. Total macroscopic inflammation scores (Wallace score) in control and treated rats at the end-

point of the experiment (means \pm SE). Column 1- control mice (n=5); column 2- saline control (n=15); column 3- Mock -host plant control cells (BY2-; n=15); column 4- PRX-106- plant cells expressing recombinant TNFR2:Fc (doseI) (n=15); column 5- PRX-106- plant cells expressing recombinant TNFR2:Fc (dose II) (n=7); column 6 -

5 Dexametason treated mice (n=10).

FIGs. 10A-C are bar graphs showing serum cytokine content in mice treated by oral administration of plant cells expressing TNFR2:Fc as measured by a cytokine antibody array. Sera from groups treated with Mock- host plant control cells (BY2-) (n=15) and Plant cells expressing recombinant TNFR2:Fc protein dose I (n=15), and 10 dose II (n=7) were collected and subjected to cytokine magnetic Luminex assay. TNBS -saline control (n=15); Mock -host plant control cells (BY2-; n=15); PRX-106- plant cells expressing recombinant TNFR2:Fc (doseI) (n=15); PRX-106- plant cells expressing recombinant TNFR2:Fc (dose II) (n=7); Dexametason treated mice (n=10); control mice (n=5).

15 FIGs. 11A-B show serum cytokine content by cytokine Antibody array. FIG. 11A - Sera from groups treated with Mock- host plant control cells (BY2-) (n=15) and plant cells expressing recombinant TNFR2:Fc protein dose I (n=15), and dose II (n=7) were pooled, collected and subjected to cytokine antibody array analysis. FIG. 11B - Cytokine quantification of array. Results indicate that treatment with PRX-106 reduced 20 level of inflammatory mediators like granulocyte colony-stimulating factor G-CSF, macrophage colony-stimulating factor (M-CSF), potentially indicating reduced systemic inflammation by lowering systemic recruitment of bone marrow derived cells from the bloodstream.

25 FIG. 12 is a bar graph showing expansion of splenic Treg population in animals treated with plant cells expressing recombinant TNFR2:Fc. Spleen of Balb/c mice, treated with PRX-106 during TNBS induced colitis were analyzed for the percentages of CD4+CD25+Foxp3+, bars indicate SE. Column 1-saline control (n=15); column 2- Mock -host plant control cells (BY2-; n=15); column 3-PRX-106- plant cells expressing 30 recombinant TNFR2:Fc (doseI) (n=15); column 4-PRX-106- plant cells expressing recombinant TNFR2:Fc (dose II) (n=7); column 5- Dexametason treated mice (n=10); column 6 -control mice (n=5).

FIGs. 13A-B are graphs showing body weight changes following DSS challenge. The mice with colitis were orally administered with plant cells expressing TNFR2:Fc for seven consecutive days 24 hours after DSS induction and the body weights of mice were determined (means \pm SE). FIG. 13A - Average weight loss at day ten following treatment with DSS, presented in % loss from original weight. column 1- saline control (n=10); column 2- Mock -host plant control cells (BY2-; n=10); column 3-oral administration of plant cells expressing recombinant TNFR2:Fc (n=10); column 4-control mice (n=5). FIG. 13B - Average weight loss during ten days following treatment with DSS, presented in % loss from original weight. Note oral treatment with PRX- 106- plant cells expressing recombinant TNFR2:Fc attenuated body weight reduction.* P<0.05, ** P<0.01, *** P<0.001

FIGs. 14A-B show that oral administration of TNFR2:Fc inhibited DSS-induced colonic shorting. The mice with colitis were orally administered with plant cells expressing recombinant TNFR2:Fc for 7 consecutive days after DSS induction and the colon lengths were determined at day 10 (means \pm SE). FIG. 14A - Column 1-saline control (n=10); column 2- Mock -host plant control cells (BY2-; n=10); column 3- plant cells expressing recombinant TNFR2:Fc (n=10); column 4-control mice(n=5). FIG. 14B - Representative photograph of colons, ten days after the induction of DSS colitis.

FIGs. 15 A-C are graphic presentations of cytokine profile in colons obtained from treated mice. Cytokine secretion by ex vivo-cultured punch biopsies harvested from the colon of Column 1-DSS treated mice receiving saline control (n=10); column 2- DSS treated mice receiving Mock -host plant control cells (BY2-; n=10); column 3- DSS treated mice receiving plant cells expressing 30 μ g recombinant TNFR2:Fc (n=10); column 4-control untreated mice (n=5).

FIGs. 16A-C are graphic presentations of serum cytokine content assayed by cytokine Antibody array. Sera from mice treated with Mock- host plant control cells (BY2-) n=15 and Plant cells expressing recombinant TNFR2:Fc protein (n=10), were collected and subjected to cytokine magnetic Luminex assay.Column 1-saline control (n=10); column 2- Mock -host plant control cells (BY2-; n=10); column 3-oral administration of plant cells expressing recombinant TNFR2:Fc (n=10); column 4- control mice (n=5). * P<0.05.

FIGs. 17A-B show that therapeutic treatment with orally administered plant cells expressing recombinant TNFR2:Fc reduces the severity of DSS-induced colitis. FIG. 17A - Representative histological sections were examined microscopically after H&E staining with magnification x40 and x100. The images are representative of at least seven mice per group. FIG. 17B - The effect of orally administered plant cells expressing recombinant TNFR2:Fc on histological colitis score was determined. White square - plant cells expressing recombinant TNFR2:Fc (n=7), Gray square - Mock -host plant control cells (BY2-; n=10), Black square -saline control (n=8). ** P<0.01, *** P<0.001.

FIG. 18 is a bar graph showing pharmacokinetics of TNFR2:Fc in rat sera. Oral administration of plant cells expressing recombinant TNFR2:Fc was initiated by free feeding. Rats (n=6) received plant cells expressing recombinant TNFR2:Fc. Negative controls received the same volumes of host BY2(-) plant.

FIG. 19 is a bar graph showing pharmacokinetics of TNFR2:Fc in rat sera following oral administration of plant cells expressing recombinant TNFR2:Fc by gavage. Rats (n=6) received plant cells expressing recombinant TNFR2:Fc. Negative controls received the same volumes of host BY2(-) plant.

FIG. 20 shows the PRX-106 sequence (SEQ ID NO: 6) elucidated by mass-spec (green shows 84.8 % coverage).

20 DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to chimeric polypeptides, polynucleotides encoding same, cells expressing same and methods of producing same.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details set forth in the following description or exemplified by the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

TNF α promotes the inflammatory response, which in turn causes many of the clinical problems associated with inflammatory, cancerous and autoimmune disorders such as rheumatoid arthritis, ankylosing spondylitis, Crohn's disease, short bowel syndrome, psoriasis, hidradenitis suppurativa and refractory asthma. These disorders are

sometimes treated by using a TNF inhibitor. Over the last decade, the FDA has approved a number of recombinant proteins as TNF α inhibitors for the treatment of leading indications, among them are Etanercept, infliximab, adalimumab, certolizumab pegol and golimumab.

5 The production of recombinant proteins in mammalian cell systems is hampered by cellular fragility and the complex nutritional requirements of cells and the possible contamination of the final product with virus or prions.

10 Etanercept is a tumor necrosis factor (TNF) blocker indicated for a number of inflammatory conditions such as rheumatoid arthritis, polyarticular juvenile idiopathic arthritis, plaque psoriasis, psoriatic arthritis and ankylosing spondylitis. Etanercept is produced by recombinant DNA technology in Chinese hamster ovary mammalian cell expression system.

15 Whilst reducing the present invention to practice, the present inventors have constructed an expression vector for recombinant expression of Enteracept (hereinafter, prh TNFR2:Fc) in plant cells, transformed tobacco cells with the vector, and have isolated catalytically active protein from the cell cultures. The expressed recombinant protein retains its TNF α binding activity and have shown favorable catalytic activity as evidenced by its apoptosis regulatory activity.

20 Thus, according to an aspect of the present invention, there is provided a plant produced TNF α polypeptide inhibitor.

25 A "TNF α polypeptide inhibitor" as used herein refers to a polypeptide that binds TNF α and inhibits and/or hinders TNF α activity as reflected in TNF α binding to a TNF α -receptor (TNFR) including any of the following: (a) TNFR, preferably endogenous (i.e., native to the individual or host), cell membrane bound TNFR; (b) the extracellular domain(s) of TNFR; and/or (c) the TNF α binding domains of TNFR (which may be a portion of the extracellular domain). According to a specific embodiment, inhibition of TNF α binding to the receptor is by at least 50 %, e.g., 50-100 %, 50-95 %, 60-90 % or even 70-90 %.

30 TNF α inhibitors include, but are not limited to, soluble TNFR (i.e., non-membrane bound) or a portion (fragment) thereof, which specifically binds TNF α and anti-TNF α antibodies.

As used herein, the "biological activity" of a TNF α inhibitor is to bind to TNF α and inhibit and/or hinder TNF α from binding to any of the following: (a) TNFR, preferably endogenous, cell membrane bound TNFR; (b) the extracellular domain(s) of TNFR; and (c) the TNF α binding domains of TNFR (which may be a portion of the extracellular domain). A TNF α inhibitor can be shown to exhibit biological activity using assays known in the art to measure TNF α activity and its inhibition, an example of which is provided herein.

As used herein, the terms "TNF receptor polypeptide" and "TNFR" refer to polypeptides derived from TNFR (from any species e.g., human) which are capable of binding TNF α . Two distinct cell-surface TNFRs have been described: Type II TNFR (or p75 TNFR or TNFRII) and Type I TNFR (or p55 TNFR or TNFRI). The mature full-length human p75 TNFR is a glycoprotein having a molecular weight of about 75-80 kilodaltons (kD). The mature full-length human p55 TNFR is a glycoprotein having a molecular weight of about 55-60 kD. The preferred TNFR polypeptides of this invention are derived from TNFR Type I and/or TNFR type II. Exemplary accession numbers are provided hereinbelow. According to a specific embodiment, the TNFR is capable of binding TNF α in a specific manner e.g., Kd below 10^{-5} M.

According to a specific embodiment, the soluble TNFR fragment is part of a chimeric polypeptide.

A "chimeric polypeptide" or "fusion polypeptide" is a polypeptide comprising regions in a different position than occurs in nature. The regions may normally exist in separate proteins and are brought together in the chimeric or fusion polypeptide, or they may normally exist in the same protein but are placed in a new arrangement in the chimeric or fusion polypeptide. A chimeric or fusion polypeptide may also arise from polymeric forms, whether linear or branched, of TNFR polypeptide(s).

As used herein, an "extracellular domain" of TNFR refers to a portion of TNFR that is found between the amino-terminus of TNFR and the amino-terminal end of the TNFR transmembrane region. The extracellular domain of TNFR binds TNF α .

The terms "polypeptide", "peptide" and "protein" are used interchangeably herein to refer to polymers of amino acids of any length. The terms also encompass an amino acid polymer that has been modified; for example, disulfide bond formation, glycosylation, lipidation, or conjugation with a labeling component.

Specific examples of TNF α polypeptide inhibitors include, but are not limited to, infliximab (RemicadeTM) and adalimumab (HumiraTM), which consist of, chimeric human-mouse anti-TNF α monoclonal antibodies and fully human anti-TNF-alpha monoclonal antibodies, respectively. Another example of an anti-TNF α antibody which can be used in accordance with the present teachings include golimumab (SimponiTM) and certolizumab pegol (CimziaTM), the latter being a pegylated antibody and as such requires a modification following recombinant polypeptide production.

Also included under this definition are chimeric polypeptides which include the commercial etanercept (further described hereinbelow) and Lenercept (a chimeric polypeptide consisting of p55sTNF-RI-IgG1) under their scope. Such chimeric polypeptides are further described hereinbelow.

Thus, according to a specific embodiment the TNF α polypeptide inhibitor is a chimeric polypeptide comprising:

- (i) a first domain which comprises a TNF α binding domain of a TNF receptor and
- (ii) a second domain which comprises an Fc domain of an immunoglobulin, wherein said first domain and said second domain are N-terminally to C-terminally respectively sequentially translationally fused and wherein the chimeric polypeptide specifically binds TNF α .

As used herein the term “plant produced” refers to the chemical signature associated with plant expression, including, but not limited to, host cell impurities in the preparation which comprises the chimeric polypeptide and glycosylation patterns on the chimeric polypeptide *per se*.

As used the term “TNF α ” refers to Tumor necrosis factor-alpha (TNF, cachexin, or cachectin) that is a cytokine involved in systemic inflammation and a member of a group of cytokines that stimulate the acute phase reaction. TNF α is produced primarily by activated macrophages (M1), although it can be produced by many other cell types as CD4+ lymphocytes, NK cells and neurons. The protein is encoded by TNFA gene and has the Ref_seq number: NP_000585. The protein is known to stimulate an inflammatory response (pro-inflammatory cytokine).

The first domain is thus composed of at least the TNF binding domain of a TNF receptor (TNFR). The first domain is a soluble protein. Thus according to a specific

embodiment, the first domain and even the entire chimeric polypeptide are soluble proteins which are not membrane anchored.

Soluble forms of TNFRs may include monomers, fusion proteins (also called "chimeric proteins), dimers, trimers or higher order multimers. In certain embodiments 5 of the invention, the soluble TNFR derivative is one that mimics the 75 kDa TNFR or the 55 kDa TNFR and that binds to TNF α in vivo. The soluble TNFR mimics of the present invention may be derived from TNFRs p55 or p75 or fragments thereof. TNFRs other than p55 and p75 also are useful for deriving soluble TNFR for treating the various 10 medical disorders described herein, such for example the TNFR that is described in WO 99/04001. Soluble TNFR molecules used to construct TNFR mimics include, for example, analogs or fragments of native TNFRs having at least 20 amino acids, that lack the transmembrane region of the native TNFR, and that are capable of binding TNF α . Such soluble forms of TNFR compete for TNF α with the receptors on the cell surface, 15 thus inhibiting TNF α from binding to cells, thereby preventing it from manifesting its biological activities. Binding of soluble TNFRs to TNF α can be assayed using ELISA or any other convenient assay.

According to a specific embodiment, the first domain is derived from TNFR2. (e.g., AAA36755).

According to an embodiment of the invention, the first domain is 200-250 amino 20 acids long.

According to a specific embodiment, the first domain comprises the amino acid sequence LCAP (SEQ ID NO: 11) and VFCT (SEQ ID NO: 12).

According to a specific embodiment, the first domain comprises the amino acid sequence LPAQVAFXPYAPEPGSTC (SEQ ID NO: 13) or 25 LPAQVAFTPYAPEPGSTC (SEQ ID NO: 17).

According to a specific embodiment, the first domain is as set forth in SEQ ID NO: 2 (encoded by SEQ ID NO: 1).

As used herein "an Fc domain of an immunoglobulin" refers to a region of a heavy chain of an antibody, typically comprising at least 2 constant domains (e.g., CH2 30 and CH3 domains, as these terms are defined in the art) of the heavy chain. The Fc domain may be obtained, for example, in the form of a dimer, by digestion of an antibody by papain. A dimer of Fc domain polypeptides, connected by disulfide bonds,

forms the “tail” region of an antibody. As is known in the art, Fc domains of some classes of antibodies may be in the form of multimers. Thus, the Fc domain is optionally monomeric, optionally dimeric and optionally multimeric. Optionally, the polypeptide described herein is in the form of a dimer, the polypeptide comprising an Fc dimer, or in the form of a multimer, the polypeptide comprising an Fc multimer.

The Fc domain may encompass modified forms of a native Fc domain (i.e., a domain which occurs naturally in an antibody), for example, polypeptides having at least 90 % homology, optionally at least 95 % homology, and optionally at least 98 % homology, to a native Fc domain. Modified Fc domains are described, for example, in International Patent Applications WO 97/34631 and WO 96/32478.

Optionally, a native Fc is modified so as to remove sites which provide structural features or biological activity that are not required for embodiments of the present invention. Examples of such sites include residues that affect or are involved in disulfide bond formation, incompatibility with a selected host cell, N-terminal heterogeneity upon expression in a selected host cell, glycosylation, interaction with complement, binding to an Fc receptor (other than a neonatal Fc receptor), and/or antibody-dependent cellular cytotoxicity.

The polypeptide according to embodiments of the present invention may also comprise a fragment of an Fc domain. Optionally, the fragment comprises at least 20 %, optionally at least 50 %, and optionally at least 80 % of an Fc domain, as defined hereinabove.

The Fc domain or fragment thereof optionally includes a binding site for a neonatal Fc receptor (FcRn). This is of particular significance when administering the chimeric polypeptide via an enteral route.

According to one embodiment, attachment of an Fc domain or a fragment thereof to the first domain results in a polypeptide having a longer half-life *in vivo* than the first domain *per se*. This may be due to the long serum half-life of the Fc domain (which may be due to salvage of the Fc via binding to FcRn) and/or due to the greater size of the polypeptide in comparison to the first domain *per se*, which reduces clearance from the bloodstream by glomerular filtration. According to another embodiment, the resulting polypeptides have reduced immunogenicity as compared to the first domain *per se*.

According to optional embodiments, the Fc domain or fragment thereof is a human Fc domain (e.g., derived from a human antibody) or fragment thereof.

According to exemplary embodiments, the Fc domain (or fragment thereof) is an IgG (e.g., IgG1) Fc domain (or fragment thereof).

5 According to a specific embodiment, the second domain is as set forth in SEQ ID NO: 9 (encoded by SEQ ID NO: 8).

Thus, the second domain of the chimeric polypeptide comprises at least a portion of a constant immunoglobulin domain, e.g. a constant heavy immunoglobulin domain or a constant light immunoglobulin domain. Preferably, the second domain comprises at 10 least a portion of a constant heavy immunoglobulin domain. The constant heavy immunoglobulin domain is preferably an Fc fragment comprising the CH2 and CH3 domain and, optionally, at least a part of the hinge region. The immunoglobulin domain may be an IgG, IgM, IgD or IgE immunoglobulin domain or a modified immunoglobulin domain derived, therefrom. Preferably, the second domain comprises at 15 least a portion of a constant IgG immunoglobulin domain. The IgG immunoglobulin domain may be selected from IgG1, IgG2, IgG3 or IgG4 domains or from modified domains such as are described in U.S. Pat. No. 5,925,734. The immunoglobulin domain may exhibit effector functions. In some embodiments, however, modified immunoglobulin domains having modified, e.g. at least partially deleted, effector 20 functions may be used. Thus for example, the receptor.

According to an embodiment of the invention the chimeric fusion of the first domain and the second domain forms Etanercept (Immunex) having SEQ ID NO: 10.

It will be appreciated that the species origin of the first domain and the second domain is selected according to the treated subject. Thus, according to a specific 25 embodiment, the first domain and the second domain are of human origin or modified such that they don't incur immunogenic reaction when administered to human subjects.

As used herein "Etanercept" and "EnbrelTM" are interchangeably used to designate the commercially available TNFR2:Fc by Immunex Corporation. Etanercept is a dimeric fusion polypeptide consisting of the extracellular ligand-binding portion of 30 the human 75 kilodalton (p75) tumor necrosis factor receptor (TNFR) linked to the Fc portion of human IgG1. The Fc component of etanercept contains the constant heavy 2

(CH2) domain, the constant heavy 3 (CH3) domain and hinge region, but not the constant heavy 1 (CH1) domain of human IgG1.

According to another embodiment of the invention there is provided a chimeric polypeptide comprising:

5 (i) a first domain which comprises a TNF α binding domain of a TNF receptor;
(ii) a second domain which comprises an Fc domain of an immunoglobulin; and
(iii) a third domain comprising an endoplasmic reticulum retention signal;
wherein the first domain, second domain and third domain are N-terminally to C-terminally respectively sequentially translationally fused and wherein the chimeric 10 polypeptide specifically binds TNF α .

Thus, according to this aspect of the invention, the chimeric protein is expressed such that it is retained in the endoplasmic reticulum.

As used herein, the term "endoplasmic reticulum retention signal peptide" refers to a peptide sequence which, when present at the N- or C- terminus of a polypeptide, 15 causes the polypeptide to be retrieved from the Golgi apparatus, and retained in the endoplasmic reticulum (see Rayon et al. Journal of Experimental Botany, Vol. 49, No. 326, pp. 1463-1472, 1998; and Neumann, et al Annals of Botany, 2003;92:167-180). In one embodiment, the endoplasmic reticulum retention signal peptide is HDEL (SEQ ID NO: 14), KDEL (SEQ ID NO: 15) or SEKDEL (SEQ ID NO: 16).

20 As mentioned, the first domain and second domain (and third domain when present) are N-terminally to C-terminally respectively sequentially translationally fused. This means that the first domain is located N-terminally to the second domain (the carboxy terminus of the first domain is translationally fused to the N-terminus of the second domain), and the second domain is located N-terminally of the third domain (the carboxy terminus of the second domain is translationally fused to the N-terminus of the 25 third domain). Thus, the second domain is practically sandwiched by the first domain at the N-terminus and the third domain at the C-terminus. Schematic presentation is as follows: first domain>second domain(>third domain) are orderly oriented from the N-terminus to the C-terminus (see Figure 1). The linkage between the domains may be 30 direct or indirect by the use of linkers such as peptide linkers.

The molecule may further comprise an additional domain which encodes for an endoplasmic reticulum signal sequence which is oriented upstream (N-terminally) of the first domain and translationally fused thereto.

As used herein "an endoplasmic reticulum (ER) signal peptide" refers to a signal sequence, leader sequence or leader peptide that is a short (e.g., 5-30 amino acids long) peptide present at the N-terminus of the majority of newly synthesized proteins that are destined towards the secretory pathway.

According to a specific embodiment, the ER signal peptide is derived (taken) from a plant protein.

According to a specific embodiment, the endoplasmic reticulum signal peptide is from *N. plumbaginifolia* Calreticulin protein.

According to a further specific embodiment, the signal peptide from *N. plumbaginifolia* Calreticulin protein is as set forth in SEQ ID NO: 4 and encoded by the nucleic acid sequence of SEQ ID NO: 3.

As used herein the term "translationally fused at the N-terminal" or "translationally fused at the C-terminal" refers to covalent attachment of the indicated peptide via a peptide bond to the N-terminal or C-terminal amino acid of the respective domain typically as a result of recombinant expression.

According to a specific embodiment, the chimeric polypeptide is as set forth in SEQ ID NO: 6.

According to a specific embodiment, the chimeric polypeptide is as set forth in SEQ ID NO: 7, 204 OR 205 or 214.

As mentioned the recombinant chimeric proteins of the invention are produced in plant cells.

In order to express the inhibitory polypeptide, an isolated polynucleotide comprising a nucleic acid sequence encoding the chimeric polypeptide as described herein is ligated into a "plant nucleic acid expression construct".

As used herein the term "plant nucleic acid expression construct" refers to a nucleic acid construct which includes the nucleic acid of some embodiments of the invention and at least one promoter for directing transcription of nucleic acid in a host plant cell. Further details of suitable transformation approaches are provided hereinbelow.

According to some embodiments of the invention, there is provided a nucleic acid expression construct comprising the nucleic acid sequence of the invention, and a promoter for directing transcription of the nucleic acid sequence in a plant host cell.

As used herein the term "nucleic acid sequence" refers to a single or double stranded nucleic acid sequence which is isolated and provided in the form of an RNA sequence, a complementary polynucleotide sequence (cDNA), a genomic polynucleotide sequence and/or a composite polynucleotide sequences (e.g., a combination of the above).

As used herein the phrase "complementary polynucleotide sequence" refers to a sequence, which results from reverse transcription of messenger RNA using a reverse transcriptase or any other RNA dependent DNA polymerase. Such a sequence can be subsequently amplified *in vivo* or *in vitro* using a DNA dependent DNA polymerase.

As used herein the phrase "genomic polynucleotide sequence" refers to a sequence derived (isolated) from a chromosome and thus it represents a contiguous portion of a chromosome.

As used herein the phrase "composite polynucleotide sequence" refers to a sequence, which is at least partially complementary and at least partially genomic. A composite sequence can include some exon sequences required to encode the polypeptide of the present invention, as well as some intronic sequences interposing therebetween. The intronic sequences can be of any source, including of other genes, and typically will include conserved splicing signal sequences. Such intronic sequences may further include *cis* acting expression regulatory elements.

According to some embodiments of the present invention, the nucleic acid sequences encoding the polypeptides of the present invention are optimized for expression in plants. Examples of such sequence modifications include, but are not limited to, an altered G/C content to more closely approach that typically found in the plant species of interest, and the removal of codons atypically found in the plant species commonly referred to as codon optimization. In one embodiment, the codon usage of the nucleic acid sequence encoding the polypeptide e.g., chimeric polypeptide, is optimized for *Nicotiana tabacum* or *Nicotiana benthamiana*.

The phrase "codon optimization" refers to the selection of appropriate DNA nucleotides for use within a structural gene or fragment thereof that approaches codon

usage within the plant of interest. Therefore, an optimized gene or nucleic acid sequence refers to a gene in which the nucleotide sequence of a native or naturally occurring gene has been modified in order to utilize statistically-preferred or statistically-favored codons within the plant. The nucleotide sequence typically is examined at the DNA level and the coding region optimized for expression in the plant species determined using any suitable procedure, for example as described in Sardana et al. (1996, Plant Cell Reports 15:677-681). In this method, the standard deviation of codon usage, a measure of codon usage bias, may be calculated by first finding the squared proportional deviation of usage of each codon of the native gene relative to that of highly expressed plant genes, followed by a calculation of the average squared deviation. The formula used is: 1 SDCU = $n = 1 N [(X_n - Y_n) / Y_n]^2 / N$, where X_n refers to the frequency of usage of codon n in highly expressed plant genes, where Y_n to the frequency of usage of codon n in the gene of interest and N refers to the total number of codons in the gene of interest. A table of codon usage from highly expressed genes of dicotyledonous plants has been compiled using the data of Murray et al. (1989, Nuc Acids Res. 17:477-498).

One method of optimizing the nucleic acid sequence in accordance with the preferred codon usage for a particular plant cell type is based on the direct use, without performing any extra statistical calculations, of codon optimization tables such as those provided on-line at the Codon Usage Database through the NIAS (National Institute of Agrobiological Sciences) DNA bank in Japan (Hypertext Transfer Protocol://World Wide Web (dot) kazusa (dot) or (dot) jp/codon/). The Codon Usage Database contains codon usage tables for a number of different species, with each codon usage table having been statistically determined based on the data present in Genbank.

By using such codon optimization tables to determine the most preferred or most favored codons for each amino acid in a particular species (for example, rice), a naturally-occurring nucleotide sequence encoding a protein of interest can be codon optimized for that particular plant species. This is effected by replacing codons that may have a low statistical incidence in the particular species genome with corresponding codons, in regard to an amino acid, that are statistically more favored. However, one or more less-favored codons may be selected to delete existing restriction sites, to create new ones at potentially useful junctions (5' and 3' ends to add signal peptide or termination cassettes, internal sites that might be used to cut and splice segments

together to produce a correct full-length sequence), or to eliminate nucleotide sequences that may negatively affect mRNA stability or expression.

The desired encoding nucleotide sequence may already, in advance of any modification, contain a number of codons that correspond to a statistically-favored codon in a particular plant species. Therefore, codon optimization of the native nucleotide sequence may comprise determining which codons, within the desired nucleotide sequence, are not statistically-favored with regards to a particular plant, and modifying these codons in accordance with a codon usage table of the particular plant to produce a codon optimized derivative. A modified nucleotide sequence may be fully or partially optimized for plant codon usage provided that the protein encoded by the modified nucleotide sequence is produced at a level higher than the protein encoded by the corresponding naturally occurring or native gene. Construction of synthetic genes by altering the codon usage is described in for example PCT Patent Application 93/07278.

Thus according to a specific embodiment, there is provided a Nicotinia tabacum optimized sequence as set forth in SEQ ID NO: 5.

According to some embodiments of the invention, the nucleic acid sequence coding for the polypeptide e.g., cimeric polypeptide is operably linked to a cis-acting regulatory sequence active in plant cells, such as a plant promoter sequence.

A coding nucleic acid sequence is "operably linked" to a regulatory sequence (e.g., promoter) if the regulatory sequence is capable of exerting a regulatory effect on (e.g. effect on the expression of) the coding sequence linked thereto.

Any suitable promoter sequence can be used by the nucleic acid construct of the present invention. Preferably the promoter is a constitutive promoter, a tissue-specific, or an inducible promoter.

As used herein the phrase "plant-expressible" refers to a promoter sequence, including any additional regulatory elements added thereto or contained therein, is at least capable of inducing, conferring, activating or enhancing expression in a plant cell, tissue or organ, preferably a monocotyledonous or dicotyledonous plant cell, tissue, or organ. Such a promoter can be constitutive, i.e., capable of directing high level of gene expression in a plurality of tissues, tissue specific, i.e., capable of directing gene expression in a particular tissue or tissues, inducible, i.e., capable of directing gene

expression under a stimulus, or chimeric, i.e., formed of portions of at least two different promoters.

Examples of preferred promoters useful for the methods of some embodiments of the invention are presented in Table I, II, III and IV.

5

Table I

Exemplary constitutive promoters for use in the performance of some embodiments of the invention

<i>Gene Source</i>	<i>Expression Pattern</i>	<i>Reference</i>
Actin	constitutive	McElroy et al, Plant Cell, 2: 163-171, 1990
CAMV 35S	constitutive	Odell et al, Nature, 313: 810-812, 1985
CaMV 19S	constitutive	Nilsson et al., Physiol. Plant 100:456-462, 1997
GOS2	constitutive	de Pater et al, Plant J Nov;2(6):837-44, 1992
ubiquitin	constitutive	Christensen et al, Plant Mol. Biol. 18: 675-689, 1992
Rice cyclophilin	constitutive	Bucholz et al, Plant Mol Biol. 25(5):837-43, 1994
Maize H3 histone	constitutive	Lepetit et al, Mol. Gen. Genet. 231: 276-285, 1992
Actin 2	constitutive	An et al, Plant J. 10(1):107-121, 1996

Table II

Exemplary seed-preferred promoters for use in the performance of some embodiments of the invention

Gene Source	Expression Pattern	Reference
Seed specific genes	seed	Simon, et al., Plant Mol. Biol. 5: 191, 1985; Scofield, et al., J. Biol. Chem. 262: 12202, 1987.; Basczynski, et al., Plant Mol. Biol. 14: 633, 1990.
Brazil Nut albumin	seed	Pearson' et al., Plant Mol. Biol. 18: 235- 245, 1992.
legumin	seed	Ellis, et al. Plant Mol. Biol. 10: 203-214, 1988
Glutelin (rice)	seed	Takaiwa, et al., Mol. Gen. Genet. 208: 15-22, 1986; Takaiwa, et al., FEBS Letts. 221: 43-47, 1987
Zein	seed	Matzke et al. Plant Mol Biol, 143).323-32 1990
napA	seed	Stalberg, et al, Planta 199: 515- 519, 1996
wheat LMW and HMW, glutenin-1	endosperm	Mol Gen Genet 216:81-90, 1989; NAR 17:461-2,
Wheat SPA	seed	Albanietal, Plant Cell, 9: 171- 184, 1997
wheat a, b and g gliadins	endosperm	EMBO3:1409-15, 1984
Barley lrl promoter	endosperm	
barley B1, C, D hordein	endosperm	Theor Appl Gen 98:1253-62, 1999; Plant J 4:343-55, 1993; Mol Gen Genet 250:750- 60, 1996
Barley DOF	endosperm	Mena et al, The Plant Journal, 116(1): 53- 62, 1998
Biz2	endosperm	EP99106056.7
Synthetic promoter	endosperm	Vicente-Carabajosa et al., Plant

		J. 13: 629-640, 1998
rice prolamin NRP33	endosperm	Wu et al, Plant Cell Physiology 39(8) 885- 889, 1998
rice -globulin Glb-1	endosperm	Wu et al, Plant Cell Physiology 39(8) 885-889, 1998
rice OSH1	embryo	Sato et al, Proc. Nati. Acad. Sci. USA, 93: 8117-8122
rice alpha-globulin REB/OHP-1	endosperm	Nakase et al. Plant Mol. Biol. 33: 513-S22, 1997
rice ADP-glucose PP	endosperm	Trans Res 6:157-68, 1997
maize ESR gene family	endosperm	Plant J 12:235-46, 1997
sorghum gamma- kafirin	endosperm	PMB 32:1029-35, 1996
KNOX	embryo	Postma-Haarsma et al, Plant Mol. Biol. 39:257-71, 1999
rice oleosin	Embryo and aleuton	Wu et al, J. Biochem., 123:386, 1998
sunflower oleosin	Seed (embryo and dry seed)	Cummins, et al., Plant Mol. Biol. 19: 873- 876, 1992

Table III*Exemplary flower-specific promoters for use in the performance of the invention*

Gene Source	Expression Pattern	Reference
AtPRP4	flowers	www.dotsalusdotmediumdotedu/mmg/tierney/html
chalcone synthase (chsA)	flowers	Van der Meer, et al., Plant Mol. Biol. 15, 95-109, 1990.
LAT52	anther	Twell et al Mol. Gen Genet. 217:240-245 (1989)
apetala- 3	flowers	

Table IV

Alternative rice promoters for use in the performance of the invention

PRO #	gene	expression
PR00001	Metallothionein Mte	transfer layer of embryo + calli
PR00005	putative beta-amylase	transfer layer of embryo
PR00009	Putative cellulose synthase	Weak in roots
PR00012	lipase (putative)	
PR00014	Transferase (putative)	
PR00016	peptidyl prolyl cis-trans isomerase (putative)	
PR00019	unknown	
PR00020	prp protein (putative)	
PR00029	noduline (putative)	
PR00058	Proteinase inhibitor Rgpi9	seed
PR00061	beta expansine EXPB9	Weak in young flowers
PR00063	Structural protein	young tissues+calli+embryo
PR00069	xylosidase (putative)	
PR00075	Prolamine 10Kda	strong in endosperm
PR00076	allergen RA2	strong in endosperm
PR00077	prolamine RP7	strong in endosperm
PR00078	CBP80	
PR00079	starch branching enzyme I	
PR00080	Metallothioneine-like ML2	transfer layer of embryo + calli
PR00081	putative caffeoyl- CoA 3-O methyltransferase	shoot
PR00087	prolamine RM9	strong in endosperm
PR00090	prolamine RP6	strong in endosperm
PR00091	prolamine RP5	strong in endosperm
PR00092	allergen RA5	
PR00095	putative methionine aminopeptidase	embryo
PR00098	ras-related GTP binding protein	
PR00104	beta expansine EXPB1	
PR00105	Glycine rich protein	
PR00108	metallothionein like protein (putative)	

PR00110	RCc3 strong root	
PR00111	uclacyanin 3-like protein	weak discrimination center / shoot meristem
PR00116	26S proteasome regulatory particle non-ATPase subunit 11	very weak meristem specific
PR00117	putative 40S ribosomal protein	weak in endosperm
PR00122	chlorophyll a/b-binding protein precursor (Cab27)	very weak in shoot
PR00123	putative protochlorophyllide reductase	Strong leaves
PR00126	metallothionein RiCMT	strong discrimination center shoot meristem
PR00129	GOS2	Strong constitutive
PR00131	GOS9	
PR00133	chitinase Cht-3	very weak meristem specific
PR00135	alpha- globulin	Strong in endosperm
PR00136	alanine aminotransferase	Weak in endosperm
PR00138	Cyclin A2	
PR00139	Cyclin D2	
PR00140	Cyclin D3	
PR00141	Cyclophyllin 2	Shoot and seed
PR00146	sucrose synthase SS1 (barley)	medium constitutive
PR00147	trypsin inhibitor ITR1 (barley)	weak in endosperm
PR00149	ubiquitine 2 with intron	strong constitutive
PR00151	WSI18	Embryo and stress
PR00156	HVA22 homologue (putative)	
PR00157	EL2	
PR00169	aquaporine	medium constitutive in young plants
PR00170	High mobility group protein	Strong constitutive
PR00171	reversibly glycosylated protein RGP1	weak constitutive
PR00173	cytosolic MDH	shoot
PR00175	RAB21	Embryo and stress
PR00176	CDPK7	
PR00177	Cdc2-1	very weak in meristem
PR00197	sucrose synthase 3	
PR00198	OsVPI	

PRO0200	OSH1	very weak in young plant meristem
PRO0208	putative chlorophyllase	
PRO0210	OsNRT1	
PRO0211	EXP3	
PRO0216	phosphate transporter OjPT1	
PRO0218	oleosin 18kd	aleurone + embryo
PRO0219	ubiquitine 2 without intron	
PRO0220	RFL	
PRO0221	maize UBI delta intron	not detected
PRO0223	glutelin-1	
PRO0224	fragment of prolamin RP6 promoter	
PRO0225	4xABRE	
PRO0226	glutelin OSGLUA3	
PRO0227	BLZ-2_short (barley)	
PRO0228	BLZ-2_long (barley)	

The nucleic acid construct of some embodiments of the invention can further include an appropriate selectable marker and/or an origin of replication. According to some embodiments of the invention, the nucleic acid construct utilized is a shuttle vector, which can propagate both in *E. coli* (wherein the construct comprises an appropriate selectable marker and origin of replication) and be compatible with propagation in cells. The construct according to the present invention can be, for example, a plasmid, a bacmid, a phagemid, a cosmid, a phage, a virus or an artificial chromosome.

The nucleic acid construct of some embodiments of the invention can be utilized to stably or transiently transform plant cells. In stable transformation, the nucleic acid is integrated into the plant genome and as such it represents a stable and inherited trait. In transient transformation, the exogenous polynucleotide is expressed by the cell transformed but it is not integrated into the genome and as such it represents a transient trait.

Thus, according to some aspects of the present invention, there is provided an isolated cell comprising the nucleic acid construct of the invention.

As used herein, the term "isolated cell" refers to a cell at least partially separated from the natural environment e.g., from a plant. In some embodiments, the isolated cell is a plant cell of a whole plant. In some embodiments, the isolated cell is a plant cell, for example, a plant cell in culture.

5 The term "plant" as used herein encompasses whole plants, ancestors and progeny of the plants and plant parts, including seeds, shoots, stems, roots (including tubers), and plant cells, tissues and organs. The plant may be in any form including suspension cultures, embryos, meristematic regions, callus tissue, leaves, gametophytes, sporophytes, pollen, and microspores. Plants that are particularly useful in the methods 10 of the invention include all plants which belong to the superfamily Viridiplantae, in particular monocotyledonous and dicotyledonous plants including a fodder or forage legume, ornamental plant, food crop, tree, or shrub selected from the list comprising *Acacia* spp., *Acer* spp., *Actinidia* spp., *Aesculus* spp., *Agathis australis*, *Albizia amara*, *Alsophila tricolor*, *Andropogon* spp., *Arachis* spp., *Areca catechu*, *Astelia fragrans*, *Astragalus cicer*, *Baikiaea plurijuga*, *Betula* spp., *Brassica* spp., *Bruguiera gymnorhiza*, *Burkea africana*, *Butea frondosa*, *Cadaba farinosa*, *Calliandra* spp., *Camellia sinensis*, *Canna indica*, *Capsicum* spp., *Cassia* spp., *Centroema pubescens*, *Chacoomeles* spp., *Cinnamomum cassia*, *Coffea arabica*, *Colophospermum mopane*, *Coronilla varia*, *Cotoneaster serotina*, *Crataegus* spp., *Cucumis* spp., *Cupressus* spp., *Cyathea dealbata*, *Cydonia oblonga*, *Cryptomeria japonica*, *Cymbopogon* spp., *Cynthea dealbata*, *Cydonia oblonga*, *Dalbergia monetaria*, *Davallia divaricata*, *Desmodium* spp., *Dicksonia squarosa*, *Dibeteropogon amplectens*, *Dioclea* spp., *Dolichos* spp., *Dorycnium rectum*, *Echinochloa pyramidalis*, *Ehraffia* spp., *Eleusine coracana*, *Eragrestis* spp., *Erythrina* spp., *Eucalypfus* spp., *Euclea schimperi*, *Eulalia vi/losa*, *Pagopyrum* spp., *Feijoa sellowiana*, *Fragaria* spp., *Flemingia* spp., *Freycinetia banksii*, *Geranium thunbergii*, *GinAgo biloba*, *Glycine javanica*, *Gliricidia* spp., *Gossypium hirsutum*, *Grevillea* spp., *Guibourtia coleosperma*, *Hedysarum* spp., *Hemaffhia altissima*, *Heteropogon contortus*, *Hordeum vulgare*, *Hyparrhenia rufa*, *Hypericum erectum*, *Hypothelia dissolute*, *Indigo incamata*, *Iris* spp., *Leptarrhena pyrolifolia*, *Lespediza* spp., *Lettuca* spp., *Leucaena leucocephala*, *Loudetia simplex*, *Lotus bainesii*, *Lotus* spp., *Macrotyloma axillare*, *Malus* spp., *Manihot esculenta*, *Medicago saliva*, *Metasequoia glyptostroboides*, *Musa sapientum*, *Nicotianum* spp., *Onobrychis* spp., *Ornithopus* spp., *Oryza* spp.,

Peltophorum africanum, Pennisetum spp., Persea gratissima, Petunia spp., Phaseolus spp., Phoenix canariensis, Phormium cookianum, Photinia spp., Picea glauca, Pinus spp., Pisum sativum, Podocarpus totara, Pogonarthria fleckii, Pogonaffhria squarrosa, Populus spp., Prosopis cineraria, Pseudotsuga menziesii, Pterolobium stellatum, Pyrus communis, Quercus spp., Rhaphiolepsis umbellata, Rhopalostylis sapida, Rhus natalensis, Ribes grossularia, Ribes spp., Robinia pseudoacacia, Rosa spp., Rubus spp., Salix spp., Schyzachyrium sanguineum, Sciadopitys vefficillata, Sequoia sempervirens, Sequoiadendron giganteum, Sorghum bicolor, Spinacia spp., Sporobolus fimbriatus, Stiburus alopecuroides, Stylosanthos humilis, Tadehagi spp, Taxodium distichum, Themeda triandra, Trifolium spp., Triticum spp., Tsuga heterophylla, Vaccinium spp., Vicia spp., Vitis vinifera, Watsonia pyramidata, Zantedeschia aethiopica, Zea mays, amaranth, artichoke, asparagus, broccoli, Brussels sprouts, cabbage, canola, carrot, cauliflower, celery, collard greens, flax, kale, lentil, oilseed rape, okra, onion, potato, rice, soybean, straw, sugar beet, sugar cane, sunflower, tomato, squash tea, maize, wheat, barely, rye, oat, peanut, pea, lentil and alfalfa, cotton, rapeseed, canola, pepper, sunflower, tobacco, eggplant, eucalyptus, a tree, an ornamental plant, a perennial grass and a forage crop. Alternatively algae and other non-Viridiplantae can be used for the methods of the present invention.

According to some embodiments of the invention, the plant or plant cell is a duckweed plant, cell or nodule. Duckweed (members of the monocotyledonous family Lemnaceae, or Lemma) plant or duckweed nodule cultures can be efficiently transformed with an expression cassette containing a nucleotide sequence of interest by any one of a number of methods including Agrobacterium-mediated gene transfer, ballistic bombardment, or electroporation. Methods for molecular engineering of duckweed cells and detailed description of duckweed expression systems useful for commercial production of polypeptides are known in the art (see, for example, US Patent Nos. 6,040,498 and 6,815,184 to Stomp, et al, and 8,022,270 to Dickey et al, all of which are incorporated fully by reference herein).

According to some embodiments of the invention, the plant or plant cell used by the method of the invention is a crop plant or cell of a crop plant such as rice, maize, wheat, barley, peanut, potato, sesame, olive tree, palm oil, banana, soybean, sunflower,

canola, sugarcane, alfalfa, millet, leguminosae (bean, pea), flax, lupinus, rapeseed, tobacco, poplar and cotton.

According to further embodiments the plant cells includes tobacco cells, *Agrobacterium rihzogenes* transformed root cell, celery cell, ginger cell, horseradish cell and carrot cells. In one embodiment the tobacco cells are from a tobacco cell line, such as, but not limited to *Nicotiana tabacum* L. cv Bright Yellow (BY-2) cells. The plant cells may be grown according to any type of suitable culturing method, including but not limited to, culture on a solid surface (such as a plastic culturing vessel or plate for example) or in suspension. It will be noted that some cells, such as the BY-2 and 10 carrot cells can be cultured and grown in suspension. Suitable devices and methods for culturing plant cells in suspension are known in the art, for example, as described in International Patent Application PCT IL2008/000614. In yet another embodiment the cells are cells of whole tobacco plants or plant tissues, including, but not limited to *Nicotiana benthamiana*.

15 There are various methods of introducing foreign genes into both monocotyledonous and dicotyledonous plants (Potrykus, I., Annu. Rev. Plant. Physiol., Plant. Mol. Biol. (1991) 42:205-225; Shimamoto et al., Nature (1989) 338:274-276).

The principle methods of causing stable integration of exogenous DNA into plant genomic DNA include two main approaches:

20 (i) Agrobacterium-mediated gene transfer: Klee et al. (1987) Annu. Rev. Plant Physiol. 38:467-486; Klee and Rogers in Cell Culture and Somatic Cell Genetics of Plants, Vol. 6, Molecular Biology of Plant Nuclear Genes, eds. Schell, J., and Vasil, L. K., Academic Publishers, San Diego, Calif. (1989) p. 2-25; Gatenby, in Plant Biotechnology, eds. Kung, S. and Arntzen, C. J., Butterworth Publishers, Boston, Mass. 25 (1989) p. 93-112.

(ii) Direct DNA uptake: Paszkowski et al., in Cell Culture and Somatic Cell Genetics of Plants, Vol. 6, Molecular Biology of Plant Nuclear Genes eds. Schell, J., and Vasil, L. K., Academic Publishers, San Diego, Calif. (1989) p. 52-68; including methods for direct uptake of DNA into protoplasts, Toriyama, K. et al. (1988) 30 Bio/Technology 6:1072-1074. DNA uptake induced by brief electric shock of plant cells: Zhang et al. Plant Cell Rep. (1988) 7:379-384. Fromm et al. Nature (1986) 319:791-793. DNA injection into plant cells or tissues by particle bombardment, Klein

et al. *Bio/Technology* (1988) 6:559-563; McCabe et al. *Bio/Technology* (1988) 6:923-926; Sanford, *Physiol. Plant.* (1990) 79:206-209; by the use of micropipette systems: Neuhaus et al., *Theor. Appl. Genet.* (1987) 75:30-36; Neuhaus and Spangenberg, *Physiol. Plant.* (1990) 79:213-217; glass fibers or silicon carbide whisker transformation of cell cultures, embryos or callus tissue, U.S. Pat. No. 5,464,765 or by the direct incubation of DNA with germinating pollen, DeWet et al. in *Experimental Manipulation of Ovule Tissue*, eds. Chapman, G. P. and Mantell, S. H. and Daniels, W. Longman, London, (1985) p. 197-209; and Ohta, *Proc. Natl. Acad. Sci. USA* (1986) 83:715-719.

The *Agrobacterium* system includes the use of plasmid vectors that contain defined DNA segments that integrate into the plant genomic DNA. Methods of inoculation of the plant tissue vary depending upon the plant species and the *Agrobacterium* delivery system. A widely used approach is the leaf disc procedure which can be performed with any tissue explant that provides a good source for initiation of whole plant differentiation. See, e.g., Horsch et al. in *Plant Molecular Biology Manual A5*, Kluwer Academic Publishers, Dordrecht (1988) p. 1-9. A supplementary approach employs the *Agrobacterium* delivery system in combination with vacuum infiltration. The *Agrobacterium* system is especially viable in the creation of transgenic dicotyledonous plants.

There are various methods of direct DNA transfer into plant cells. In electroporation, the protoplasts are briefly exposed to a strong electric field. In microinjection, the DNA is mechanically injected directly into the cells using very small micropipettes. In microparticle bombardment, the DNA is adsorbed on microprojectiles such as magnesium sulfate crystals or tungsten particles, and the microprojectiles are physically accelerated into cells or plant tissues.

Following stable transformation plant propagation is exercised. The most common method of plant propagation is by seed. Regeneration by seed propagation, however, has the deficiency that due to heterozygosity there is a lack of uniformity in the crop, since seeds are produced by plants according to the genetic variances governed by Mendelian rules. Basically, each seed is genetically different and each will grow with its own specific traits. Therefore, it is preferred that the transformed plant be produced such that the regenerated plant has the identical traits and characteristics of the parent transgenic plant. Therefore, it is preferred that the transformed plant be regenerated by

micropropagation which provides a rapid, consistent reproduction of the transformed plants.

Micropropagation is a process of growing new generation plants from a single piece of tissue that has been excised from a selected parent plant or cultivar. This 5 process permits the mass reproduction of plants having the preferred tissue expressing the fusion protein. The new generation plants which are produced are genetically identical to, and have all of the characteristics of, the original plant. Micropropagation allows mass production of quality plant material in a short period of time and offers a rapid multiplication of selected cultivars in the preservation of the characteristics of the 10 original transgenic or transformed plant. The advantages of cloning plants are the speed of plant multiplication and the quality and uniformity of plants produced.

Micropropagation is a multi-stage procedure that requires alteration of culture medium or growth conditions between stages. Thus, the micropropagation process involves four basic stages: Stage one, initial tissue culturing; stage two, tissue culture multiplication; stage three, differentiation and plant formation; and stage four, 15 greenhouse culturing and hardening. During stage one, initial tissue culturing, the tissue culture is established and certified contaminant-free. During stage two, the initial tissue culture is multiplied until a sufficient number of tissue samples are produced to meet production goals. During stage three, the tissue samples grown in stage two are divided 20 and grown into individual plantlets. At stage four, the transformed plantlets are transferred to a greenhouse for hardening where the plants' tolerance to light is gradually increased so that it can be grown in the natural environment.

According to some embodiments of the invention, the transgenic plants are generated by transient transformation of leaf cells, meristematic cells or the whole plant.

25 Transient transformation can be effected by any of the direct DNA transfer methods described above or by viral infection using modified plant viruses.

Viruses that have been shown to be useful for the transformation of plant hosts include CaMV, Tobacco mosaic virus (TMV), brome mosaic virus (BMV) and Bean Common Mosaic Virus (BV or BCMV). Transformation of plants using plant viruses is 30 described in U.S. Pat. No. 4,855,237 (bean golden mosaic virus; BGV), EP-A 67,553 (TMV), Japanese Published Application No. 63-14693 (TMV), EPA 194,809 (BV), EPA 278,667 (BV); and Gluzman, Y. et al., Communications in Molecular Biology: Viral

Vectors, Cold Spring Harbor Laboratory, New York, pp. 172-189 (1988). Pseudovirus particles for use in expressing foreign DNA in many hosts, including plants are described in WO 87/06261.

According to some embodiments of the invention, the virus used for transient transformations is avirulent and thus is incapable of causing severe symptoms such as reduced growth rate, mosaic, ring spots, leaf roll, yellowing, streaking, pox formation, tumor formation and pitting. A suitable avirulent virus may be a naturally occurring avirulent virus or an artificially attenuated virus. Virus attenuation may be effected by using methods well known in the art including, but not limited to, sub-lethal heating, chemical treatment or by directed mutagenesis techniques such as described, for example, by Kurihara and Watanabe (Molecular Plant Pathology 4:259-269, 2003), Galon et al. (1992), Atreya et al. (1992) and Huet et al. (1994).

Suitable virus strains can be obtained from available sources such as, for example, the American Type culture Collection (ATCC) or by isolation from infected plants. Isolation of viruses from infected plant tissues can be effected by techniques well known in the art such as described, for example by Foster and Tatlor, Eds. "Plant Virology Protocols: From Virus Isolation to Transgenic Resistance (Methods in Molecular Biology (Humana Pr), Vol 81)", Humana Press, 1998. Briefly, tissues of an infected plant believed to contain a high concentration of a suitable virus, preferably young leaves and flower petals, are ground in a buffer solution (e.g., phosphate buffer solution) to produce a virus infected sap which can be used in subsequent inoculations.

Construction of plant RNA viruses for the introduction and expression of non-viral nucleic acid sequences in plants is demonstrated by the above references as well as by Dawson, W. O. et al., Virology (1989) 172:285-292; Takamatsu et al. EMBO J. (1987) 6:307-311; French et al. Science (1986) 231:1294-1297; Takamatsu et al. FEBS Letters (1990) 269:73-76; and U.S. Pat. No. 5,316,931.

When the virus is a DNA virus, suitable modifications can be made to the virus itself. Alternatively, the virus can first be cloned into a bacterial plasmid for ease of constructing the desired viral vector with the foreign DNA. The virus can then be excised from the plasmid. If the virus is a DNA virus, a bacterial origin of replication can be attached to the viral DNA, which is then replicated by the bacteria. Transcription and translation of this DNA will produce the coat protein which will encapsidate the

viral DNA. If the virus is an RNA virus, the virus is generally cloned as a cDNA and inserted into a plasmid. The plasmid is then used to make all of the constructions. The RNA virus is then produced by transcribing the viral sequence of the plasmid and translation of the viral genes to produce the coat protein(s) which encapsidate the viral

5 RNA.

In one embodiment, a plant viral polynucleotide is provided in which the native coat protein coding sequence has been deleted from a viral polynucleotide, a non-native plant viral coat protein coding sequence and a non-native promoter, preferably the subgenomic promoter of the non-native coat protein coding sequence, capable of expression in the plant host, packaging of the recombinant plant viral polynucleotide, and ensuring a systemic infection of the host by the recombinant plant viral polynucleotide, has been inserted. Alternatively, the coat protein gene may be inactivated by insertion of the non-native polynucleotide sequence within it, such that a protein is produced. The recombinant plant viral polynucleotide may contain one or 10 more additional non-native subgenomic promoters. Each non-native subgenomic promoter is capable of transcribing or expressing adjacent genes or polynucleotide sequences in the plant host and incapable of recombination with each other and with native subgenomic promoters. Non-native (foreign) polynucleotide sequences may be 15 inserted adjacent the native plant viral subgenomic promoter or the native and a non-native plant viral subgenomic promoters if more than one polynucleotide sequence is included. The non-native polynucleotide sequences are transcribed or expressed in the 20 host plant under control of the subgenomic promoter to produce the desired products.

In a second embodiment, a recombinant plant viral polynucleotide is provided as in the first embodiment except that the native coat protein coding sequence is placed 25 adjacent one of the non-native coat protein subgenomic promoters instead of a non-native coat protein coding sequence.

In a third embodiment, a recombinant plant viral polynucleotide is provided in which the native coat protein gene is adjacent its subgenomic promoter and one or more non-native subgenomic promoters have been inserted into the viral polynucleotide. The 30 inserted non-native subgenomic promoters are capable of transcribing or expressing adjacent genes in a plant host and are incapable of recombination with each other and with native subgenomic promoters. Non-native polynucleotide sequences may be

inserted adjacent the non-native subgenomic plant viral promoters such that the sequences are transcribed or expressed in the host plant under control of the subgenomic promoters to produce the desired product.

In a fourth embodiment, a recombinant plant viral polynucleotide is provided as
5 in the third embodiment except that the native coat protein coding sequence is replaced
by a non-native coat protein coding sequence.

The viral vectors are encapsidated by the coat proteins encoded by the recombinant plant viral polynucleotide to produce a recombinant plant virus. The recombinant plant viral polynucleotide or recombinant plant virus is used to infect
10 appropriate host plants. The recombinant plant viral polynucleotide is capable of replication in the host, systemic spread in the host, and transcription or expression of foreign gene(s) (exogenous polynucleotide) in the host to produce the desired protein.

Techniques for inoculation of viruses to plants may be found in Foster and Taylor, eds. "Plant Virology Protocols: From Virus Isolation to Transgenic Resistance
15 (Methods in Molecular Biology (Humana Pr), Vol 81)", Humana Press, 1998; Maramorosh and Koprowski, eds. "Methods in Virology" 7 vols, Academic Press, New York 1967-1984; Hill, S.A. "Methods in Plant Virology", Blackwell, Oxford, 1984; Walkey, D.G.A. "Applied Plant Virology", Wiley, New York, 1985; and Kado and Agrawa, eds. "Principles and Techniques in Plant Virology", Van Nostrand-Reinhold, 20 New York.

In addition to the above, the polynucleotide of the present invention can also be introduced into a chloroplast genome thereby enabling chloroplast expression.

A technique for introducing exogenous nucleic acid sequences to the genome of the chloroplasts is known. This technique involves the following procedures. First, plant cells are chemically treated so as to reduce the number of chloroplasts per cell to about one. Then, the exogenous polynucleotide is introduced via particle bombardment into the cells with the aim of introducing at least one exogenous polynucleotide molecule into the chloroplasts. The exogenous polynucleotides selected such that it is integratable into the chloroplast's genome via homologous recombination which is readily effected by enzymes inherent to the chloroplast. To this end, the nucleic acid sequence includes, in addition to a gene of interest, at least one polynucleotide stretch which is derived from the chloroplast's genome. In addition, the exogenous polynucleotide includes a

selectable marker, which serves by sequential selection procedures to ascertain that all or substantially all of the copies of the chloroplast genomes following such selection will include the exogenous polynucleotide. Further details relating to this technique are found in U.S. Pat. Nos. 4,945,050; and 5,693,507 which are incorporated herein by reference. A polypeptide can thus be produced by the protein expression system of the chloroplast and become integrated into the chloroplast's inner membrane.

According to some embodiments of the invention, the method further comprises growing the plant cell expressing the nucleic acid. The plant cells can be any plant cells desired. The plant cells can be cultured cells, cells in cultured tissue or cultured organs, or cells in a plant. In some embodiments, the plant cells are cultured cells, or cells in cultured tissue or cultured organs. In yet further embodiments, the plant cells are any type of plant that is used in gene transference. The plant cell can be grown as part of a whole plant, or, alternatively, in plant cell culture.

According to some aspects of the invention, the plant cells are grown in a plant cell suspension culture. As used herein, the term "suspension culture" refers to the growth of cells separate from the organism. Suspension culture can be facilitated via use of a liquid medium (a "suspension medium"). Suspension culture can refer to the growth of cells in liquid nutrient media. Methods and devices suitable for growing plant cells of the invention in plant cell suspension culture are described in detail in, for example, PCT WO2008/135991, US Patent No. 6,391,683, US Patent Application No. 10/784,295; International Patent Publications PCT Nos. WO2004/091475, WO2005/080544 and WO 2006/040761, all of which are hereby incorporated by reference as if fully set forth herein.

Thus, the invention encompasses plants or plant cultures expressing the nucleic acid sequences, so as to produce the recombinant polypeptide of the invention. Once expressed within the plant cell or the entire plant, the level of the chimeric polypeptide encoded by the nucleic acid sequence can be determined by methods well known in the art such as, activity assays, Western blots using antibodies capable of specifically binding the chimeric polypeptide (e.g., for the chimeric polypeptide according to some embodiments of the invention use anti TNFR2, and anti Fc, See Examples section which follows), Enzyme-Linked Immuno Sorbent Assay (ELISA), radio-immuno-assays

(RIA), immunohistochemistry, immunocytochemistry, immunofluorescence and the like.

Methods of determining the level in the plant of the RNA transcribed from the nucleic acid sequence are well known in the art and include, for example, Northern blot analysis, reverse transcription polymerase chain reaction (RT-PCR) analysis (including quantitative, semi-quantitative or real-time RT-PCR) and RNA-*in situ* hybridization.

According to some embodiments of the invention, the expressed recombinant chimeric polypeptide of the present invention is glycosylated in the plant cell, resulting in a chimeric polypeptide having one, or two or three or more glycan structures having plant specific glycan residues. Thus, according to some embodiments of the invention, the cells expressing the expression vector of the invention produce a chimeric polypeptide having various amounts of glycan structures arranged in one, two, three or more antennae. All structures may contain a core structure of two GlcNAcs and one mannose, and variations of different amounts of mannose, in addition to core alpha (1,3) fucose, beta (1,2) xylose, and/or GlcNAc residues. Structures can be of the high mannose type, having at least one, optionally at least two, optionally at least three or optionally at least four or more mannose residues in addition to the core structure ; or complex type having both mannose and other glycan types on each glycan, or of the hybrid type having both high mannose and complex antennae.

In other embodiments the cells expressing the expression vector of the invention produce a polypeptide having at least one, optionally at least two, optionally at least three or optionally at least four or more core xylose residues. In yet other embodiments the cells expressing the expression vector of the invention produce a polypeptide having at least one, optionally at least two, optionally at least three or optionally at least four or more core α -(1,3) fucose residues. In one embodiment the cells expressing the expression vector of the invention produce a polypeptide protein having at least one exposed mannose residue, at least one core xylose residue and at least one α -(1,3) fucose residue. In yet further embodiments, the cells expressing the expression vector of the invention produce a polypeptide having at least one, at least two, at least 3 or more terminal N-acetyl glucosamine substitutions on the outer mannose sugars.

According to a specific embodiment the polypeptide inhibitor e.g., chimeric polypeptide, lacks sialic acid residues. Yet further according to a specific embodiment, the polypeptide comprises at least 40 %, 45 %, 50 %, 55 %, 60 %, 65 %, 70 % or more complex glycans. According to a specific embodiment, the polypeptide comprises 40-70 % complex glycans.

Purification of the secreted plant cell-expressed inhibitory polypeptide from the cell yields a highly purified composition e.g., comprising the prhTNFR:Fc. Thus, in some embodiments the polypeptide protein is purified to a homogeneity of at least 98 %. Thus the purified preparation is characterized by a purity of at least 85%, at least 87%, at least 90%, at least 91%, at least 91.5%, at least 92%, at least 92.5%, at least 93%, at least 93.1%, at least 93.2%, at least 93.3%, at least 93.4%, at least 93.5%, at least 93.6%, at least 93.7%, at least 93.8%, at least 93.9%, at least 94%, at least 94.5%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least 99.5%, at least 99.6%, at least 99.7%, at least 99.8%, at least 99.9%, in a range of at least 95.0-99.8% or 100% purity. In some embodiments, purity of the polypeptide is measured by HPLC.

In some embodiments the plant-expressed polypeptide preparation comprises impurities derived from the plant host cell, such as, but not limited to nucleic acids and polynucleotides, amino acids, oligopeptides and polypeptides, glycans and other carbohydrates, lipids and the like. In some embodiments the host-cell derived impurities comprise biologically active molecules, such as enzymes. In other embodiments, the plant-expressed polypeptide composition comprises plant beta-N-acetylhexosaminidase. Where the host cell is a tobacco cell, or tobacco cell line cell, the plant beta-N-acetylhexosaminidase is a tobacco beta-N-acetylhexosaminidase.

In further embodiments the plant beta-N-acetylhexosaminidase is inactivated plant beta-N-acetylhexosaminidase. Inactivation of plant beta-N-acetylhexosaminidase can be effected by physical means, chemical means or biochemical means. Physical inactivation can be performed by heating, freezing, desiccation, etc. Chemical inactivation can be performed by extremes of pH, chemical denaturation, addition or removal of side chains, glycans, amino acids, etc. Biochemical inactivation includes, but is not limited to inhibition by reversible or irreversible inhibitors. Exemplary beta-N-acetylhexosaminidase inhibitors include end-product inhibitors such as N-acetyl-D-

glucosamine and beta-methyl-N-acetyl glucosamine, and selective inhibitors such as the compounds disclosed in US Patent Applications US2010016386, US20110237631, US20100087477 and US20120046337. It will be appreciated that preferred methods for inhibition and/or inactivation of the plant beta-N-acetylhexosaminidase are those which 5 also effectively preserve the structural and functional integrity of the plant-expressed polypeptide.

In some embodiments the plant beta-N-acetylhexosaminidase is inactivated by heating the composition comprising the polypeptide. Suitable temperatures for plant beta-N-acetylhexosaminidase inhibition and/or activation include heating within a range 10 of 37-60 °C for a period of 2 to 5, 10, 20, 30, 40, 50, 60 or more minutes. It will be appreciated that effective inhibition and/or inactivation of the plant beta-N-acetylhexosaminidase is achieved more rapidly at higher temperatures and more slowly at lower temperatures of the range. In some embodiments, the plant-expressed polypeptide composition is heated in the range of 45-55 °C for 2-10 minutes. In some 15 embodiments, the inhibition/inactivation results in 20, 30, 40, 50, 60, 70, 80% or greater inactivation of the plant beta-N-acetylhexosaminidase.

The polypeptide of the invention is utilized for the treatment of TNF α -associated medical conditions.

The term “treating” refers to inhibiting, preventing or arresting the development 20 of a pathology (disease, disorder or condition) and/or causing the reduction, remission, or regression of a pathology. Those of skill in the art will understand that various methodologies and assays can be used to assess the development of a pathology, and similarly, various methodologies and assays may be used to assess the reduction, remission or regression of a pathology.

25 As used herein, the term “preventing” refers to keeping a disease, disorder or condition from occurring in a subject who may be at risk for the disease, but has not yet been diagnosed as having the disease.

As used herein “a TNF α -associated medical condition” refers to a medical 30 condition in which TNF α activity is associated with onset, progression of the medical conditions and/or related symptoms in a subject.

Thus, TNF α -associated medical condition disease, in a cell, tissue, organ, animal, or subject in need thereof including, but not limited to, at least one of obesity,

an immune related disease, a cardiovascular disease, an infectious disease, a malignant disease or a neurologic disease (see WO0212502).

Specific examples of a TNF α -associated medical condition include, but are not limited to, rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis, Wegener's disease (granulomatosis), Crohn's disease, inflammatory bowel disease, cholitis, short bowel syndrome, ulcerative cholitis, chronic obstructive pulmonary disease (COPD), Hepatitis C, endometriosis, asthma, cachexia, psoriasis, and atopic dermatitis. Additional diseases or disorders that can be treated with the inhibitory polypeptide e.g., the chimeric polypeptide, of the invention include those described in WO 00/62790, 10 WO 01/62272 and U.S. Patent Application No. 2001/0021380, U.S. Patent 7,648,702, the relevant portions of which are incorporated herein by reference.

Additional examples of TNF α -associated medical condition include, but are not limited to, immune related disease, such as rheumatoid arthritis, juvenile rheumatoid arthritis, systemic onset juvenile rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis, gastric ulcer, seronegative arthropathies, osteoarthritis, inflammatory bowel disease, ulcerative colitis, short bowel syndrome, systemic lupus erythematosis, antiphospholipid syndrome, iridocyclitis/uveitis/optic neuritis, idiopathic pulmonary fibrosis, systemic vasculitis/wegener's granulomatosis, sarcoidosis, orchitis/vasectomy reversal procedures, allergic/atopic diseases, asthma, allergic rhinitis, eczema, allergic contact dermatitis, allergic conjunctivitis, hypersensitivity pneumonitis, transplants, organ transplant rejection, graft- versus-host disease, systemic inflammatory response syndrome, sepsis syndrome, gram positive sepsis, gram negative sepsis, culture negative sepsis, fungal sepsis, neutropenic fever, urosepsis, meningococcemia, trauma/hemorrhage, burns, ionizing radiation exposure, acute pancreatitis, adult respiratory distress syndrome, rheumatoid arthritis, alcohol-induced hepatitis, chronic inflammatory pathologies, sarcoidosis, Crohn's pathology, sickle cell anemia, diabetes, nephrosis, atopic diseases, hypersensitivity reactions, allergic rhinitis, hay fever, perennial rhinitis, conjunctivitis, endometriosis, asthma, urticaria, systemic anaphylaxis, dermatitis, pernicious anemia, hemolytic disease, thrombocytopenia, graft rejection of 30 any organ or tissue, kidney transplant rejection, heart transplant rejection, liver transplant rejection, pancreas transplant rejection, lung transplant rejection, bone marrow transplant (BMT) rejection, skin allograft rejection, cartilage transplant

rejection, bone graft rejection, small bowel transplant rejection, fetal thymus implant rejection, parathyroid transplant rejection, xenograft rejection of any organ or tissue, allograft rejection, anti-receptor hypersensitivity reactions-, Graves disease, Raynoud's disease, type B insulin-resistant diabetes, asthma, myasthenia gravis, antibody-mediated cytotoxicity, type III hypersensitivity reactions, systemic lupus erythematosus, POEMS syndrome (polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy, and skin changes syndrome), polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy, skin changes syndrome, antiphospholipid syndrome, pemphigus, scleroderma, mixed connective tissue disease, idiopathic Addison's disease, diabetes mellitus, chronic active hepatitis, primary biliary cirrhosis, vitiligo, vasculitis, post-MI cardiotomy syndrome, type IV hypersensitivity, contact dermatitis, hypersensitivity pneumonitis, allograft rejection, granulomas due to intracellular organisms, drug sensitivity, metabolic/idiopathic, Wilson's disease, hemachromatosis, alpha- 1-antitrypsin deficiency, diabetic retinopathy, hashimoto's thyroiditis, osteoporosis, hypothalamic-pituitary-adrenal axis evaluation, primary biliary cirrhosis, thyroiditis, encephalomyelitis, cachexia, cystic fibrosis, neonatal chronic lung disease, chronic obstructive pulmonary disease (COPD), familial hematophagocytic lymphohistiocytosis, dermatologic conditions, psoriasis, alopecia, nephrotic syndrome, nephritis, glomerular nephritis, acute renal failure, hemodialysis, uremia, toxicity, preeclampsia, okt3 therapy, anti-*cd3* therapy, cytokine therapy, chemotherapy, radiation therapy (e.g, including but not limited to anemia, cachexia, and the like), chronic salicylate intoxication, and the like. See, e.g, the Merck Manual, 12th- 17th Editions, Merck & Company, Rahway, NJ (1972, 1977, 1982, 1987, 1992, 1999), Pharmacotherapy Handbook, Wells et al, eds. Second Edition, Appleton and Lange, Stamford, Conn. (1998, 2000), each entirely incorporated by reference. The present invention also provides a method for treating at least one cardiovascular disease in a cell, tissue, organ, animal, or patient, including, but not limited to, at least one of cardiac stun syndrome, myocardial infarction, congestive heart failure, stroke, ischemic stroke, hemorrhage, arteriosclerosis, atherosclerosis, restenosis, diabetic atherosclerotic disease, hypertension, arterial hypertension, renovascular hypertension, syncope, shock, syphilis of the cardiovascular system, heart failure, cor pulmonale, primary pulmonary hypertension, cardiac arrhythmias, atrial ectopic beats, atrial flutter, atrial fibrillation

(sustained or paroxysmal), post perfusion syndrome, cardiopulmonary bypass inflammation response, chaotic or multifocal atrial tachycardia, regular narrow QRS tachycardia, specific arrhythmias, ventricular fibrillation, His bundle arrhythmias, atrioventricular block, bundle branch block, myocardial ischemic disorders, coronary artery disease, angina pectoris, myocardial infarction, cardiomyopathy, dilated congestive cardiomyopathy, restrictive cardiomyopathy, valvular heart diseases, endocarditis, pericardial disease, cardiac tumors, aortic and peripheral aneurysms, aortic dissection, inflammation of the aorta, occlusion of the abdominal aorta and its branches, peripheral vascular disorders, occlusive arterial disorders, peripheral atherosclerotic disease, thromboangiitis obliterans, functional peripheral arterial disorders, Raynaud's phenomenon and disease, acrocyanosis, erythromelalgia, venous diseases, venous thrombosis, varicose veins, arteriovenous fistula, lymphedema, lipedema, unstable angina, reperfusion injury, post pump syndrome, ischemia-reperfusion injury, and the like.

Additional examples of a TNF α -associated medical condition include, but are not limited to, infectious diseases, such as acute or chronic bacterial infection, acute and chronic parasitic or infectious processes, including bacterial, viral and fungal infections, HIV infection/HIV neuropathy, meningitis, hepatitis (A,B or C, or the like), septic arthritis, peritonitis, pneumonia, epiglottitis, e. coli 0157:h7, hemolytic uremic syndrome/thrombolytic thrombocytopenic purpura, malaria, dengue hemorrhagic fever, leishmaniasis, leprosy, toxic shock syndrome, streptococcal myositis, gas gangrene, mycobacterium tuberculosis, mycobacterium avium intracellulare, pneumocystis carinii pneumonia, pelvic inflammatory disease, orchitis/epididymitis, legionella, lyme disease, influenza a, epstein-barr virus, vital-associated hemaphagocytic syndrome, vital encephalitis/aseptic meningitis, and the like;

Additional examples of a TNF α -associated medical condition include, but are not limited to, malignant diseases such as leukemia, acute leukemia, acute lymphoblastic leukemia (ALL), B-cell, T-cell or FAB ALL, acute myeloid leukemia (AML), chronic myelocytic leukemia (CML), chronic lymphocytic leukemia (CLL), hairy cell leukemia, myelodysplastic syndrome (MDS), a lymphoma, Hodgkin's disease, a malignant lymphoma, non-hodgkin's lymphoma, Burkitt's lymphoma, multiple myeloma, Kaposi's sarcoma, colorectal carcinoma, pancreatic carcinoma,

nasopharyngeal carcinoma, malignant histiocytosis, paraneoplastic syndrome/hypercalcemia of malignancy, solid tumors, adenocarcinomas, sarcomas, malignant melanoma, hemangioma, metastatic disease, cancer related bone resorption, cancer related bone pain, and the like.

5 Additional examples of a TNF α -associated medical condition include, but are not limited to, neurologic diseases, such as neurodegenerative diseases, multiple sclerosis, migraine headache, AIDS dementia complex, demyelinating diseases, such as multiple sclerosis and acute transverse myelitis; extrapyramidal and cerebellar disorders' such as lesions of the corticospinal system; disorders of the basal ganglia or 10 cerebellar disorders; hyperkinetic movement disorders such as Huntington's Chorea and senile chorea; drug-induced movement disorders, such as those induced by drugs which block CNS dopamine receptors; hypokinetic movement disorders, such as Parkinson's disease; Progressive supranucleo Palsy; structural lesions of the cerebellum; spinocerebellar degenerations, such as spinal ataxia, Friedreich's ataxia, cerebellar 15 cortical degenerations, multiple systems degenerations (Mencel, Dejerine-Thomas, Shiodrager, and Machado- Joseph); systemic disorders (Refsum's disease, abetalipoproteinemia, ataxia, telangiectasia, and mitochondrial multi.system disorder); demyelinating core disorders, such as multiple sclerosis, acute transverse myelitis; and disorders of the motor unit' such as neurogenic muscular atrophies (anterior horn cell 20 degeneration, such as amyotrophic lateral sclerosis, infantile spinal muscular atrophy and juvenile spinal muscular atrophy); Alzheimer's disease; Down's Syndrome in middle age; Diffuse Lewy body disease; Senile Dementia of Lewy body type; Wernicke-Korsakoff syndrome; chronic alcoholism; Creutzfeldt- Jakob disease; Subacute sclerosing panencephalitis, Hallerrorden-Spatz disease; and Dementia 25 pugilistica, and the like.

As used herein, the term "subject" includes mammals, e.g., human beings at any age which suffer from the pathology. According to a specific embodiment, this term encompasses individuals who are at risk to develop the pathology.

It has been shown that plant cells expressing biologically active human 30 recombinant polypeptides can be used as an effective systemic delivery system, when provided for enteral administration to the subject (see WO2007/010533). Thus, in some embodiments, the polypeptide (e.g., chimeric polypeptide) can be formulated in a

pharmaceutical composition for oral or enteral delivery comprising transformed plant cell expressing the polypeptide and a pharmaceutically acceptable carrier. In some embodiments, the transformed plant cells of the pharmaceutical composition are lyophilized plant cells.

5 As used herein the phrase "enteral administration" refers to administration through any part of the gastro-intestinal tract, such as rectal administration, colonic administration, intestinal administration (proximal or distal) and gastric administration. In some embodiments, enteral administration refers to oral administration.

10 It will be appreciated that the present teachings are also directed at mucosal administration of plant cells expressing the polypeptide (e.g., chimeric polypeptide) of the invention.

The cells may be formulated as a solid, formulated as a liquid or formulated as a powder. In some embodiments, the cells are resuspended, lyophilized cells.

15 Thus, in some embodiments, the polypeptide (e.g., chimeric polypeptide) can be formulated in a pharmaceutical composition for oral or enteral delivery comprising transformed plant cell expressing the polypeptide and a pharmaceutically acceptable carrier. In some embodiments, the transformed plant cells of the pharmaceutical composition are lyophilized plant cells, although the use of fresh (non-lyophilized cells) is also contemplated herein.

20 Prior to lyophilization the cells may be washed to remove any cell debris that may be present in the growth medium.

As the cells are being prepared for lyophilization, it is sometimes desirable to incubate the cells in a maintenance medium to reduce the metabolic processes of the cells.

25 Pretreatment (although not necessary) can be performed at room temperature or at temperatures in which the plant cells are typically cultured. Pretreatment is performed at about room temperature (20 °C) for ease of handling and as most plant cells are fairly stable at room temperature. Stabilizers can be added directly to the medium and replenished as necessary during the pretreatment process.

30 Pretreatments may also involve incubating cells in the presence of one or more osmotic agents. Examples of useful osmotic agents include sugars such as saccharides and saccharide derivatives, amino or imino acids such as proline and proline derivatives,

or combinations of these agents. Some of the more useful sugars and sugar derivatives are fructose, glucose, maltose, mannitol, sorbitol, sucrose and trehalose. Osmotic agents are utilized at a concentration that prepares cells for subsequent lyophilization.

Lyophilization is directed at reducing the water content of the cells by vacuum evaporation. Vacuum evaporation involves placing the cells in an environment with reduced air pressure. Depending on the rate of water removal desired, the reduced ambient pressure operating at temperatures of between about -30 °C to -50° C may be at 100 torr, 1 torr, 0.01 torr or less. According to a specific embodiment, the cells are lyophilized by freezing to -40 °C and then applying a vacuum to a pressure of 0.1 mbar for overnight. The cells are then heated to -10 °C so all the ice content will be sublimated and evaporated. Under conditions of reduced pressure, the rate of water evaporation is increased such that up to 60-95 % of the water in a cell can be removed.

According to a specific embodiment, lyophilization removes over 60 %, 70 %, 80% or specifically over 90 %, 91 %, 92 %, 93 %, 94 %, 95 % or 98 % of the water from the cells. According to a specific embodiment, the final water content is about 5-10 %, 5-8 % or 6-7 %.

Thus, the oral dosage form may be provided as an oral nutritional form (e.g., as long as the protein is not exposed to denaturing conditions which include heating above 37 °C and compression), as a complete meal, as a powder for dissolution, e.g. health drinks, as a solution, as a ready-made drink, optionally low calorie, such as a soft drink, including juices, milk-shake, yoghurt drink, smoothie or soy-based drink, in a bar, or dispersed in foods of any sort, such as baked products, cereal bars, dairy bars, snack-foods, breakfast cereals, muesli, candies, tabs, cookies, biscuits, crackers (such as a rice crackers), chocolate, and dairy products.

Of note is the use of plant cells expressing the chimeric polypeptide in the treatment of inflammatory bowel disease. The plant's cell wall is expected to protect the chimeric polypeptide while moving through the stomach and small intestine. In the colon, where the polysaccharides are digested, the plant cell is expected to release its content and hence prh TNRF:Fc is available to bind its cytokine ligand. Moreover, prh TNRF2:Fc is a chimeric protein carries an Fc segment of human IgG1. In the epithelial monolayer lining the mucosal barrier, the FcRn receptor transcytoses IgG molecules

across by binding to their Fc. Therefore, prh TNRF:Fc can also cross the epithelial barrier to bind its cytokine ligand on the serosal side of the epithelia.

It will be appreciated that the present teachings exclude the use of plant cells expressing the polypeptide (e.g., chimeric polypeptide) by enteral administration for the treatment of medical conditions directly associated with obesity, metabolic syndrome, diabetes and a liver disease or disorder.

The metabolic syndrome is a constellation of interrelated risk factors of metabolic origin—*metabolic risk factors*—that appear to directly promote the development of atherosclerotic cardiovascular disease (ASCVD). Patients with the metabolic syndrome also are at increased risk for developing type 2 diabetes mellitus, the multiple components of the metabolic syndrome. These criteria have varied somewhat in specific elements, but in general they include a combination of both underlying and metabolic risk factors. The most widely recognized of the metabolic risk factors are atherogenic dyslipidemia, elevated blood pressure, and elevated plasma glucose. Individuals with these characteristics commonly manifest a prothrombotic state and a proinflammatory state as well. Atherogenic dyslipidemia consists of an aggregation of lipoprotein abnormalities including elevated serum triglyceride and apolipoprotein B (apoB), increased small LDL particles, and a reduced level of HDL cholesterol (HDL-C). Available data suggest that it truly is a syndrome, ie, a grouping of ASCVD risk factors, but one that probably has more than one cause.

According to a specific embodiment, the liver disease or disorder is selected from the group consisting of hepatitis, liver cirrhosis, liver cancer, hepatotoxicity, chronic liver disease, fatty liver disease and non-alcoholic steatohepatitis (NASH).

According to a specific embodiment, the hepatotoxicity is induced by a chemical agent selected from the group consisting of acetaminophen, NSAIDS, glucocorticoid, isniaized, arsenic, chemotherapy, carbon tetrachloride and vinyl chloride.

According to a specific embodiment, the diabetes is selected from the group consisting of type I diabetes, type II diabetes and LADA disease.

Alternatively or additionally, the chimeric polypeptide of some embodiments of the invention can be administered to an organism *per se*, or in a pharmaceutical composition where it is mixed with suitable carriers or excipients.

As used herein a "pharmaceutical composition" refers to a preparation of one or more of the active ingredients described herein with other chemical components such as physiologically suitable carriers and excipients. The purpose of a pharmaceutical composition is to facilitate administration of a compound to an organism.

5 Herein the term "active ingredient" refers to the chimeric polypeptide or cells expressing same accountable for the biological effect.

Hereinafter, the phrases "physiologically acceptable carrier" and "pharmaceutically acceptable carrier" which may be interchangeably used refer to a carrier or a diluent that does not cause significant irritation to an organism and does not 10 abrogate the biological activity and properties of the administered compound. An adjuvant is included under these phrases.

Herein the term "excipient" refers to an inert substance added to a pharmaceutical composition to further facilitate administration of an active ingredient. Examples, without limitation, of excipients include calcium carbonate, calcium 15 phosphate, various sugars and types of starch, cellulose derivatives, gelatin, vegetable oils and polyethylene glycols.

Techniques for formulation and administration of drugs may be found in "Remington's Pharmaceutical Sciences," Mack Publishing Co., Easton, PA, latest edition, which is incorporated herein by reference.

20 Suitable routes of administration may, for example, include oral, rectal, transmucosal, especially transnasal, intestinal or parenteral delivery, including intramuscular, subcutaneous and intramedullary injections as well as intrathecal, direct intraventricular, intracardiac, e.g., into the right or left ventricular cavity, into the common coronary artery, intravenous, intraperitoneal, intranasal, or intraocular 25 injections.

The pharmaceutical compositions of this invention are particularly useful for parenteral administration, i.e., subcutaneously, intramuscularly, intravenously, intraperitoneal, intracerebrospinal, intra-articular, intrasynovial, and/or intrathecal. Parenteral administration can be by bolus injection or continuous infusion. 30 Pharmaceutical compositions for injection may be presented in unit dosage form, e.g., in ampoules or in multi-dose containers, with an added preservative. In addition, a number of recent drug delivery approaches have been developed and the pharmaceutical

compositions of the present invention are suitable for administration using these new methods, e.g., Inject-easeTM, GenjectTM, injector pens such as GenPen.TM., and needleless devices such as MediJectorTM and BioJectorTM.

The pharmaceutical composition can also be formulated as a depot preparation.

5 Such long acting formulations may be administered by implantation (for example subcutaneously or intramuscularly) or by intramuscular injection. Thus, for example, the formulations may be modified with suitable polymeric or hydrophobic materials (for example as an emulsion in an acceptable oil) or ion exchange resins, or as sparingly soluble derivatives, for example, as a sparingly soluble salt.

10 Pharmaceutical compositions of some embodiments of the invention may be manufactured by processes well known in the art, e.g., by means of conventional mixing, dissolving, granulating, dragee-making, levigating, emulsifying, encapsulating, entrapping or lyophilizing processes.

15 Pharmaceutical compositions for use in accordance with some embodiments of the invention thus may be formulated in conventional manner using one or more physiologically acceptable carriers comprising excipients and auxiliaries, which facilitate processing of the active ingredients into preparations which, can be used pharmaceutically. Proper formulation is dependent upon the route of administration chosen.

20 For injection, the active ingredients of the pharmaceutical composition may be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hank's solution, Ringer's solution, or physiological salt buffer. For transmucosal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

25 For oral administration, the pharmaceutical composition can be formulated readily by combining the active compounds with pharmaceutically acceptable carriers well known in the art. Such carriers enable the pharmaceutical composition to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions, and the like, for oral ingestion by a patient. Pharmacological preparations for oral use 30 can be made using a solid excipient, optionally grinding the resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries if desired, to obtain tablets or dragee cores. Suitable excipients are, in particular, fillers such as sugars,

including lactose, sucrose, mannitol, or sorbitol; cellulose preparations such as, for example, maize starch, wheat starch, rice starch, potato starch, gelatin, gum tragacanth, methyl cellulose, hydroxypropylmethyl-cellulose, sodium carbomethylcellulose; and/or physiologically acceptable polymers such as polyvinylpyrrolidone (PVP). If desired, 5 disintegrating agents may be added, such as cross-linked polyvinyl pyrrolidone, agar, or alginic acid or a salt thereof such as sodium alginate.

Dragee cores are provided with suitable coatings. For this purpose, concentrated sugar solutions may be used which may optionally contain gum arabic, talc, polyvinyl pyrrolidone, carbopol gel, polyethylene glycol, titanium dioxide, lacquer solutions and 10 suitable organic solvents or solvent mixtures. Dyestuffs or pigments may be added to the tablets or dragee coatings for identification or to characterize different combinations of active compound doses.

Pharmaceutical compositions which can be used orally, include push-fit capsules made of gelatin as well as soft, sealed capsules made of gelatin and a plasticizer, such as 15 glycerol or sorbitol. The push-fit capsules may contain the active ingredients in admixture with filler such as lactose, binders such as starches, lubricants such as talc or magnesium stearate and, optionally, stabilizers. In soft capsules, the active ingredients may be dissolved or suspended in suitable liquids, such as fatty oils, liquid paraffin, or liquid polyethylene glycols. In addition, stabilizers may be added. All formulations for 20 oral administration should be in dosages suitable for the chosen route of administration.

For buccal administration, the compositions may take the form of tablets or lozenges formulated in conventional manner.

For administration by nasal inhalation, the active ingredients for use according 25 to some embodiments of the invention are conveniently delivered in the form of an aerosol spray presentation from a pressurized pack or a nebulizer with the use of a suitable propellant, e.g., dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane or carbon dioxide. In the case of a pressurized aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges of, e.g., gelatin for use in a dispenser may be formulated containing a 30 powder mix of the compound and a suitable powder base such as lactose or starch.

The pharmaceutical composition described herein may be formulated for parenteral administration, e.g., by bolus injection or continuous infusion. Formulations

for injection may be presented in unit dosage form, e.g., in ampoules or in multidose containers with optionally, an added preservative. The compositions may be suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilizing and/or dispersing agents.

5 Pharmaceutical compositions for parenteral administration include aqueous solutions of the active preparation in water-soluble form. Additionally, suspensions of the active ingredients may be prepared as appropriate oily or water based injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acids esters such as ethyl oleate, triglycerides or liposomes.

10 Aqueous injection suspensions may contain substances, which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol or dextran. Optionally, the suspension may also contain suitable stabilizers or agents which increase the solubility of the active ingredients to allow for the preparation of highly concentrated solutions.

15 Alternatively, the active ingredient may be in powder form for constitution with a suitable vehicle, e.g., sterile, pyrogen-free water based solution, before use.

The pharmaceutical composition of some embodiments of the invention may also be formulated in rectal compositions such as suppositories or retention enemas, using, e.g., conventional suppository bases such as cocoa butter or other glycerides.

20 Pharmaceutical compositions suitable for use in context of some embodiments of the invention include compositions wherein the active ingredients are contained in an amount effective to achieve the intended purpose. More specifically, a therapeutically effective amount means an amount of active ingredients (chimeric polypeptide) effective to prevent, alleviate or ameliorate symptoms of a disorder or prolong the 25 survival of the subject being treated.

Determination of a therapeutically effective amount is well within the capability of those skilled in the art, especially in light of the detailed disclosure provided herein.

For any preparation used in the methods of the invention, the therapeutically effective amount or dose can be estimated initially from in vitro and cell culture assays.

30 For example, a dose can be formulated in animal models to achieve a desired concentration or titer. Such information can be used to more accurately determine useful doses in humans.

Toxicity and therapeutic efficacy of the active ingredients described herein can be determined by standard pharmaceutical procedures in vitro, in cell cultures or experimental animals. The data obtained from these in vitro and cell culture assays and animal studies can be used in formulating a range of dosage for use in human. The 5 dosage may vary depending upon the dosage form employed and the route of administration utilized. The exact formulation, route of administration and dosage can be chosen by the individual physician in view of the patient's condition. (See e.g., Fingl, et al., 1975, in "The Pharmacological Basis of Therapeutics", Ch. 1 p.1).

Dosage amount and interval may be adjusted individually to provide the 10 chimeric polypeptide (the target tissue) levels of the active ingredient are sufficient to induce or suppress the biological effect (minimal effective concentration, MEC). The MEC will vary for each preparation, but can be estimated from in vitro data. Dosages necessary to achieve the MEC will depend on individual characteristics and route of administration. Detection assays can be used to determine plasma concentrations.

15 Depending on the severity and responsiveness of the condition to be treated, dosing can be of a single or a plurality of administrations, with course of treatment lasting from several days to several weeks or until cure is effected or diminution of the disease state is achieved.

The amount of a composition to be administered will, of course, be dependent 20 on the subject being treated, the severity of the affliction, the manner of administration, the judgment of the prescribing physician, etc.

In one embodiment, the effective chimeric polypeptide amount per adult dose ranges from about 1-500 mg/m², or from about 1-200 mg/m², or from about 1-40 mg/m² or about 5-25 mg/m². Alternatively, a flat dose may be administered, whose amount 25 may range from 2-500 mg/dose, 2-100 mg/dose or from about 10-80 mg/dose.

In one embodiment, the effective chimeric polypeptide amount per adult dose is about 1-500 mg/m², or about 1-200 mg/m², or about 1-40 mg/m² or about 5-25 mg/m². Alternatively, a flat dose may be administered, whose amount may range about 2-500 mg/dose, 2-100 mg/dose or from about 10-80 mg/dose.

30 In another embodiment the effective chimeric polypeptide amount per adult dose range is about 0.0002 mg/kg to 2 mg/kg, about 0.002-2 mg/kg, about 0.02-2 mg/kg, about 0.2-2 mg/kg, about 0.002-0.2 mg/kg, about 0.0002-1 mg/kg, about 0.002-0.1

mg/kg, about 0.002-0.02 mg/kg, about 0.002-0.01 mg/kg, about 0.002-0.008 mg/kg, about 0.02-0.1 mg/kg, about 0.001-0.05 mg/kg, about 0.001-0.01 mg/kg, about 0.01-1 mg/kg, about 0.01-15 mg/kg, about 0.005 -1 mg/kg, about 0.01-5 mg/kg, about 0.005-0.01 mg/kg or about 0.05-0.1 mg/kg. According to a specific embodiment, these dose ranges are used for oral administration such as of plant cells expressing the chimeric protein.

According to a specific embodiment, the effective chimeric polypeptide amount per adult dose ranges about 0.002-0.2 mg/kg. According to a specific embodiment, this dose range is used for oral administration such as of plant cells expressing the chimeric protein.

Alternatively, a flat dose may be administered, whose amount may range about 2-500 mg/dose, 2-100 mg/dose or from 10-80 mg/dose. According to a specific embodiment, this dose range is used for oral administration such as of plant cells expressing the chimeric protein.

According to a specific embodiment, a flat dose of 0.01-100 mg, 0.1-100 mg, 0.1-50 mg, 0.1-20 mg, 0.1-10 mg, 0.1-5 mg is administered. According to a specific embodiment, this dose range is used for oral administration such as of plant cells expressing the chimeric protein.

According to a specific embodiment the flat dose is about 0.1-10 mg. According to a specific embodiment, this dose range is used for oral administration such as of plant cells expressing the chimeric protein.

According to a specific embodiment, the oral dose is administered daily. The dose may be divided for a number of administrations during the day (say 2-4 times a day). The dose can also be administered every two days, two times a week, three times a week, biweekly, weekly doses, or separated by several weeks (for example 2 to 8).

According to a specific embodiment, if the dose is to be administered more than one time per week, an exemplary dose range is the same as the foregoing described dose ranges or lower and administered two or more times per week (e.g., 25-100 mg/dose). In another embodiment, an acceptable dose for administration by injection contains 80-100 mg/dose, or alternatively, containing 80 mg per dose.

The dose may be modified for children and infants.

The dose can be administered at biweekly, weekly doses, or separated by several weeks (for example 2 to 8). According to a specific embodiment the chimeric polypeptide is generally administered at 25 mg by a single subcutaneous (SC) injection.

In many instances, an improvement in a patient's condition will be obtained by a 5 dose of up to about 100 mg of the pharmaceutical composition one to three times per week over a period of at least three weeks, though treatment for longer periods may be necessary to induce the desired degree of improvement. For incurable chronic conditions the regimen may be continued indefinitely. For pediatric patients (ages 4-17), a suitable regimen involves a dose of 0.4 mg/kg to 5 mg/kg of the chimeric polypeptides 10 of the invention by injection, administered one or more times per week.

In another embodiment, it is contemplated that the pharmaceutical formulation of the invention is prepared in a bulk formulation and as such, the components of the pharmaceutical composition are adjusted so that it is higher than would be required for administration and diluted appropriately prior to administration.

15 Compositions of some embodiments of the invention may, if desired, be presented in a pack or dispenser device, such as an FDA approved kit, which may contain one or more unit dosage forms containing the active ingredient. The pack may, for example, comprise metal or plastic foil, such as a blister pack. The pack or dispenser device may be accompanied by instructions for administration. The pack or 20 dispenser may also be accommodated by a notice associated with the container in a form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals, which notice is reflective of approval by the agency of the form of the compositions or human or veterinary administration. Such notice, for example, may be of labeling approved by the U.S. Food and Drug Administration for prescription drugs 25 or of an approved product insert. Compositions comprising a preparation of the invention formulated in a compatible pharmaceutical carrier may also be prepared, placed in an appropriate container, and labeled for treatment of an indicated condition, as is further detailed above. The concentration of the polypeptide in the aqueous pharmaceutical composition can vary over a wide range, but is generally within the 30 range of from about 0.05 to about 20,000 micrograms per milliliter μ /ml) of aqueous formulation.

Of note dosage forms which comprise the plant cells may include additives such as one or more of calcium, magnesium, iron, zinc, phosphorus, vitamin D and vitamin K. A suitable daily amount is 0.1 mg to 3.6 g calcium, preferably 320 to 530 mg. In general, the daily dosage of vitamins and minerals in the nutritional formulation or medicament of the invention is 25-100% by weight of the dosages recommended by the health authorities. Dietary fiber may also be a component of the compositions of the invention. Further components of the supplement may include any bioactive compounds or extracts which are known to have health benefits, especially for improving physical performance.

Generally the unit dosage form may further comprise an antioxidant (exemplary embodiments are provided above-. In another embodiment, the antioxidant is a pharmaceutically acceptable antioxidant. In another embodiment, the antioxidant is selected from the group consisting of vitamin E, superoxide dismutase (SOD), omega-3, and beta-carotene.

In another embodiment, the unit dosage form further comprises an enhancer of the biologically active protein or peptide. In another embodiment, the unit dosage form further comprises a cofactor of the biologically active protein or peptide.

In another embodiment, a unit dosage form of the present invention further comprises pharmaceutical-grade surfactant. Surfactants are well known in the art, and are described, *inter alia*, in the *Handbook of Pharmaceutical Excipients* (eds. Raymond C Rowe, Paul J Sheskey, and Sian C Owen, copyright Pharmaceutical Press, 2005). In another embodiment, the surfactant is any other surfactant known in the art.

In another embodiment, a unit dosage form of the present invention further comprises pharmaceutical-grade emulsifier or emulgator (emollient). Emulsifiers and emulgators are well known in the art, and are described, *inter alia*, in the *Handbook of Pharmaceutical Excipients* (*ibid*). Non-limiting examples of emulsifiers and emulgators are eumulgin, Eumulgin B1 PH, Eumulgin B2 PH, hydrogenated castor oil cetostearyl alcohol, and cetyl alcohol. In another embodiment, the emulsifier or emulgator is any other emulsifier or emulgator known in the art.

In another embodiment, a unit dosage form of the present invention further comprises pharmaceutical-grade stabilizer. Stabilizers are well known in the art, and are

described, *inter alia*, in the Handbook of Pharmaceutical Excipients (*ibid*). In another embodiment, the stabilizer is any other stabilizer known in the art.

In another embodiment, a unit dosage form of the present invention further comprises an amino acid selected from the group consisting of arginine, lysine, aspartate, glutamate, and histidine. In another embodiment, analogues and modified versions of arginine, lysine, aspartate, glutamate and histidine are included in the terms "arginine," "lysine," "aspartate", "glutamate" and "histidine," respectively. In another embodiment, the amino acid provides additional protection of ribonuclease or other active molecules. In another embodiment, the amino acid promotes interaction of biologically active protein or peptide with a target cell. In another embodiment, the amino acid is contained in an oil component of the unit dosage form.

In another embodiment, a unit dosage form of the present invention further comprises one or more pharmaceutically acceptable excipients, into which the matrix carrier unit dosage form is mixed. In another embodiment, the excipients include one or more additional polysaccharides. In another embodiment, the excipients include one or more waxes. In another embodiment, the excipients provide a desired taste to the unit dosage form. In another embodiment, the excipients influence the drug consistency, and the final dosage form such as a gel capsule or a hard gelatin capsule.

Non limiting examples of excipients include: Antifoaming agents (dimethicone, simethicone); Antimicrobial preservatives (benzalkonium chloride, benzethonium chloride, butylparaben, cetylpyridinium chloride, chlorobutanol, chlorocresol, cresol, ethylparaben, methylparaben, methylparaben sodium, phenol, phenylethyl alcohol, phenylmercuric acetate, phenylmercuric nitrate, potassium benzoate, potassium sorbate, propylparaben, propylparaben sodium, sodium benzoate, sodium dehydroacetate, sodium propionate, sorbic acid, thimerosal, thymol); Chelating agents (edetate disodium, ethylenediaminetetraacetic acid and salts, edetic acid); Coating agents (sodium carboxymethyl-cellulose, cellulose acetate, cellulose acetate phthalate, ethylcellulose, gelatin, pharmaceutical glaze, hydroxypropyl cellulose, hydroxypropyl methylcellulose, hydroxypropyl methylcellulose phthalate, methacrylic acid copolymer, methylcellulose, polyethylene glycol, polyvinyl acetate phthalate, shellac, sucrose, titanium dioxide, carnauba wax, microcrystalline wax, zein); Colorants (caramel, red, yellow, black or blends, ferric oxide); Complexing agents (ethylenediaminetetraacetic

acid and salts (EDTA), edetic acid, gentisic acid ethanolmaide, oxyquinoline sulfate); Desiccants (calcium chloride, calcium sulfate, silicon dioxide); Emulsifying and/or solubilizing agents (acacia, cholesterol, diethanolamine (adjunct), glyceryl monostearate, lanolin alcohols, lecithin, mono- and di-glycerides, monoethanolamine (adjunct), oleic acid (adjunct), oleyl alcohol (stabilizer), poloxamer, polyoxyethylene 50 stearate, polyoxyl 35 castor oil, polyoxyl 40 hydrogenated castor oil, polyoxyl 10 oleyl ether, polyoxyl 20 cetostearyl ether, polyoxyl 40 stearate, polysorbate 20, polysorbate 40, polysorbate 60, polysorbate 80, propylene glycol diacetate, propylene glycol monostearate, sodium lauryl sulfate, sodium stearate, sorbitan monolaurate, sorbitan monooleate, sorbitan monopalmitate, sorbitan monostearate, stearic acid, trolamine, emulsifying wax); Flavors and perfumes (anethole, benzaldehyde, ethyl vanillin, menthol, methyl salicylate, monosodium glutamate, orange flower oil, peppermint, peppermint oil, peppermint spirit, rose oil, stronger rose water, thymol, tolu balsam tincture, vanilla, vanilla tincture, vanillin); Humectants (glycerin, hexylene glycol, propylene glycol, sorbitol); Polymers (e.g., cellulose acetate, alkyl celluloses, hydroxyalkylcelluloses, acrylic polymers and copolymers); Suspending and/or viscosity-increasing agents (acacia, agar, alginic acid, aluminum monostearate, bentonite, purified bentonite, magma bentonite, carbomer 934p, carboxymethylcellulose calcium, carboxymethylcellulose sodium, carboxymethylcellulose sodium 12, carrageenan, microcrystalline and carboxymethylcellulose sodium cellulose, dextrin, gelatin, guar gum, hydroxyethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, magnesium aluminum silicate, methylcellulose, pectin, polyethylene oxide, polyvinyl alcohol, povidone, propylene glycol alginate, silicon dioxide, colloidal silicon dioxide, sodium alginate, tragacanth, xanthan gum); Sweetening agents (aspartame, dextrates, dextrose, excipient dextrose, fructose, mannitol, saccharin, calcium saccharin, sodium saccharin, sorbitol, solution sorbitol, sucrose, compressible sugar, confectioner's sugar, syrup); This list is not meant to be exclusive, but instead merely representative of the classes of excipients and the particular excipients which may be used in oral dosage unit dosage forms of the present invention.

Conventional additives may be included in the compositions of the invention, including any of those selected from preservatives, chelating agents, effervescent agents, natural or artificial sweeteners, flavoring agents, coloring agents, taste masking

agents, acidulants, emulsifiers, thickening agents, suspending agents, dispersing or wetting agents, antioxidants, and the like. Flavoring agents can be added to the compositions of the invention to aid in compliance with a dosing regimen. Typical flavoring agents include, but are not limited to natural or synthetic essences, oils and/or extracts of pineapple, orange, lemon, mint, berry, chocolate, vanilla and melon.

5 As used herein the term "about" refers to $\pm 10\%$.

The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

The term "consisting of" means "including and limited to".

10 The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

15 As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

20 Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well 25 as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

30 Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases "ranging/ranges between" a first indicate number and a second indicate number and "ranging/ranges from" a first indicate number "to" a second indicate number are used herein

interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numerals therebetween.

As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical and medical arts.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Various embodiments and aspects of the present invention as delineated hereinabove and as claimed in the claims section below find experimental support in the following examples.

20

EXAMPLES

Reference is now made to the following examples, which together with the above descriptions illustrate some embodiments of the invention in a non limiting fashion.

Generally, the nomenclature used herein and the laboratory procedures utilized in the present invention include molecular, biochemical, microbiological and recombinant DNA techniques. Such techniques are thoroughly explained in the literature. See, for example, "Molecular Cloning: A laboratory Manual" Sambrook et al., (1989); "Current Protocols in Molecular Biology" Volumes I-III Ausubel, R. M., ed. (1994); Ausubel et al., "Current Protocols in Molecular Biology", John Wiley and Sons, Baltimore, Maryland (1989); Perbal, "A Practical Guide to Molecular Cloning", John Wiley & Sons, New York (1988); Watson et al., "Recombinant DNA", Scientific American Books, New York; Birren et al. (eds) "Genome Analysis: A Laboratory Manual Series", Vols. 1-4, Cold Spring Harbor Laboratory Press, New York (1998);

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methodologies as set forth in U.S. Pat. Nos. 4,666,828; 4,683,202; 4,801,531; 5,192,659 and 5,272,057; "Cell Biology: A Laboratory Handbook", Volumes I-III Cellis, J. E., ed. (1994); "Culture of Animal Cells - A Manual of Basic Technique" by Freshney, Wiley-Liss, N. Y. (1994), Third Edition; "Current Protocols in Immunology" Volumes I-III Coligan J. E., ed. (1994); Stites et al. (eds), "Basic and Clinical Immunology" (8th Edition), Appleton & Lange, Norwalk, CT (1994); Mishell and Shiigi (eds), "Selected Methods in Cellular Immunology", W. H. Freeman and Co., New York (1980); available immunoassays are extensively described in the patent and scientific literature, see, for example, U.S. Pat. Nos. 3,791,932; 3,839,153; 3,850,752; 3,850,578; 3,853,987; 3,867,517; 3,879,262; 3,901,654; 3,935,074; 3,984,533; 3,996,345; 4,034,074; 4,098,876; 4,879,219; 5,011,771 and 5,281,521; "Oligonucleotide Synthesis" Gait, M. J., ed. (1984); "Nucleic Acid Hybridization" Hames, B. D., and Higgins S. J., eds. (1985); "Transcription and Translation" Hames, B. D., and Higgins S. J., eds. (1984); "Animal Cell Culture" Freshney, R. I., ed. (1986); "Immobilized Cells and Enzymes" IRL Press, (1986); "A Practical Guide to Molecular Cloning" Perbal, B., (1984) and "Methods in Enzymology" Vol. 1-317, Academic Press; "PCR Protocols: A Guide To Methods And Applications", Academic Press, San Diego, CA (1990); Marshak et al., "Strategies for Protein Purification and Characterization - A Laboratory Course Manual" CSHL Press (1996); all of which are incorporated by reference as if fully set forth herein. Other general references are provided throughout this document. The procedures therein are believed to be well known in the art and are provided for the convenience of the reader. All the information contained therein is incorporated herein by reference.

25

EXAMPLE 1

MATERIALS AND EXPERIMENTAL PROCEDURES

Expression constructs and expression

cDNA encoding prh TNFR2:Fc was optimized and synthesized by GENEART AG (Regensburg, Germany). The codon usage was adapted to the codon bias of *Nicotiana tabacum* genes. The IgG1 portion was cloned from Fc IgG1 heavy chain constant region [Homo sapiens] ACCESSION AEV43323.

During the optimization process the following cis-acting sequence motifs were avoided: Internal TATA-boxes, chi-sites and ribosomal entry sites, AT-rich or GC-rich sequence stretches, RNA instability elements ("Killer motifs"), Repeat sequences and RNA secondary structures, splice donor (cryptic) and acceptor sites, branch points. In 5 addition, regions of very high (>80%) or very low (<30%) GC content were avoided. The resultant DNA sequence is as set forth in SEQ ID NO: 1. The encoded polypeptide is as set forth in SEQ ID NO: 2. To the native cDNA sequence, a signal peptide (e.g. endoplasmic reticulum target signal peptide) from *N. plumbaginifolia* Calreticulin protein was added to the N' terminus of the gene, allowing efficient targeting of prh 10 TNFR2:Fc to the secretory pathway and is then cleaved from the polypeptide, by signal peptidase, once the protein has been translocated into the endoplasmic reticulum (SEQ ID NO: 3, SEQ ID NO: 4, representing the DNA and peptide sequences of the ER signal peptide, respectively). Additionally, an ER retention signal SEKDEL was added to the C' terminus of the gene. This signal allows protein retrieval from the Golgi 15 apparatus to the ER, and localization in the ER. The entire coding sequence (signal peptide- prh TNFR2:Fc-SEKDEL) is encoded by SEQ ID NO: 5 and the encoded polypeptide is as set forth in SEQ ID NO: 6. The resultant protein following cleavage is as set forth in SEQ ID NO: 7, 204 OR 205 or 214 (prh TNFR2:Fc-SEKDEL).

Stable expression in N. tabacum BY2 cells

20 Agrobacterium mediated transformation is widely used to introduce foreign genes into a plant cell genome. Using this approach, a T-DNA molecule consisting of a foreign gene and its regulatory elements is randomly introduced into the plant genome. Since the site of integration, as well as the copy number of the gene insertions cannot be controlled, the transformation process results in a highly heterogeneous transgenic 'pool' 25 composed of cells with various levels of transgene expression. The transgenic 'pool' is subsequently used for clone isolation. The transformation process, results in establishment of numerous single cell lines, each representing an individual transformation event, from which the clone with the highest expression level of the foreign gene is selected. For prh TNFR2:Fc, the transformation was conducted with a 30 plasmid carrying the prh TNFR2:Fc cassette (Figure 1 SEQ ID NOS: 7 and 8). As a result, the recombinant protein is targeted to the Endoplasmic reticulum (ER) of the cells. The transformations of the BY2 cells with the prh TNFR2:FC-ER expression

vector were performed by the *Agrobacterium tumefaciens* mediated plant transformation procedure as follow: BY2 (Bright Yellow 2) suspension culture was co-cultivated, for 48 hours, with the *Agrobacterium tumefaciens* strain carrying the vector harboring the prhTNFR2:FC- gene and the neomycin phosphotransferase (NPTII) selection gene. Subsequently, cells were kept in media supplemented with 50mg/L of Kanamycin and 250mg/L Cefotaxime. The NPTII gene confers resistance to Kanamycin, thus only NPTII positive BY2 cells survive in this selection media. The Cefotaxime was used to selectively kill the agrobacterium, the plant cells being resistant to this antibiotic.

10 ***Screening for the optimal expressing clone***

In order to select individual cell lines, aliquots of highly diluted cell suspension were spread on solid BY-2 medium (Toshiyuki Nagata & Fumi Kumagai *Methods in Cell Science* 21: 123–127, 1999). The cells were then grown until small calli developed. Each callus was then re-suspended in liquid culture. Cells were then sampled and evaluated for prh TNFR2:FC. About 500 cell lines were screened by Western blot under denaturing conditions (Figure 4). The lines with high expression levels were further re-analyzed by the same method to select the highest expressing clone of prh TNFR2:FC producing clone.

15 ***Gel electrophoresis:***

20 Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis (SDS-PAGE) separates proteins on an electrical field according to their size. Proteins in the presence of the detergent SDS migrate as a linear function of the logarithm of their molecular weight. Migration pattern and identification of prh TNFR2:FC on SDS-PAGE was compared to commercial molecular weight standard proteins (New England BioLabs; 25 cat No. P7708S) and to the commercially available, mammalian-cell derived Enbrel expressed in CHO cells (Entanercept; Wyeth). prh TNFR2:FC was extracted from cells either by reducing sample buffer containing β -mercaptoethanol or by native extraction buffer. The native extraction supernatant was mixed with non-reducing sample buffer prior to analysis. Electrophoresis was performed using CriterionTM cell vertical 30 electrophoresis apparatus (Bio-Rad Lab.) with premixed electrophoresis Tris-Glycine-SDS running buffer (Bio-Rad Laboratories). Following electrophoresis, the proteins were transferred from the Polyacrylamide gel to a protein binding nitrocellulose

membrane (iBlotTM). Membranes were blocked for 1hr at RT with 5% milk buffer containing 0.1% Tween 20. For identification of the Fc portion of the molecule, Goat anti human IgG conjugated to HRP (cat # 109-035-098, Jackson.) was used .For TNFR2 detection, a Rabbit Anti-TNFRII (ID: ab109853, Abcam) followed by Goat anti Rabbit HRP (cat # 111-035-003, Jackson) were employed. Detection was carried out with ECL detection kit (Pierce). The immunoreactivity of prh TNFR2:FC was compared to that of commercial Enbrel (Entanercept; Wyeth). Bands were detected using the Molecular Imager Gel Doc XR System (Bio-Rad Laboratories).

Amino acid sequencing by Mass-spectrometry

prhTNFR2:FC is sent for sequencing analysis at the Smoler Proteomics Center at the Technion - Israel Institute of Technology (Haifa, Israel). The protein is extracted from the gel, reduced with 2.8mM DTT (60°C for 30 min), modified with 8.8mM iodoacetamide in 100mM ammonium bicarbonate (in the dark, room temperature for 30 min) and digested in 10% ACN and 10mM ammonium bicarbonate with modified Trypsin (Promega) or with ChymoTrypsin overnight at 37°C in a 1:50 enzyme-to-substrate ratio. 3% of the resulting peptides are resolved by reverse-phase chromatography on 0.075 X 200-mm fused silica capillaries (J&W) packed with ReproSil reversed phase material (Dr Maisch GmbH, Germany). The peptides are eluted with linear 60 minutes gradients of 5 to 45 % and 15 minutes at 95 % acetonitrile with 0.1 % formic acid in water at flow rates of 0.25 µl/min. On line mass spectrometry is performed by an ion-trap mass spectrometer (Orbitrap, Thermo) in a positive mode using repetitively full MS scan followed by collision induces dissociation (CID) of the 7 most dominant ion selected from the first MS scan.

The mass spectrometry data is analyzed using the Sequest 3.31 software (J. Eng and J. Yates, University of Washington and Finnigan, San Jose) vs a specific sequence.

Glycosylation analysis

The major difference between glycoproteins produced in Chinese Hamster Ovary (CHO) cell and plant cell systems is the glycosylation profile and glycan structure. Preliminary analysis has been performed to characterize the various N-linked 5 glycan structures attached to the protein. These results are compared to results of the N-glycosylation profile found in commercial Enbrel. The presence of O-linked glycans, and glycan site analysis is determined.

Samples of prh TNFR2:FC and commercial Enbrel are reduced, alkylated and separated on SDS-PAGE. The protein bands at ~75 KDa (a total of about 200 μ g 10 protein) are taken for glycan analysis using Trypsin digestion followed by either PNGase A or PNGase F digestion (~80% and ~20% of the total protein, respectively) for prh TNFR2:FC and PNGase F digestion only for commercial Enbrel. Digestion with Trypsin, followed by PNGase A releases all the *N*-linked glycans and digestion with PNGase F releases all glycans except those containing alpha 1-3 core fucose 15 (found in plants). The released glycans are extracted, cleaned and then labeled with the fluorescent reagent anthranilamide (2-aminobenzamide, 2AB) followed by removal of excess 2AB. The analytical method includes separation of the glycans on a Waters HPLC system with a normal phase amide-based column (Tosoh TSK Amide-80 column), coupled with a fluorescence detector (330 nm excitation, 420 nm emission). 20 Sequencing of the labeled glycan pool is achieved by sequential digestion with various exoglycosidases followed by additional HPLC analysis. Using sequential digestion with various exoglycosidases provides additional information on the profile of the glycans structures and their relative amounts. The exoglycosidase digestions that are carried out for the glycans released from prh TNFR2:FC are with JBH (Jack bean beta- 25 N-Acetylhexosaminidase) that removes beta 1-2, 3, 4 and 6 *N*-acetylglucosamine (GlcNAc), with JBM (Jack bean mannosidase) that removes mannose alpha 1-2, 6 > 3 mannose and with BKF (Bovine testis fucosidase) that removes alpha 1-6 and alpha 1-3 core fucose. The fluorescence labeling enables a semi-quantitative analysis of the distribution of the various glycan structures in the total digested glycan pool. The 30 glycans are then separated according to unique glycan linkages and in order of increasing size using a gradient solvent flow consisting of ammonium formate and acetonitrile. Retention time of individual glycans is compared to the retention times of a

standard mix of partially hydrolysed dextran fragments, giving a ladder of glucose units (GU). The glycans are assigned to peaks according to their GU values, based on standards and a comparison to an external data base (http://glycobasedotnibrtdotie:8080/database/show_glycobasedotaction). The final assignment and relative peak areas are calculated from the chromatogram of the PNGase A digestion.

Enzyme-linked immunosorbent assay (ELISA)

Binding ELISA: TNF α binding ELISA is a combination of a commercial TNF α detection ELISA kit (Human TNF- α ; Hycult Biotech Inc.#HK307) and a commercial anti human IgG antibody (Goat anti human IgG FC specific HRP; Sigma). The assay is a quantitative non radioactive assay for prhTNFR2:FC binding activity. This binding ELISA enables to detect functional (capable of binding TNF α) molecules comprising both the TNFR and IgG domains.

An ELISA plate pre-coated with antibodies against TNF α was incubated with TNF α (60ng/ml, Sigma) for 1 hour at room temperature. Between each ELISA step the plate was washed three times with commercial wash buffer. Commercial Enbrel and supernatant from BY2 cells expressing prh TNFR2:FC (serial dilutions) were incubated on ELISA plate for 2hr at RT. Goat anti human IgG Fc HRP was diluted 1:10,000 and incubated on plate for 1hr at RT. TMB was used as substrate for HRP. The colorimetric reaction was stopped with 10% HCL and absorbance determined at 450nm.

Prevention of TNF α induced apoptosis in A375 cells

A375 cells (human melanoma cells) were grown in suspension in culture medium (ATCC, # 30-2002, supplemented with 10% FBS). 10⁴ /well cells were plated in 96-well assay plates and incubated overnight in assay medium (ATCC, # 30-2002, supplemented with 5% FBS). Recombinant TNF α (2ng/ml, ProSpec, Rehovot, Israel) was incubated for 2 hr at 37 °C in the presence of different concentrations (1.562-100ng/ml) of prhTNFR2:FC or commercial Enbrel (Entanercept; Wyeth). Following incubation, the mixed solution was added to A375 cells in the presence of actinomycin-D (0.8 μ g/ml), incubated for further 24hr at 37°C, 5% CO₂ in a humidified incubator and quantification of apoptosis was determined by MTT assay (Sigma Cat. No. M5655). The plate was read at 570-650nm and the inhibition of TNF- α induced cytotoxicity (%) was calculated.

EXAMPLE 2**PROTEIN ANALYSIS**

prhTNFR2:FC was analyzed under reducing (Figure 2A) and non-reducing conditions (native extraction in the Figure 2B). prhTNFR2:FC (Lane 1) and commercial Enbrel (lane 2) were detected using anti Fc antibody (upper panel) and anti TNFR2 antibody (lower panel). The two proteins demonstrate a slight difference in migration characteristics, presumably due to differences in glycosylation patterns between the plant and mammalian cell-expressed enzymes.

TNF α binding by both commercial Enbrel and prh TNFR2:Fc was examined by comparing serial dilutions of lysates of BY2 cells expressing prh TNFR2:Fc (PRX-106) to commercial Enbrel. prh TNFR2:Fc serial dilutions demonstrate a dose response binding pattern similar to the commercial protein (see Figure 3). The selection of transgenic cell lines according to protein expression was done by Western blotting. Thus, to allow for the selection of individual cell lines, aliquots of highly diluted cell suspension were spread on solid BY-2 medium. The cells were then grown until small calli developed. Each callus was then re-suspended in liquid culture. Cells were then sampled and evaluated for prh TNFR2:Fc expression levels by extraction under reducing conditions followed by Western Blot identification (anti FC antibody) of the produced target protein (Figure 4). The functionality of the expressed protein was established by its ability to prevent TNF α induced apoptosis. Specifically, TNF α activity can be measured by its ability to induce cell death of certain cell lines in the presence of the transcriptional inhibitor, actinomycin D. Pre-incubation with a neutralizing protein of TNF α prevents binding to the receptors (TNF-R1 and TNF-R2), thereby inhibiting the cytokine effect and preventing TNF α induced cell death. Quantification of cell viability by MTT assay provides an in-cell activity assay for TNF α cytotoxicity. The results are shown in Figures 5A-G on melanoma cells A375 and in Figures 6A-G on L929 fibroblasts.

EXAMPLE 3**prh TNFR2:FC SUPPRESSES INFLAMMATORY BOWEL DISEASE (IBD)**

Inflammatory bowel disease (IBD) is a chronic intestinal inflammatory condition that is mediated by genetic, immune, and environmental factors. About 0.2-

0.3 % of the population are diagnosed with IBD annually. IBD is characterized by a tendency for chronic or relapsing immune activation and inflammation within the Gastro-intestinal Tract (GIT). It has two presentations: Crohn's disease (CD), a chronic inflammation potentially involving any location of the GIT from mouth to anus, and

5 Ulcerative colitis (UC), an inflammatory disorder that affects the rectum and extends proximally to affect variable extent of the colon. CD is regulated more by the TH1 immune cell response, overproducing the cytokines IL-12, IFN-gamma and TNFalpha among others. UC, on the other hand, is mainly regulated by the TH2 immune cell response.

10 PRX106 is a soluble receptor for a cytokine overproduced in inflammation involving among others, the TH1 immune cell response. PRX106 was shown to be very effective when injected IV in other models of inflammation (Rheumatoid Arthritis). PRX106 is overexpressed in Protalix's ProCellEx™ system, in BY2 plant cells. Being a plant cell, BY2 has a cell wall that can help protect PRX106 while moving through the 15 stomach and small intestine. In the colon, where the polysaccharides are digested, the plant cell releases its content and hence PRX106 is free to bind its cytokine ligand. Moreover, PRX106 is a chimeric protein carrying an Fc segment of human IgG1. In the epithelial monolayer lining the mucosal barrier, the FcRn receptor transcytoses IgG molecules across by binding to their Fc. Therefore, PRX106 can also cross the 20 epithelial barrier to bind its cytokine ligand on the serosal side of the epithelia.

IBD models are classified into five major groups: chemically induced model, cell-transfer model, spontaneous model, congenital (spontaneous gene mutation) model, and genetically engineered model. In the most widely used chemically induced models, colitis is induced by intrarectal administration of the covalently reactive reagents 25 TNBS/oxazolone, which are believed to induce a T-cell-mediated response against hapten-modified autologous proteins/luminal antigens. In the DSS model, mice are subjected several days to drinking water supplemented with DSS (dextran sodium sulfate), which seems to be directly toxic to colonic epithelial cells of the basal crypts. The disease severity is evaluated by scoring 3 major clinical signs (weight loss, 30 diarrhea, and rectal bleeding). The mouse models TNBS (Example 3A) and DSS (Example 3B) are used to determine the therapeutic efficacy of the plant cells expressing the chimeric polypeptide *in vivo*.

EXAMPLE 3A

PRX106-EXPRESSING CELLS ARE EFFECTIVE IN ALLEVIATING
SYMPTOMS OF IBD AS EVIDENCED IN AN IN VIVO TRINITROBENZENE-
SULPHONIC ACID (TNBS) MODEL5 *Materials and Methods*

Ethics Statement - All procedures were strictly performed in accordance with the Guide for the Care and Use of Laboratory Animals.

Animals

10 Male Balb/c mice, 8-9 weeks old were used in all experiments. Each experimental group included 5 to 10 mice. The mice were purchased from Harlan Laboratories, Israel. All mice were moved to SPF-free room (natural bacterial flora) several days before starting the experiment.

TNBS Induction

15 TNBS was induced in mice by rectal installation of TNBS [M.F. Neurath, I.Fuss et al: *j exp. Med* 182' 1281-1290 (1995)]. Mice were sensitized by painting 100 μ L of 1 % TNBS in ethanol onto the shaved skin of their abdomens 7 days before challenge. On the day of challenge, the mice were given 120 μ L of 1 % TNBS (Sigma Aldrich) slowly injected into the lumen of the colon via a catheter. Following TNBS treatment, mice were treated per os (PO) daily from day 0 to day 4 with BY-2 cells expressing 20 PRX-106, equivalent to 5 μ g protein (Dose I) and 30 μ g protein (Dose II); BY-2(-) control cells in the same orally administered volumes of the PRX-106 expressing cells; and saline. TNBS control mice received PBS alone. The animals were monitored once daily for weight. Weight loss was calculated by subtracting the weight on each day from the weight on day 0. After the experiment, the animals were sacrificed and 25 dissected. On day 5, blood samples were collected by cardiac puncture, and were left to clot and then centrifuged to obtain serum for determination of serum cytokine levels. (Cury et al. *Cell Immunol.* 2013, 282 (1); 66-70. Experiments were performed on 5-15 mice per group in three separate experiments; results followed the same pattern in all experiments

30 *Oral administration of recombinant plant cells*

Oral administration of plant cells expressing recombinant TNFR2:Fc was initiated 6 hours after administration of TNBS. Mice received plant cells expressing

recombinant TNFR2:Fc, resuspended in 350-500 μ L. Negative controls received the same orally administered volumes of host Mock plant cells, instead of the plant cells expressing recombinant TNFR2:Fc. Oral administration was performed by gavage. Two more controls were untreated mice and TNBS treated mice that received saline.

5 *Analysis of cytokine profiles*

Serum levels of cytokines TNF- α , and IL-10 were determined using ELISA kits following the manufacturer's instructions (R&D Systems, Minneapolis, MN, USA).

Antibody array

Serum qualitative measurement of cytokine content was performed using the 10 Mouse Cytokine Antibody Array (R&D Systems, Minneapolis, MN, USA), according to the manufacturer's manual.

Immunohistochemistry

Paraffin-embedded colonic tissue sections (5 μ m) were deparaffinized, rehydrated, washed and incubated in 3% H₂O₂ and blocked (Bar Sela et al 2006). 15 Slides were incubated with I kB-alpha pSer32/Ser36 antibodies (Abcam). Color was developed using the DAB substrate kit (Thermo Scientific) or Zymed AEC substrate kit (Zymed Laboratories), followed by counterstaining with Mayer's hematoxylin. Controls without addition of primary antibody showed low or no background staining in all cases. Blocking was performed according to Bar-Sela et al. Histopathology. 20 2006;49:188-193.

Flow cytometry

Spleens were harvested from mice in RPMI 1640 medium. Cell suspensions were prepared by dicing spleens with a razor blade, followed by passage through a 40 μ m Nylon filter (BD Falcon). Splenocytes were incubated with anti-mouse CD4 (R&D Systems, Minneapolis, MN, USA) and anti-mouse CD25 (R&D Systems, Minneapolis, MN, USA). Cells were then fixed and permeabilized for 20 min at 4 °C and then incubated with anti-mouse Foxp3 (Mouse Regulatory T cell 3-Color Flow kit, R&D Systems, Minneapolis, MN, USA) diluted in permeabilization buffer for 30 min. Ten thousand CD4 $^{+}$ cells were analyzed by FACS.

30 *Macroscopic colon damage*

Macroscopic appearance of the colon was assessed using the Wallace macroscopic scoring system [W. Vermeulen, J. G. de Man, S. Nullens, P. A. Pelekmans,

B. Y. de Winter, and T. G. Moreels, "The use of colonoscopy to follow the inflammatory time course of TNBS colitis in rats," *Acta Gastro-Enterologica Belgica*, vol. 74, no. 2, pp. 304–311, 2011]. In this scoring system, the inflammation is assessed on the following scale from 0 to 10 based on ulceration, inflammation, and extent of disease: 0 = normal aspect of the mucosa, 1 = localized hyperemia without ulcerations, 2 = ulceration, 3 = ulceration with thickening of bowel wall at one site, 4 = two or more sites of ulceration and thickening of the bowel wall, 5 = major sites of damage extending <2 cm along the length of the colon, and 6–10 = damage extending >2 cm (with the score increasing by 1 for each centimeter of damaged tissue).

10 *Results*

Oral administration of plant cells expressing recombinant TNFR2:Fc improved TNBS-Induced body weight loss as monitored 4 days after initiation of TNBS administration (Figures 7A-B).

15 Colon lengths were measured as morphological indicators of colon inflammation in TNBS-treated mice; short colon indicating an inflammatory state. As shown in Figure 8, the colon length of mice treated with TNBS was significantly shortened compared to the control mice. The length of colon of the treated group (oral administration of cells expressing prTNFR2:Fc) was significantly longer than that in the TNBS-treated group.

20 Oral administration of plant cells expressing recombinant TNFR2:Fc also improved the macroscopic features of TNBS-induced colitis. Macroscopic examination of colons, showed reduced colon damage severity compared with the non treated colons (Figure 9).

25 Oral administration of plant cells expressing recombinant TNFR2:Fc reduced the expression of proinflammatory cytokines in mice with TNBS-induced colitis (Figures 10A-C). The effect of the treatment on the serum levels of proinflammatory cytokines linked to TNBS colitis and anti-inflammatory cytokines was evaluated. Note that in most of the TNFR2:Fc treated groups the expression levels of proinflammatory cytokines IL-6 and TNF- α were reduced, and the expression levels of anti-inflammatory cytokine IL-10 were elevated.

30 Figures 11A-B showed that treatment with oral administration of plant cells expressing recombinant TNFR2:Fc reduced level of inflammatory mediators like granulocyte colony-stimulating factor G-CSF, macrophage colony-stimulating factor

(M-CSF), potentially indicating reduced systemic inflammation by lowering systemic recruitment of bone marrow derived cells from the bloodstream

Recently, imbalance of the development and function of IL-17-producing Th17 cells and CD4⁺CD25⁺FOXP3⁺ Treg cells has been demonstrated to play an important role in

5 autoimmune diseases, including IBD. Treg cells, also known as CD4⁺CD25⁺, FOXP3⁺, are involved in the maintenance of peripheral tolerance and in controlling the immune response by initiating suppressive effects on activated immune cells. The present analysis shows that oral administration of plant cells expressing TNFR2:Fc expands population of functional regulatory T (T reg) cells in the spleen (Figure 12).

10 To conclude the above-results demonstrate that oral administration of plant cells expressing recombinant TNFR2:Fc is an anti-inflammatory agent that ameliorates TNBS -induced colitis.

EXAMPLE 3B

15 PRX106-EXPRESSING CELLS ARE EFFECTIVE IN ALLEVIATING SYMPTOMS OF IBD AS EVIDENCED IN AN IN VIVO DEXTRAN SULFATE SODIUM-INDUCED (DSS-INDUCED) MODEL

20 The Dextran Sulfate Sodium-induced (DSS-induced) mouse model of IBD is used for compounds for efficacy in Inflammatory Bowel Disease. This is an experimental acute Ulcerative Colitis model with symptoms similar to those observed in human UC, such as diarrhea, bloody feces, body weight loss, mucosal ulceration and shortening of the large intestine.

Ethics Statement

25 All procedures were strictly performed in accordance with the Guide for the Care and Use of Laboratory Animals.

Animals

Male C67/Bl mice, 8-9 weeks old were used in all experiments. Each experimental group included 10 mice. The mice were purchased from Harlan Laboratories, Israel. All mice were moved to SPF-free room (natural bacterial flora) 30 several days before starting the experiment.

Induction and evaluation of colitis in mice treated with DSS and following oral administration of plant cells expressing recombinant TNFR2:Fc

Colitis was induced by administration of 1.5% (wt/vol) DSS (reagent-grade DSS salt; molecular mass = 36–50 kD; MP Biomedicals) in normal drinking water for 5 days, followed by 5 days of normal water consumption. Daily treatment with orally administered plant cells expressing recombinant TNFR2:Fc; Mock cells comprising vector alone or control treatment (saline) began 24 hours following DSS induction, for a period of 7 days. Colonic inflammation was assessed 5 days after DSS treatment by punch biopsies and histological score. The animals were monitored once daily for weight, weight loss was calculated by subtracting the daily weight from the weight on day 0. After the experiment, the animals were sacrificed and dissected; colon shortening was assessed by colon length measurements in comparison to untreated colon; Blood samples were collected by cardiac puncture, and were left to clot and then centrifuged to obtain serum for determination of serum cytokine levels.

Oral administration of recombinant plant cells:

Oral administration of plant cells expressing recombinant TNFR2:Fc was initiated 24 hours following DSS administration. Mice received plant cells expressing recombinant TNFR2:Fc (comprising 30 μ g of protein), suspended in 500 μ l saline. Negative controls received the equivalent volumes of host Mock plant cells, to the plant cells expressing recombinant TNFR:Fc. Two more control groups were DSS treated mice administered with saline and untreated mice. Oral administration was performed by gavage.

Analysis of colon inflammation.

Paraffin-embedded colon tissue sections were stained with hematoxylin and eosin for light microscopic examination to assess colon injury and inflammation. Samples from entire colon were analyzed pathologically by a pathologist blinded to treatment conditions. A scoring system including degree of inflammation, crypt damage, percentage of area involved by inflammation and depth of inflammation was used.

Punch biopsies.

Mouse colons were flushed 3 times with PBS containing antibiotics and opened along a longitudinal axis. Thereafter, 4-mm² punch biopsies were obtained and

incubated for 24 hours in RPMI-1640 medium supplemented with antibiotics. Supernatants were collected and kept in -20°C until assessed for cytokine expression. Qualitative measurement of cytokine content in medium conditioned by colonic explants was performed using the Magnetic Luminex Screening Assay according to the manufacturer's manual R&D Systems, Minneapolis, MN, USA).

Analysis of cytokine profiles

Serum levels of cytokines TNF- α , IL-6 and IL-10 were determined using Magnetic Luminex Screening Assay following the manufacturer's instructions (R&D Systems, Minneapolis, MN, USA).

10 *Results*

1. Oral administration of plant cells expressing recombinant TNFR2:Fc improved DSS-induced body weight loss

Body weight was monitored each day following DSS administration (Figures 13A-B). As can be seen, treatment of mice orally with plant cells expressing recombinant TNFR2:Fc attenuated the weight loss induced by DSS.

2. Oral administration of plant cells expressing recombinant TNFR2:Fc suppressed DSS-induced colitis in mice

Colon lengths were measured as it is well established that a short colon can be used as a morphological indicator of colon inflammation in DSS-treated mice. As shown in Figures 14A-B, the colon length of mice treated with DSS was significantly shortened compared with the control mice. The length of colon in the oral administration of plant cells expressing recombinant TNFR2:Fc group was significantly longer than that in the DSS-treated group.

3. Effect of oral administration of plant cells expressing recombinant TNFR2:Fc on gut inflammatory cytokines following DSS colitis

Figure 15 shows a statistically significant decrease in gut proinflammatory cytokines following oral treatment with plant cells expressing recombinant TNFR2:Fc.

4. Oral administration of plant cells expressing recombinant TNFR2:Fc reduced the expression of proinflammatory cytokines in mice with DSS-Induced Colitis

The effect of Oral administration of plant cells expressing recombinant TNFR2:Fc on the production of proinflammatory cytokines linked to DSS colitis was evaluated. As

shown in Figure 16, DSS induced protein expression of proinflammatory cytokines, such as IL-6 and TNF- α , in sera, whereas Oral administration of plant cells expressing recombinant TNFR2:Fc suppressed the host protein secretion of proinflammatory cytokines. These results pointed out that oral administration of plant cells expressing recombinant TNFR2:Fc inhibited the production of proinflammatory cytokine in the DSS-induced colitis model.

5. *Histopathological examination as an indication for colon inflammation*

The severity of colon inflammation was further evaluated by histological examinations (Figure 17). Following DSS administration, colons exhibited transmural inflammation and intense infiltration of inflammatory cells. This cell influx associated with ulceration, loss of goblet cells and marked disruption in the crypts throughout the colon. On note, oral treatment with plant cells expressing TNFR2:Fc markedly improved the histological features of DSS-induced colitis. Histological examination of colons, showed reduced colon damage severity in colons of orally administered plant cells expressing recombinant TNFR2:Fc treated mice, compared with the DSS and Mock treated colons.

In conclusion, the present study supports a role for orally administered plant cells expressing recombinant TNFR2:Fc as an anti-inflammatory agent with the capacity to ameliorate IBD.

EXAMPLE 4

20 EVALUATING THE RECOMBINANT TNFR2:Fc PROTEIN PHARMACOKINETIC PROFILE IN RAT PLASMA AT VARIOUS TIME POINTS POST FEEDING OF PLANT CELLS EXPRESSING RECOMBINANT TNFR2:Fc

Materials and Methods

25 *Animals*

Rats (SD, females/9-10 weeks/n=6) were subject to a 20 hours fast and then fed (free feeding) with cells expressing recombinant TNFR2:Fc (PRX-106) and host BY2(-). Following two hours from feeding, food consumption was measured. Young suckling rats (SD, males and females/16 days /n=6) were 3 hours fasted and fed (by gavage) with cells expressing recombinant TNFR2: Fc (PRX-106) and host BY2(-) cells.

Analysis of TNFR2 profiles

Blood samples were collected in the each time point (e.g., 0, 1h, 2h, 4h, 6h, 8h, and 24h), left to clot and then centrifuged to obtain serum. Serum levels of human TNFRII were determined using ELISA kits following the manufacturer's instructions (R&D Systems, Minneapolis, MN, USA).

Results

TNFR2:Fc level in serum is shown in Figure 18. Results demonstrates the elevation of TNFR2:Fc level in plasma following oral administration of plant cells expressing the protein. TNFR2:Fc level in serum was detected at 8h, and was still detectable at 24 hours. TNFR2:Fc level in rat's serum fed with host BY2(-) was not detectable.

The experiment was then followed by analysis of recombinant TNFR2:Fc protein pharmacokinetic profile in the suckling rat plasma various time points post feeding of plant cells expressing TNFR2:Fc. TNFR2:Fc level in serum is shown in Figure 19. Results demonstrates the significant elevation of TNFR2:Fc level in plasma following oral administration of TNFR2:Fc. TNFR2:Fc level in plasma peaked at 4h. Probably, increased level of TNFR2:Fc in serum of suckling rats relative to adult rat was due to expression of FcNR in intestine of suckling rats. TNFR2:Fc level in rat's serum fed with host BY2(-) was not detectable.

20

EXAMPLE 5
TOXICOLOGY STUDIES IN MICE

*Methods**Animals*

Male and female SD Rats (Harlan Laboratories, Israel) 8 weeks at study initiation were housed under standard laboratory conditions. Mean weight at study initiation was approximately 6.8 gr for males and 6.3 gr for females. Animals were fed with commercial rodent diet (Teklad Certified Global 18% Protein Diet cat #: 2018SC) and had free access to autoclaved and acidified drinking water (pH between 2.5 and 3.5).

Study design

Four groups, 3 dosing groups comprising 12 rats per group (6 males and 6 females) and a control group comprising 6 rats per group (3 males and 3 females), were assigned. In each gender, the control group received dilution buffer (0.2 M mannitol) and three treated groups received cells expressing TNFR2:Fc at dose levels of 0.1, 0.5 and 1 mg TNFR2:Fc/Kg body weight. Cells were aliquoted in accordance with requested expressed protein amount. Each aliquot was mixed with 30 grams powder of commercial rodent diet and dilution buffer, to create a pellet. The control pellet was made with dilution buffer and commercial rodent diet powder alone. All animals were daily orally fed with the pellets for 14 days. During the study, mortality and general clinical observation were performed, bodyweight was monitored daily. At study termination (Day 15) after light anesthesia with carbon dioxide inhalation, three blood samples were drawn from all animals from the retro orbital sinus gross, after which, animals were sacrificed, pathology was executed and selected organs were harvested.

Results

No adverse clinical symptoms were recorded throughout the 14-day safety study. All blood parameters were within the normal range with no significant deviations. Body weight gain was persistent and normal with no significant difference between the groups (treated or Control). Cells expressing were found to be safe and well tolerated with no adverse effects. No effect on biochemical parameters or clinical symptoms was found. Gross necropsy observation did not reveal pathological findings. No animal was found in a moribund state or under severe distress conditions. There were no observations of animals presenting severe pain or decreased body weight.

EXAMPLE 6***SEQUENCING OF PRX-106******N terminus sequencing by Edman degradation***

Analysis was performed at Alphalyse (Denmark) using, an ABI Procise 494 sequencer. The procedure determines the N-terminal amino acid sequence of proteins and peptides by the Edman degradation chemistry. The Edman degradation is a cyclic procedure where amino acid residues are cleaved off one at a time and identified by chromatography. Here are 3 steps in the cyclic procedure. In step 1, the PITC reagent

is coupled to the N-terminal amino group under alkaline conditions. In step 2, the N-terminal residue is cleaved in acidic media. In step 3, the PITC coupled residue is transferred to a flask, converted to a PTH-residue and identified by HPLC chromatography. The next cycle is then started for identification of the next N-terminal residue.

Results:

The sequence was determined to be **LPAQV (SEQ ID NO: 18)**.

Amino Acid Sequence verification by reverse phase HPLC coupled to a Mass Spectrometry detector.

Sequencing was performed at the Smoler Proteomics Center (Technion- Israel Institute of Technology, Haifa, Israel). Analyses were carried out using reverse-phase HPLC coupled to a mass spectrometry detector.

Method

Proteolysis

The analyzed samples were resuspended in 8 M Urea, 100 mM ammonium bicarbonate (ABC) followed by reduction with 2.8 mM DTT (60°C for 30 min) and modified with 8.8 mM iodoacetamide in 100 mM ABC in the dark, at ambient temperature for an additional 30 min. The proteins were digested overnight at 37 °C using modified trypsin (Promega) at a 1:50 enzyme-to-substrate ratio in 2 M Urea, 25 mM ABC.

Mass spectrometry analysis

The tryptic or chymotryptic peptides were desalted using stage tips (home-made C18), the residual buffer was evaporated and the pellet was resuspended in 0.1 % (v/v) formic acid. Twenty nanogram of the resulting peptides were resolved by reversed-phase liquid chromatography on a 0.075X200-mm fused silica capillaries (J and W) packed with ReproSil reversed phase material (Dr Maisch GmbH, Germany). Peptides were eluted with a linear 60 minutes gradient of 5 to 45 % followed by 15 minutes at 95 % acetonitrile with 0.1 % formic acid in water at flow rates of 0.25 µL/min. On-line mass spectrometry was performed on an ion-trap mass spectrometer (Orbitrap, Thermo) in a positive mode using repetitively full MS scan followed by collision induced dissociation (CID) of the 7 most dominant ions selected from the first MS scan. The

mass spectrometry data was analyzed using the Discoverer software version 1.3 software using a specific protein derived database.

Results

The sequence was compared to the peptide sequence of the Etanercept sequence.

5 The identified sequences are presented in Table V, below. Presented is 84.8% coverage of the reference sequence (see green color, Figure 20).

Table V- Peptides Identified Following Digestion with Trypsin (SEQ ID NO: 19-203)

WQQGnVFS_cSVMHEALHnHYTQK
WQQGNVFS_cSVMHEALHNHYTqK
GFYPSDI_AVEWESNG_qPENnYKT
qYNSTYRVVSVLTVLHQ_dWLNGK
WQqGNVFS_cSVMHEALHNHYTqKS
VVS_VLTVLHQDWLNGKEYKc
VVS_VLTVLHQDWLnGKEYK
SqHTqPTPEPSTAPSTSFL_LPmGPSPPAEGSTGDEPK
WQQGnVFS_cSVMHEALHNHY
ScDKTHTcPPcPAPELLGGPSVFLFPPKPKD
GQPREPqVYTLPPSREEMTK
GFYPSDI_AVEWESNGQPE_nYKT
LPAqVAFTPYAPEPGSTcR
EALHnHYTqK
qNR_IcTcRPGWYcALSKQEGcR
WQQGNVFS_cSVmHEALHnHYTQK
SqHTQPTPEPSTAPSTSFLPMGPSP_aEGSTGDEPK
GQPREPqVYTLPPSREEmTK
GFYPSDI_AVEWESnGQPENNYK
SqHTQPTPEPSTAPSTSFLPmGPSPPAEGSTGDEPK
VVS_VLTVLHQDWLnGK
TYTqLWNWVPEcLScGSRcSSDqVETQAcTR
WQQGNVFS_cSVMHEALHNHYTQK
GFYPSDI_AVEWESnGQPEnnYKT
VVVDVSHEDPEVK
PSTSFLPMGPSP_aEGSTGDEPK
LPAqVAFTPYAPEPGSTcR
TTPPVLDSDGSFFL
LSLSPGK
EPQVYTLPPSREEMTKN
SmAPGAVHLPQ
TTPPVLDSDGSFFLYSK
WQQGNVFS_cSVmHEALHNHYTQK
SMAPGAVH

SVmHEALHNHYTQK
VVSVLTVLH
SQHTQPTPEPSTAPSTSFLPMGPSPPAEGSTGDEPK
GQPREPQVY
AQVAFTPYAPEPGSTcR
cAPLRK
EPQVYTLPPSREEmTKhQVSLTcLVK
SmAPGAVH
VVSVLTVLHQD
LFPPKPK
GSFFLYSK
IcTcRPGWY
SQHTQPTPEPS
SVLTVLHQDWLnGKEYK
QVETQAcTR
SLSLSPGK
SDGSFFLYSK
KALPAPIEK
ALPAPIEK
AVcTSTS PTR
SQHTQPTPEPSTAPSTS
QVSLTcLVK
LREYYDQTAqmccSKcSPGQHAK
WQQGNVFsSVMHEALH
DTLmISR
PmGPSPPAEGSTGDEPK
THTcPPcPAPELLGGPSVF
DTLMISR
SDQVETQAcTR
KcRPGFGVAR
WYVDGVEVHN
YVDGVEVHN
TTPPVLDSDGSFF
THTcPPcPAPELLGGPSVFLFPPKPK
PSPPAEGSTGDEPK
SLSLSPGKSEKD
MAPGAVHLPQPVSTR
VDGVEVHN
ScDKTHTcPPcPAPELLGGPSV
VVSVLTVLHQDWLN
SLSLSPGKSEK
PPcPAPELLGGPSVFLFPPKPK
SFFLYSK
FNWYVDGVEVHN
FLLPMGPSPPAEGSTGDEPK
DAVcTSTS PTR

NQVSLTcLVK
NqVSLTcLVKG
SLSPGKSEK
TPEVTcVVVDVSHEDPEVK
LREYYDQTAQM
GFYPSDIAVEWESNGQPENNYK
FNWYVDGVEVHN
VVSVLTVLHQDWLN
SQHTQPTPEPSTAPST
RTPEVTcVVVDVSHEDPEVK
SLSLSPGKS
LSPGKSEKDEL
LPQPVSTR
TTPPVLDSDGSFFLY
TSDTVcDScEDSTYTQLWN
ALPAQVAFTPYAPEPGStR
EEQYNSTYR
ScDKTHTcPPcPAPELLGGPSVFLFPPKPK
cSPGQHAKVFcTK
TPEVTcVVVDVSHED
SMAPGAVHLPQPV
TcRPGWYcALSK
TcPPcPAPELLGGPSVFLFPPKPK
TSDTVcDScEDSTYTQLWNWVPEcLScGSR
LcAPLRK
SPPAEGSTGDEPK
WVPEcLScGSR
GPSPPAEGSTGDEPK
SSDQVETQAcTR
EEQYnSTYR
VAFTPYAPEPGStR
PGWYcALSK
cRPGFGVAR
ScSVmHEALHnHYTqK
VVSVLTVLHQDWLNGKEYK
LcAPLR
EPQVYTLPPSREEMTKnQVSLTcLVK
LLPMGPSPPAEGSTGDEPK
SQHTQPTPEPSTAPSTSFLPmGPSPPAEGSTGDEPK
SLSLSPGKSE
EEMTKNqV
SVMHEALHNHYTQK
SQHTQPTPEPSTAPSTSFLPMGPSPPAEGSTGDEPKScDK
EEmTKnQVSLTcLVKG
LREYYDQTAQmccSK
cSSDqVETQAcTR

EPQVYTLPPSREEMTK
NQVSLTcLVKG
cSSDQVETQAcTR
nQVSLTcLVK
TKPREEQYNSTYR
PAQVAFTPYAPEGSTcR
SLSLSPGKSEKDEL
AFTPYAPEPGSTcR
APGAVHLPQPVSTR
SDGSFFFLYSKLTVDK
THTcPPcPAPELLG
VVSVLTVLHQDWLn
EPQVYTLPPSR
SmAPGAVHLPQPVSTR
GQPREPQVYTLPPSREEmTK
TPYAPEPGSTcR
EVTcVVVDVSHEDPEVK
TKPREEQYnSTYR
VSnKALPAPIEK
LREYYDQTAQMccSK
FTPYAPEPGSTcR
SMAPGAVHLPQPVSTR
GPSVFLFPKPK
VVSVLTVLHQDWLnGKEYK
SQHTQPTPEPSTAPS
SMAPGAVHLPQPVS
AVHLPQPVSTR
GQPREPQVYTLPPSR
PGAVHLPQPVSTR
TLMISR
KNqVSLTcLVKGFYPSDIAVEWESNGqPENnYK
LREYYDQTAQMcc
SmAPGAVHLPQPV
LPAPIEK
EYYDQTAQMccSK
NWVPEcLScGSR
SLSPGKSEKDEL
IcTcRPGWYcALSK
SMAPGAVHLPQPVST
EYYDQTAQmccSK
ASMDAVcTSTS PTR
SQHTQPTPEPSTAPSTS
TLPPSREEMTK
SQHTQPTPEPSTAPSTSFL
TLmISR
EPQVYTLPPSREEmTK

GQPREPQVYTLPPSREEMTK
TPEVTcVVVDVSHEDPEVKFN
ScDKTHTcPPcPAPELLG
GFYPSDIAVEWESNGqPENnYK
AKGQPREPQVYTLPPSR
LREYYDQTAQMcc
LPrmGPSPPAEGSTGDEPK
ScSVMHEALHNHYTQK
FNWYVDGVEVHnAK
PMGSPSPPAEGSTGDEPK
SMAPGAVHLPqPVSTR
SMAPGAVHLPQ
LPMGSPSPPAEGSTGDEPK

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all 5 such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and 10 individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. A plant produced TNF α polypeptide inhibitor.
2. The TNF α polypeptide inhibitor of claim 1 being an anti-TNF α antibody.
3. The TNF α polypeptide inhibitor of claim 1, wherein said anti-TNF α antibody said anti-TNF α antibody is selected from the group consisting of infliximab, adalimumab, certolizumab pegol and golimumab.
4. The TNF α polypeptide inhibitor of claim 1 being a soluble TNFR fragment, which specifically binds TNF α .
5. The TNF α polypeptide inhibitor of claim 1 wherein said soluble TNFR fragment is part of a chimeric polypeptide.
6. The TNF α polypeptide inhibitor of claim 5, wherein said chimeric polypeptide comprises:
 - (i) a first domain which comprises a TNF α binding domain of a TNF receptor; and
 - (ii) a second domain which comprises an Fc domain of an immunoglobulin; wherein said first domain and said second domain are N-terminally to C-terminally respectively sequentially translationally fused and wherein the chimeric polypeptide specifically binds TNF α .
7. The TNF α polypeptide inhibitor of claim 6, wherein said chimeric polypeptide further comprises a third domain which comprises an endoplasmic reticulum retention signal, wherein said first domain, second domain and third domain are N-terminally to C-terminally respectively sequentially translationally fused.
8. The TNF α polypeptide inhibitor of any one of claims 6 and 7, comprising an additional domain encoding an endoplasmic reticulum signal peptide translationally fused N-terminally to said first domain.

9. The TNF α polypeptide inhibitor of claim 8, wherein said signal peptide is a plant signal peptide.

10. The TNF α polypeptide inhibitor of claim 9, wherein said plant signal peptide is as set forth in SEQ ID NO: 4.

11. The TNF α polypeptide inhibitor of any one of claims 6-7, wherein said first domain is 200-250 amino acids long.

12. The TNF α polypeptide inhibitor of claim 11, wherein said first domain comprises the amino acid sequence LCAP (SEQ ID NO: 11) and VFCT (SEQ ID NO: 12).

13. The TNF α polypeptide inhibitor of claim 12, wherein said first domain further comprises the amino acid sequence LPAQVAFXPYAPEPGSTC (SEQ ID NO: 13).

14. The TNF α polypeptide inhibitor of claim 13, wherein said first domain is as set forth in SEQ ID NO: 2.

15. The TNF α polypeptide inhibitor of any one of claims 6-7, wherein said immunoglobulin is IgG₁.

16. The TNF α polypeptide inhibitor of any one of claims 6-7, wherein said second domain is as set forth in SEQ ID NO: 9.

17. The TNF α polypeptide inhibitor of any one of claims 6-7, wherein said chimeric polypeptide is as set forth in SEQ ID NO: 6.

18. The TNF α polypeptide inhibitor of claim 7, wherein said chimeric polypeptide is as set forth in SEQ ID NO: 7, 204 OR 205 or 214.

19. The TNF α polypeptide inhibitor of any one of claims 6-7, wherein said chimeric polypeptide is capable of inhibiting TNF α -induced apoptosis.

20. The TNF α polypeptide inhibitor of any one of claims 1-19, wherein said TNF α polypeptide inhibitor comprises a plant-specific glycan.

21. The TNF α polypeptide inhibitor of claim 20, wherein said plant-specific glycan is selected from the group consisting of a core xylose and a core α -(1,3) fucose.

22. The TNF α polypeptide inhibitor of any one of claims 1-21, wherein the polypeptide is purified to at least 98 % homogeneity.

23. The TNF α polypeptide inhibitor of any one of claims 1-22, capable of inhibiting TNF α -induced apoptosis.

24. An isolated polynucleotide comprising a nucleic acid sequence encoding the TNF α polypeptide inhibitor of any one of claims 1-23.

25. The isolated polynucleotide of claim 24, wherein a codon usage of said nucleic acid sequence is optimized for *Nicotinia tabaccum*.

26. The isolated polynucleotide of claim 19 as set forth in SEQ ID NO: 5.

27. A nucleic acid expression construct comprising a nucleic acid sequence encoding the polynucleotide of any one of claims 24-26 and a cis-acting regulatory element active in a plant cell.

28. The nucleic acid expression construct of claim 27, wherein said cis-acting regulatory element is a promoter.

29. A plant cell comprising the nucleic acid construct of any one of claims 27 or 28.

30. The plant cell of claim 29 being a *Nicotiana tabacum* plant cell.
31. The plant cell of claim 30, wherein said *Nicotiana tabacum* L. cv plant cell is a Bright Yellow (BY-2) cell.
32. The plant cell of any one of claims 29-31, being lyophilized.
33. A plant cell suspension culture comprising the plant cell of any one of claims 29-32.
34. A pharmaceutical composition comprising as an active ingredient the polypeptide of any one of claims 1-23 and a pharmaceutically acceptable carrier.
35. A pharmaceutical composition comprising as an active ingredient the plant cell of any one of claims 29-33 and a pharmaceutically acceptable carrier.
36. A method of treating a TNF α -associated medical condition in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of the polypeptide of any one of claims 1-23, thereby treating the TNF α -associated medical condition in the subject.
37. A method of treating a TNF α -associated medical condition in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of the plant cells of claim 29-33, thereby treating the TNF α -associated medical condition in the subject.
38. The polypeptide of any one of claims 1-23 for use in treating a TNF α -associated medical condition in a subject.
39. The plant cells of any one of claims 29-33 for use in treating a TNF α -associated medical condition in a subject.

40. Use of the polypeptide of any one of claims 1-23 in treating a TNF α -associated medical condition in a subject.

41. Use of the plant cells of any one of claims 29-33 in treating a TNF α -associated medical condition in a subject.

42. The method of claim 36 or 37 or the use of claim 40 or 41, wherein said medical condition is an inflammatory disease.

43. The method of claim 36 or 37 or the use of claim 40 or 41, wherein said medical condition is an autoimmune disease.

44. The method of claim 36 or 37 or the use of claim 40 or 41, wherein said medical condition is selected from the group consisting of rheumatoid arthritis, ankylosing spondyloarthritis, plaque psoriasis and juvenile idiopathic arthritis.

45. The method of claim 36 or 37 or the use of claim 40 or 41, wherein said medical condition is an inflammatory bowel disease.

46. The method or use of claim 45, wherein said inflammatory bowel disease is selected from the group consisting of colitis and Crohn's disease.

47. The method or use of claim 46, wherein said polypeptide is formulated for parenteral administration.

48. The method or use of claim 47, wherein said polypeptide is formulated for oral administration.

49. The method of claim 36 or 37 or the use of claim 40 or 41, wherein said medical condition is selected from the group consisting of rheumatoid arthritis, inflammatory bowel disease, sepsis, endotoxic shock, AIDS, endometriosis, psoriasis, cardiovascular disease, cancer, vitiligo, arthritis, rheumatoid polyarthritis, psoriatic

rheumatism, ankylosing spondyloarthritis, plaque psoriasis, juvenile idiopathic arthritis, polyarticular juvenile idiopathic arthritis, psoriasis arthritis, Wegener's disease (granulomatosis), Crohn's disease ulcerative colitis, short bowel syndrome, chronic obstructive pulmonary disease (COPD), Hepatitis C, asthma, cachexia, atopic dermatitis, Alzheimer's disease, hepatic encephalopathy, ADHD, chronic fatigue syndrome dermatitis herpetiformis (Duhring's disease), contact dermatitis, urticaria (including chronic idiopathic urticaria), autoimmune blistering diseases, including pemphigus vulgaris, bullous pemphigoid, myesthenia gravis, sarcoidosis, including pulmonary sarcoidosis, scleroderma, reactive arthritis, hyper IgE syndrome, multiple sclerosis and idiopathic hypereosinophil syndrome, and allergy.

50. The method of claim 36 or use of claim 40, wherein said polypeptide is formulated for parenteral administration.

51. The method of claim 37 or use of claim 41 wherein said plant cells are formulated for enteral administration and wherein said medical condition is not a obesity, metabolic syndrome, diabetes and a liver disease or disorder.

52. A method of producing the polypeptide of any one of claim 1-23, comprising:

providing a cell according to claim 29-31; and
culturing said cell so as to produce said polypeptide.

53. The method of claim 52, further comprising isolating said polypeptide from said cell.

54. The polypeptide of claim 39, wherein said cell is an isolated cell cultured in a plant cell culture medium.

55. The method of claim 52, wherein said culturing is performed in a disposable bioreactor.

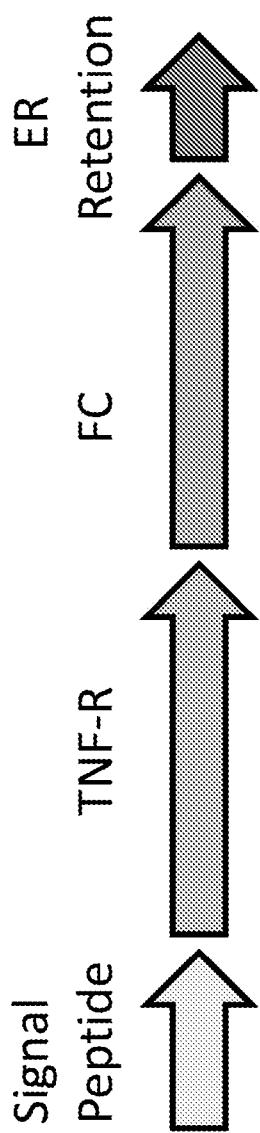


FIG.

FIG. 2B

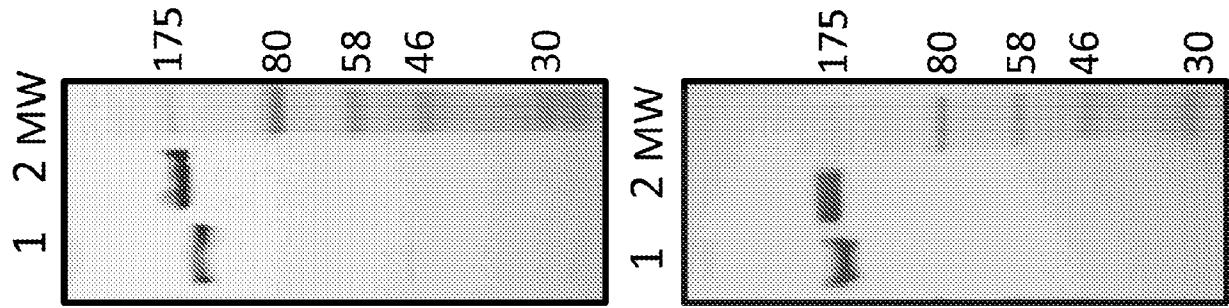
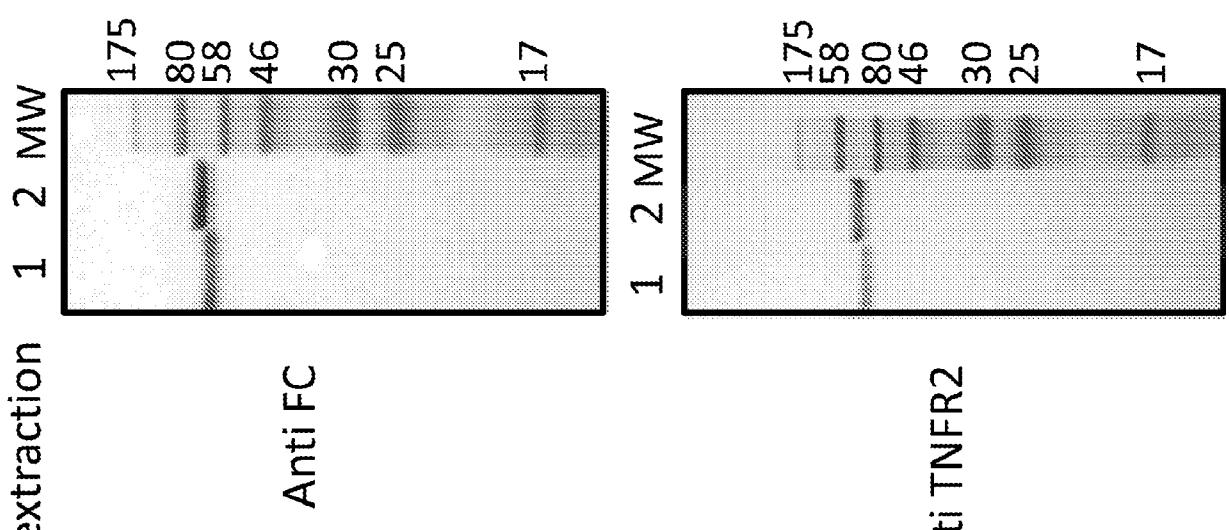


FIG. 2A



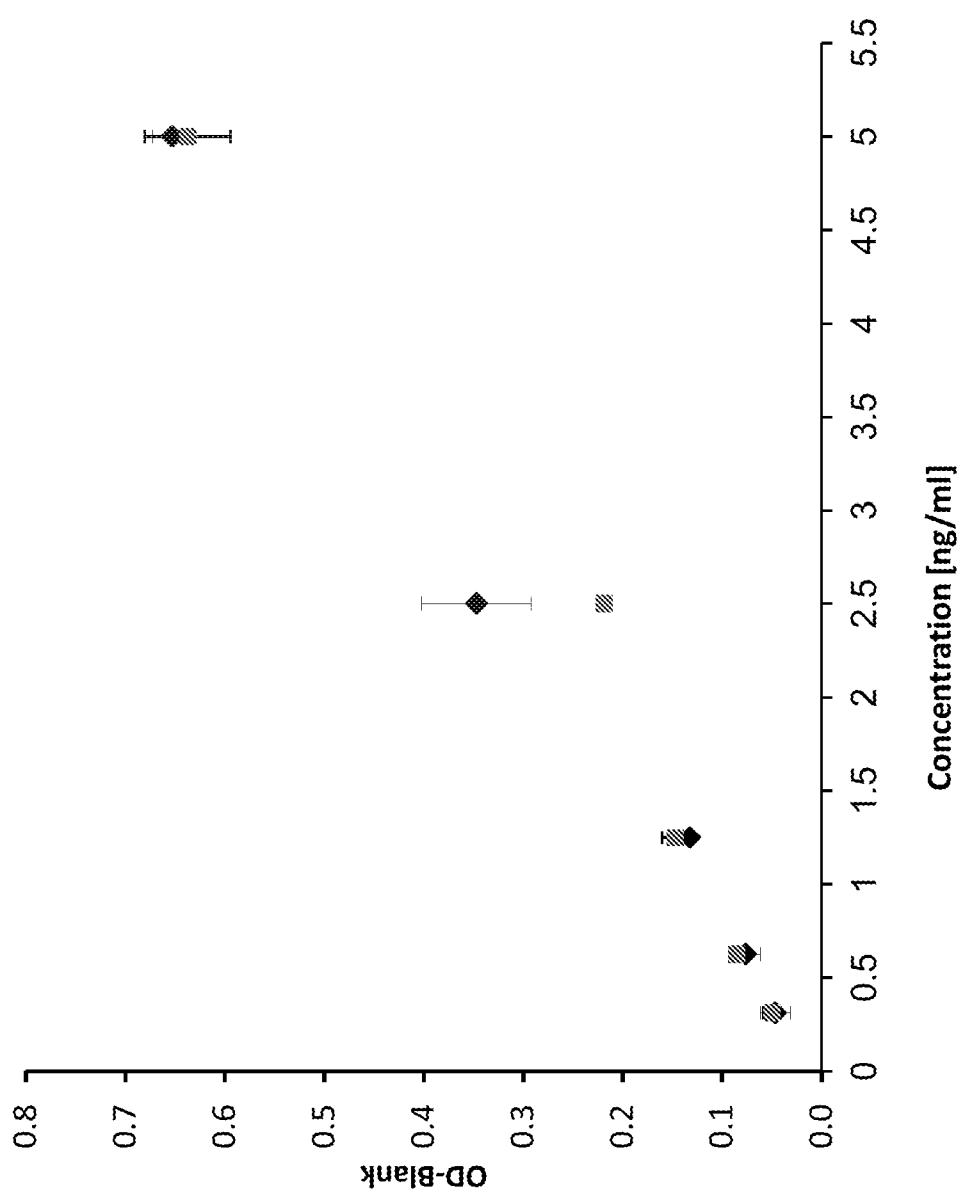


FIG. 3

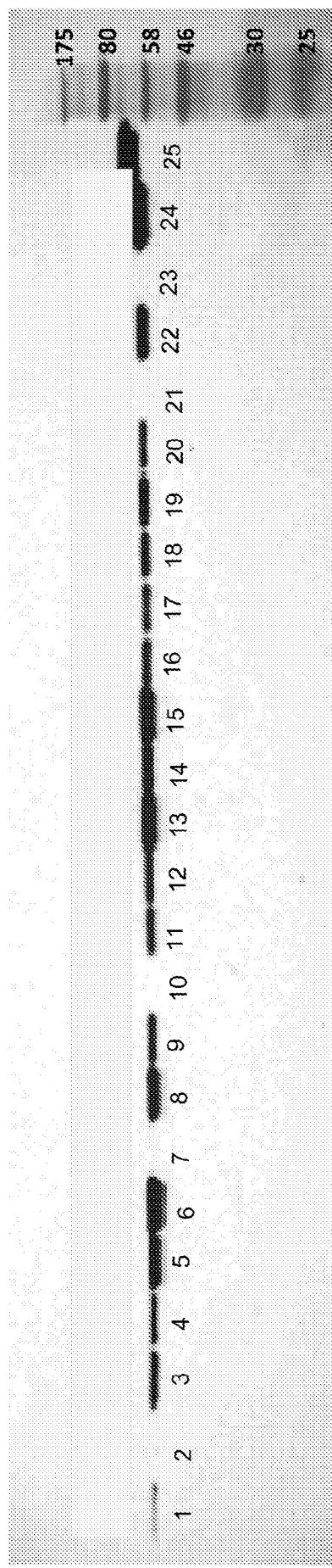
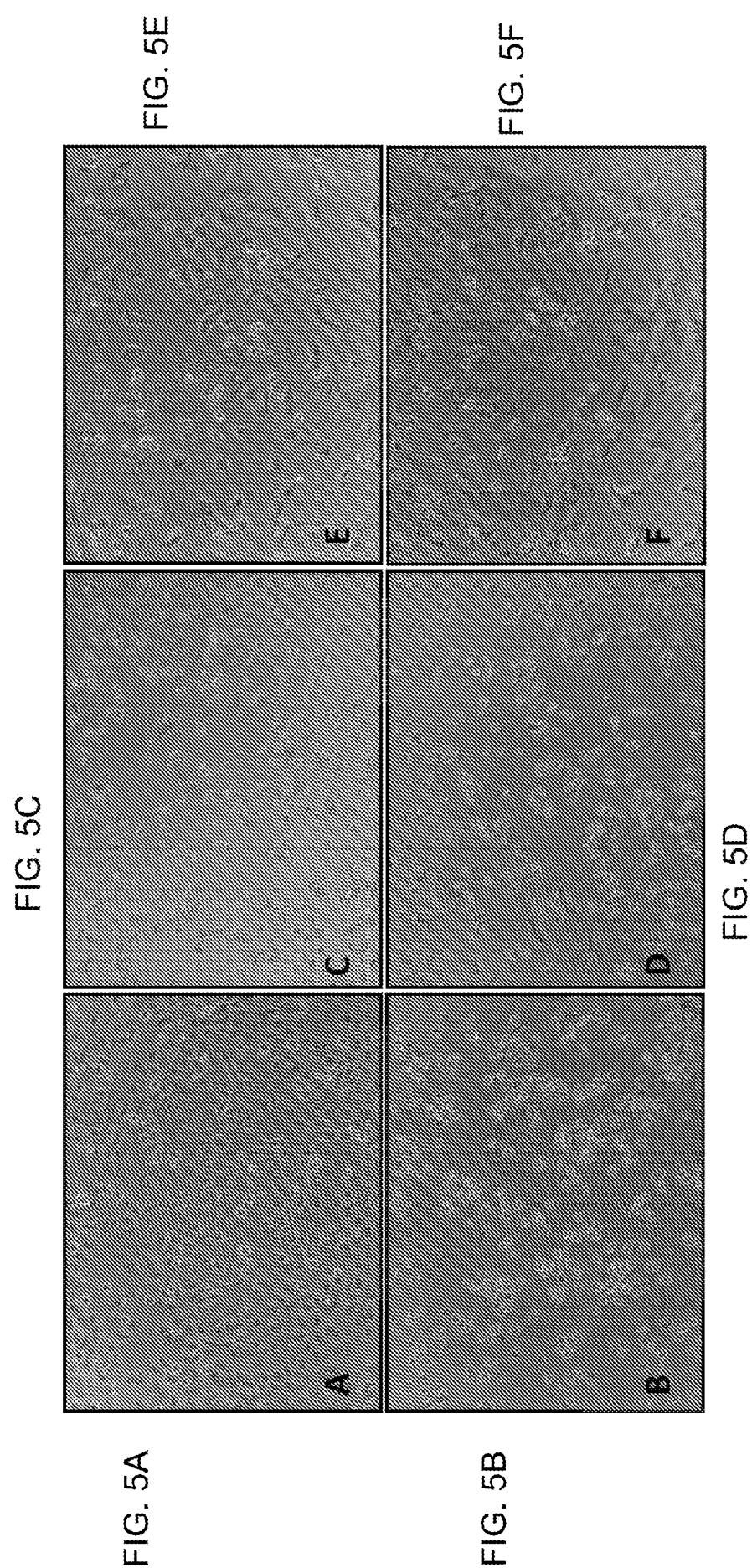


FIG. 4



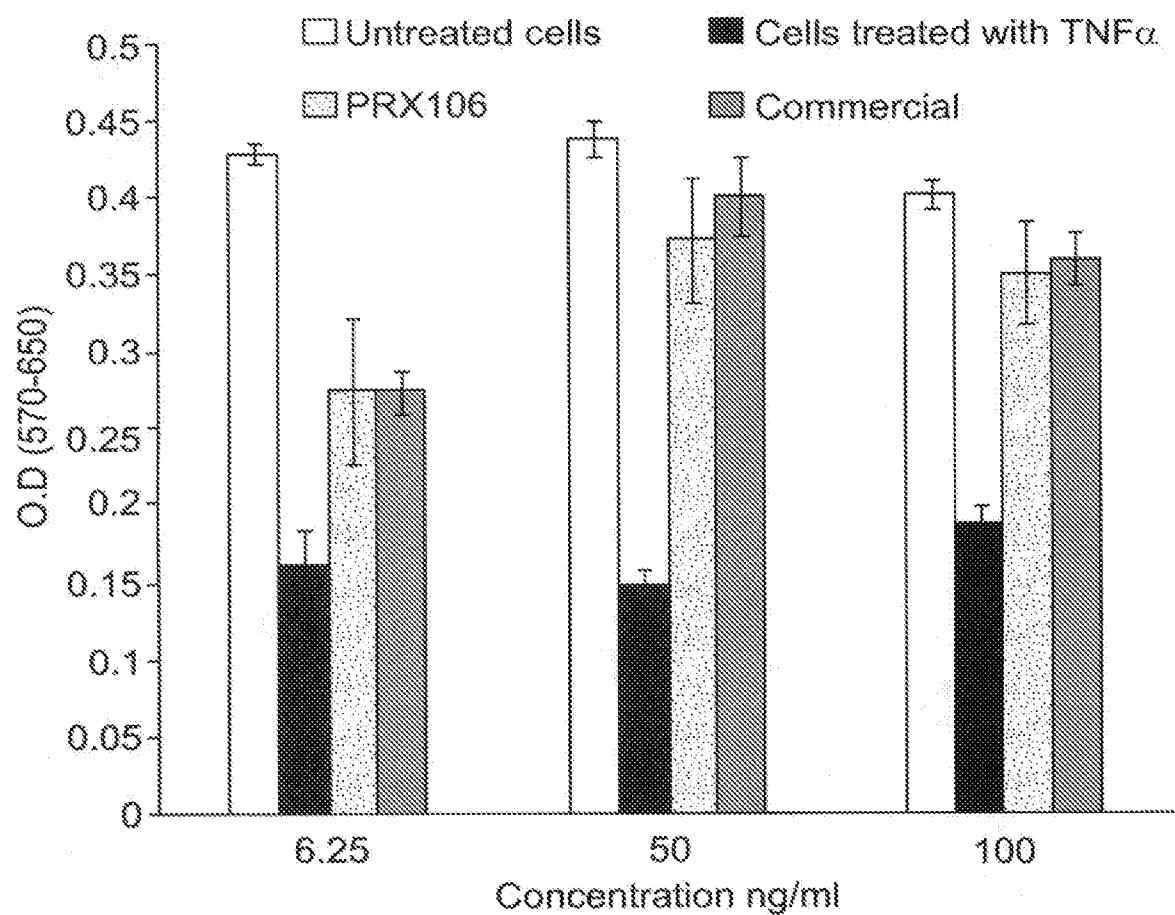
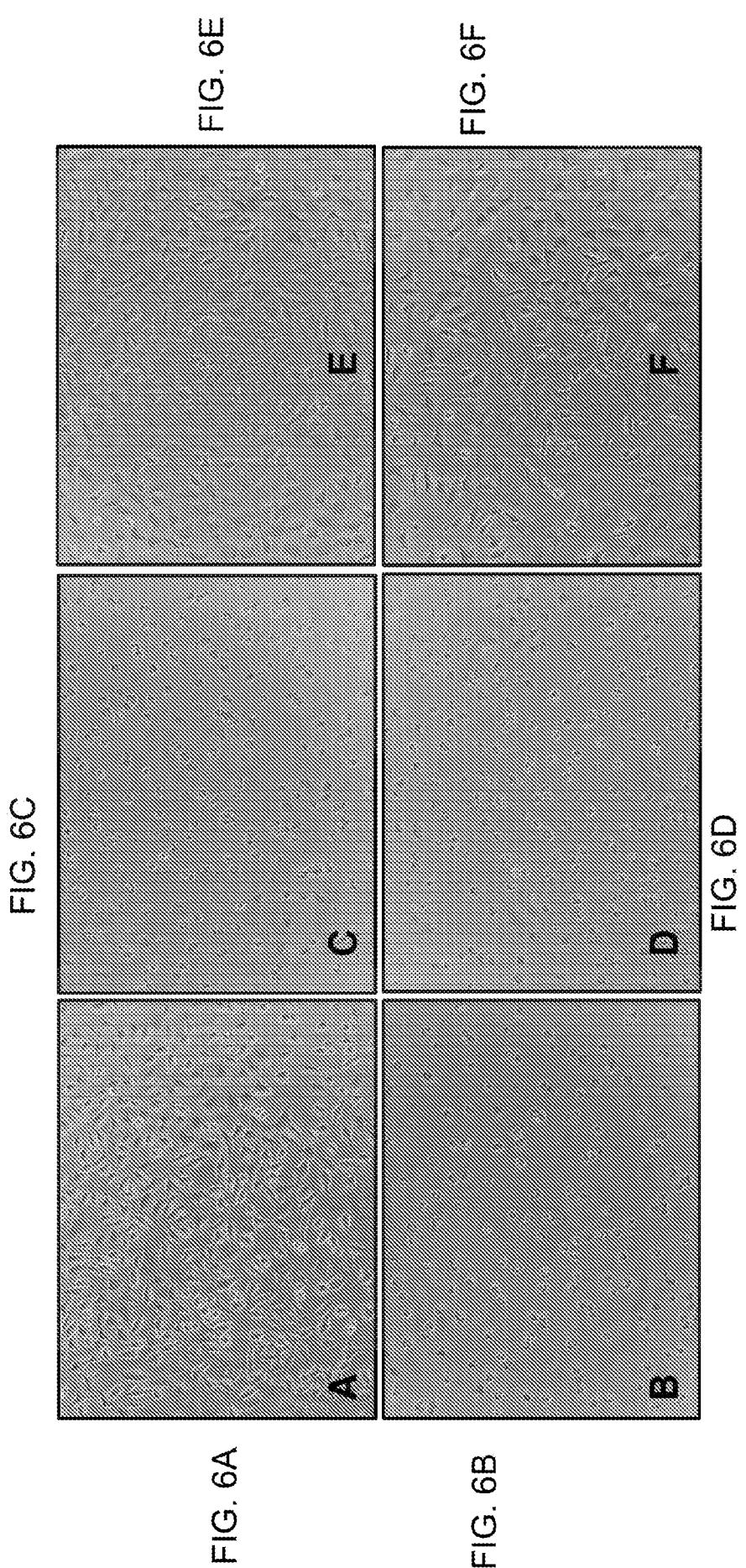


FIG. 5G



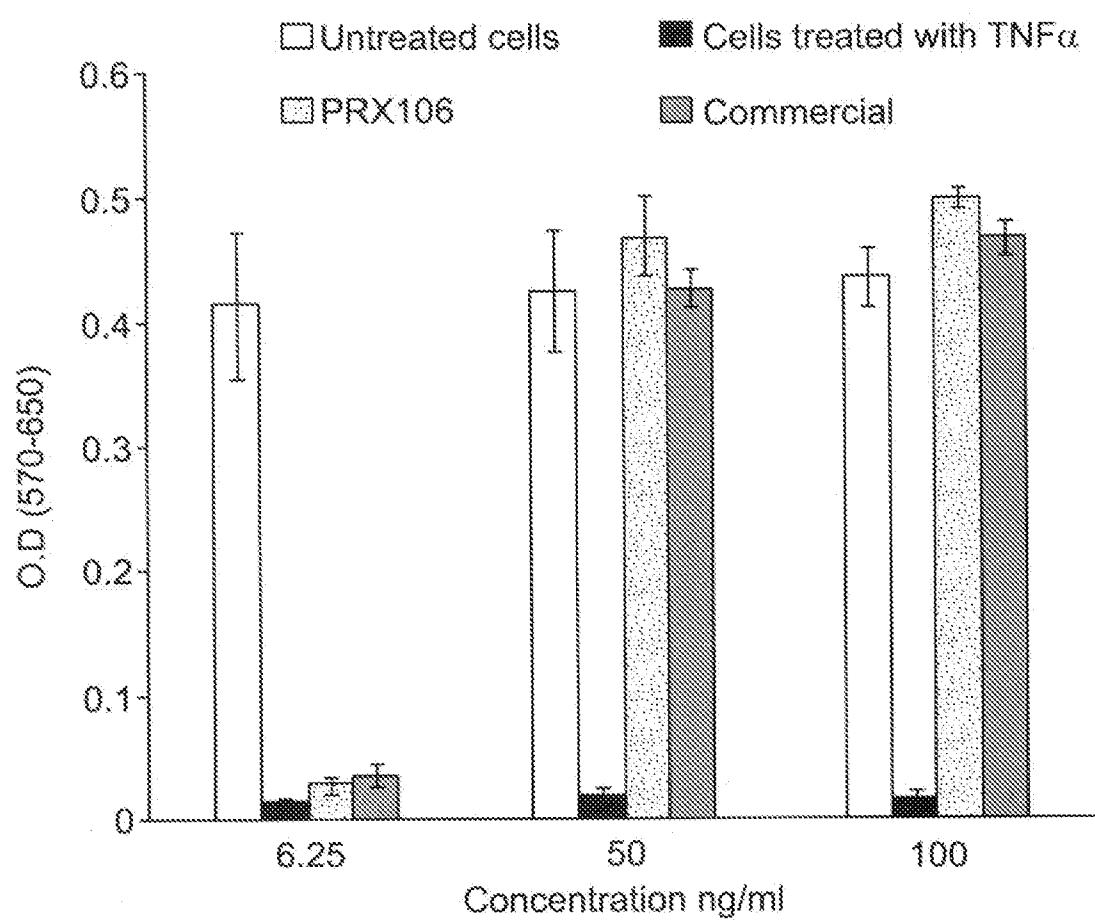


FIG. 6G

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Effect of PRX-106 on average mouse weight lost

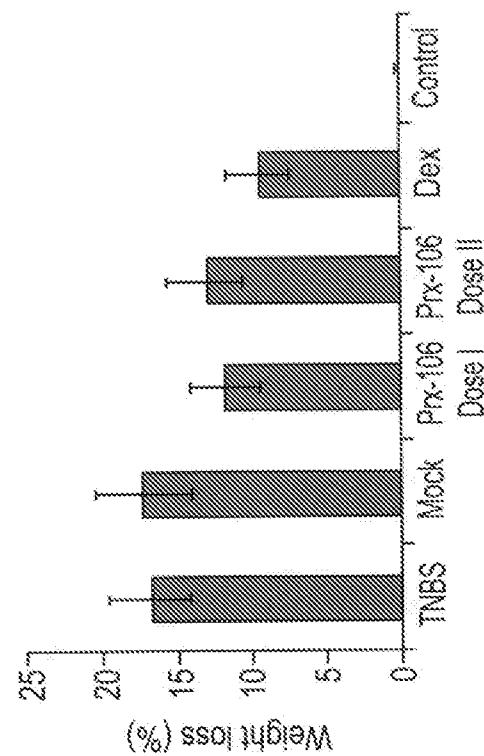


FIG. 7A

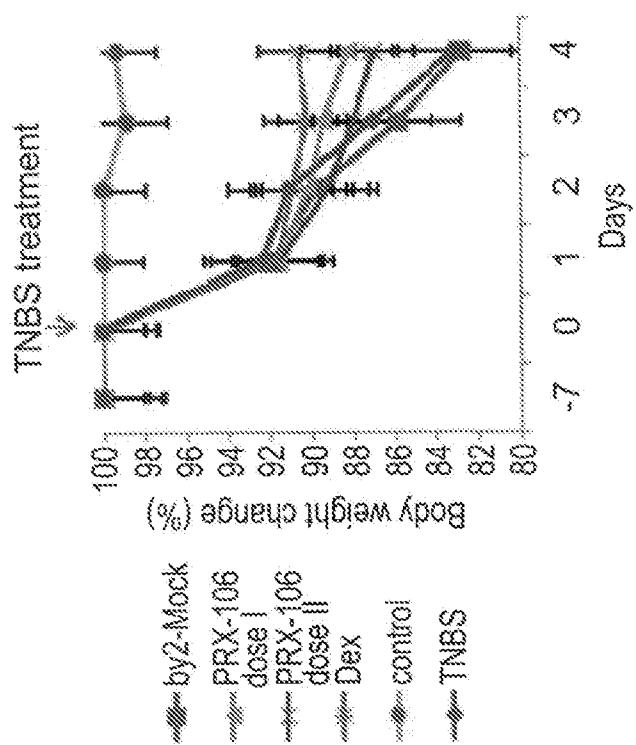


FIG. 7B

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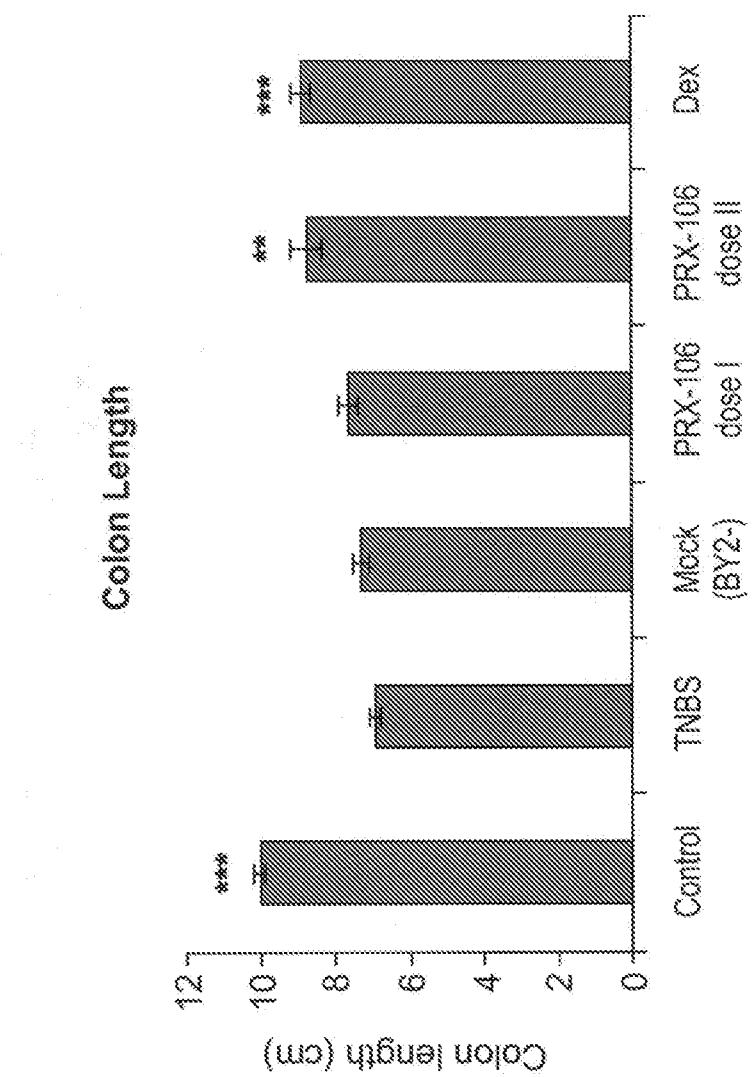


FIG. 8

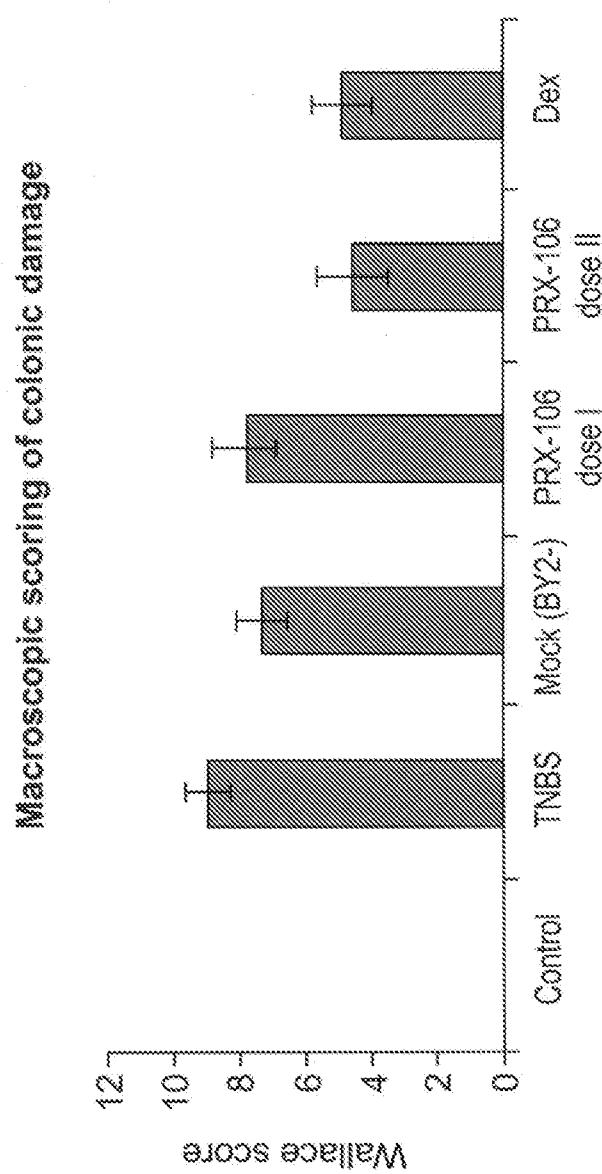


FIG. 9

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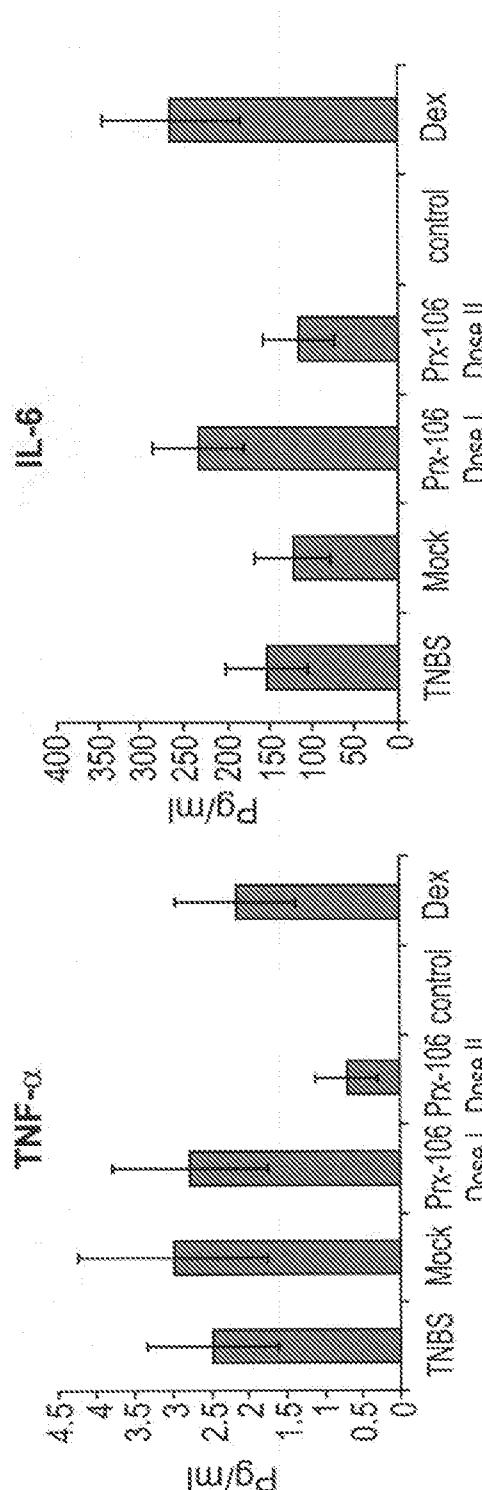


FIG. 10A

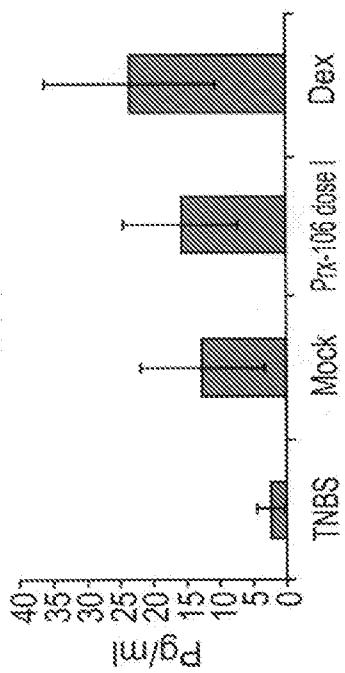


FIG. 10C

FIG. 10B

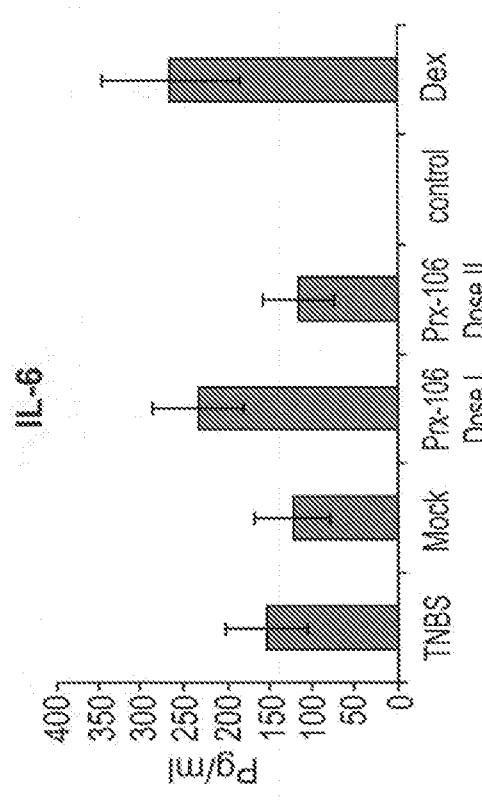
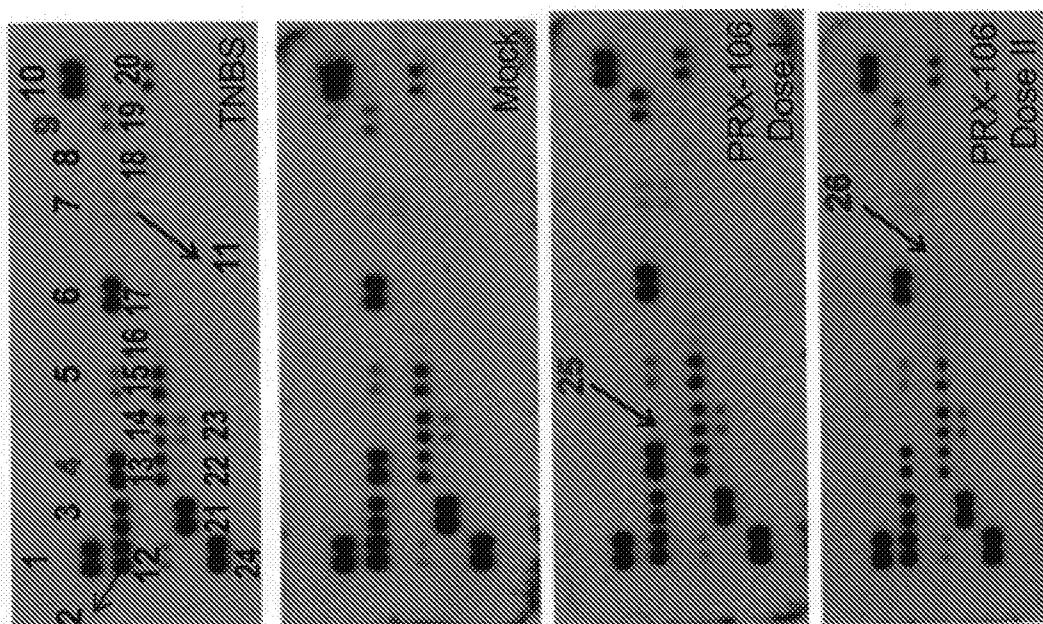


FIG. 11A
FIG. 11B

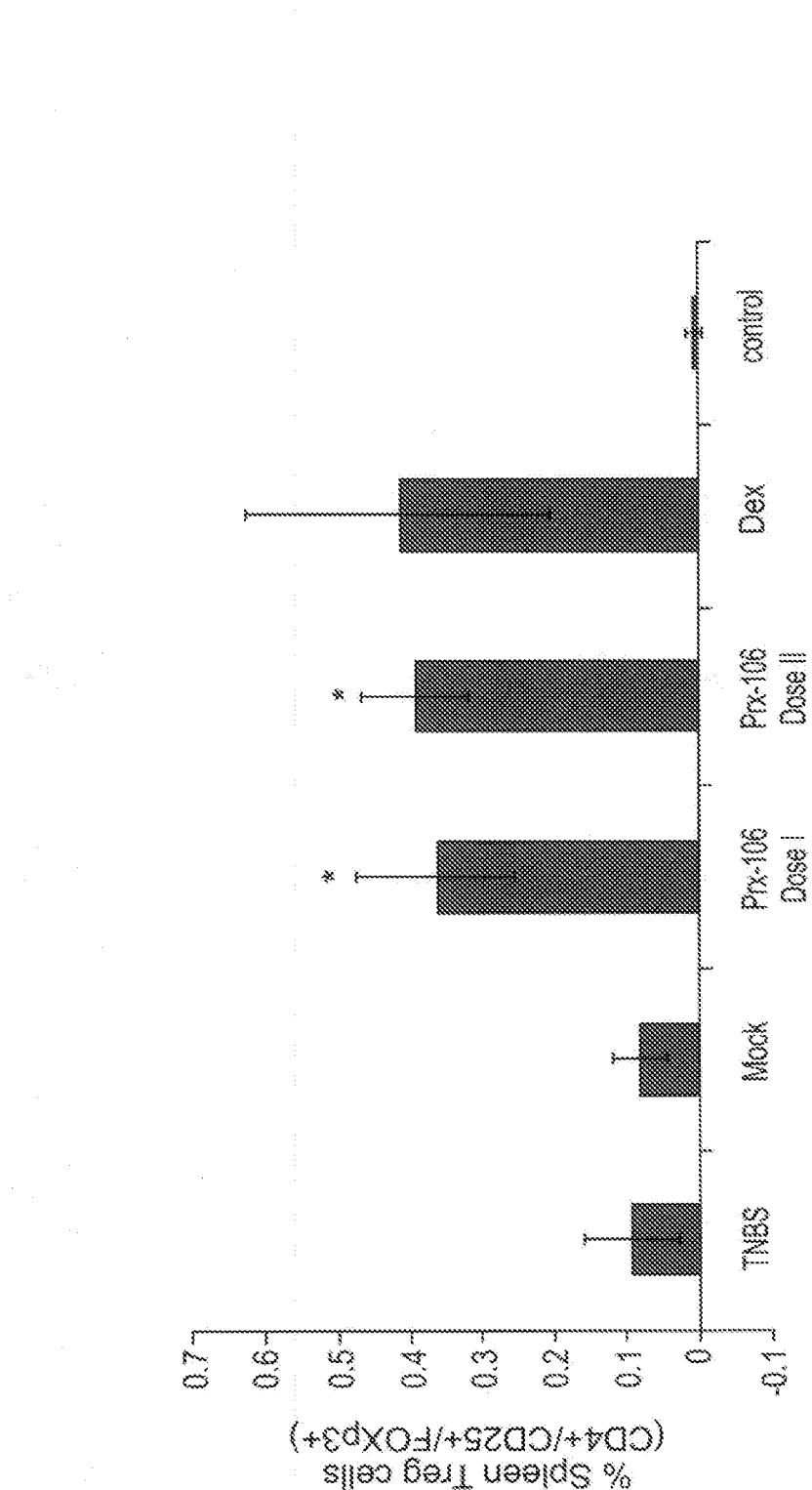


FIG. 12

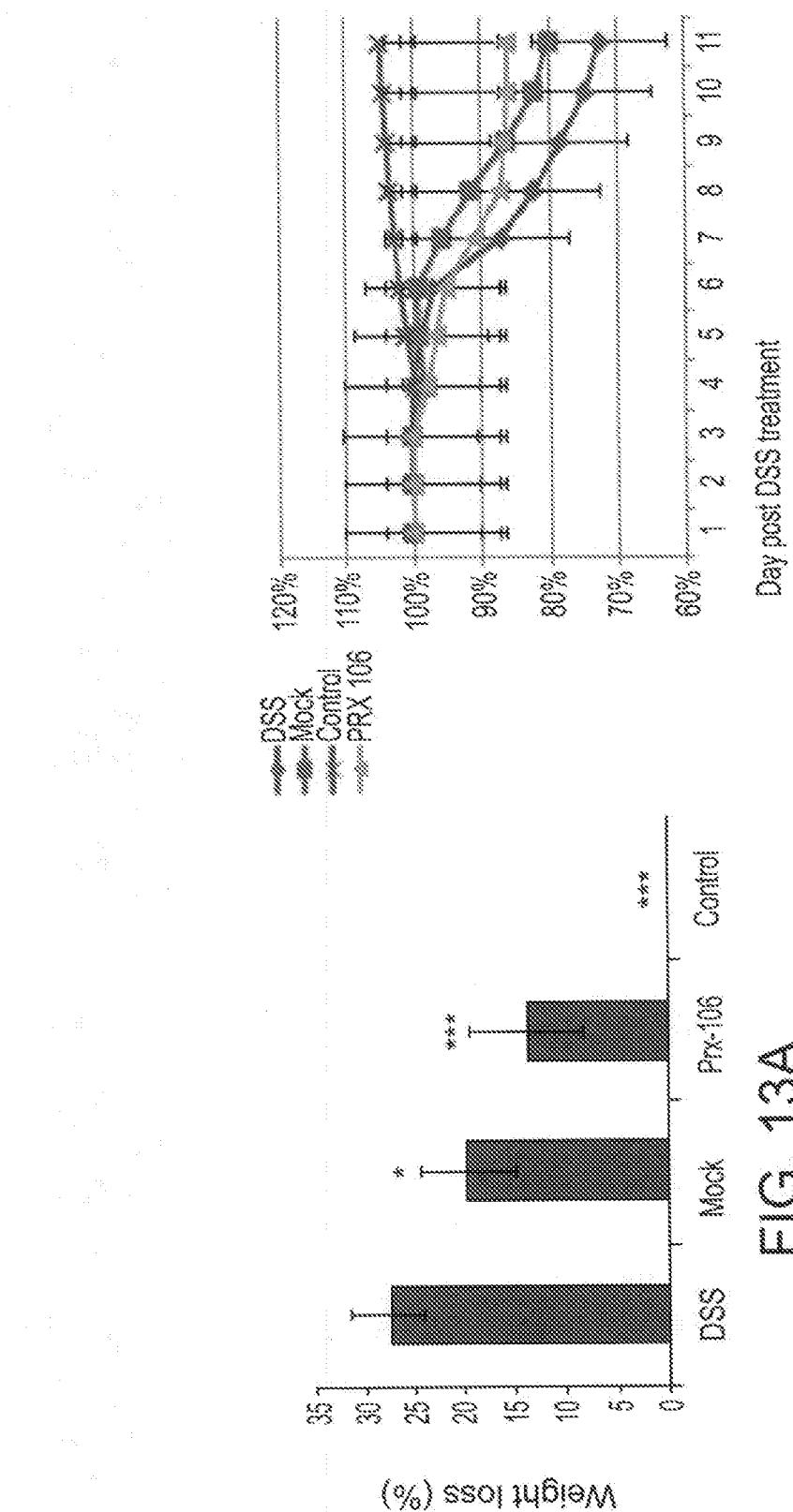


FIG. 13A

FIG. 13B

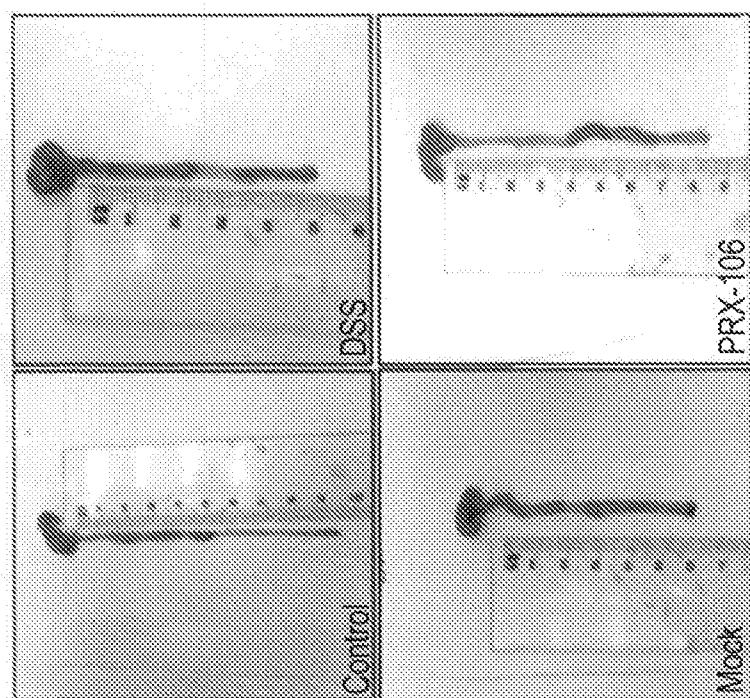


FIG. 14B

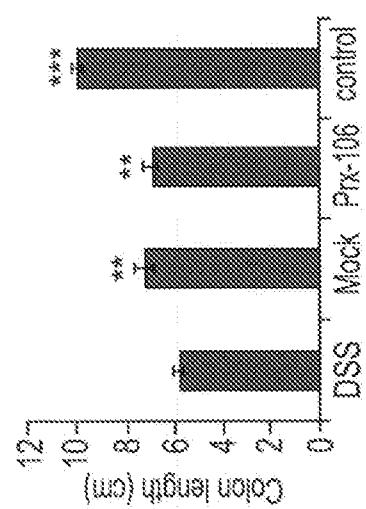


FIG. 14A

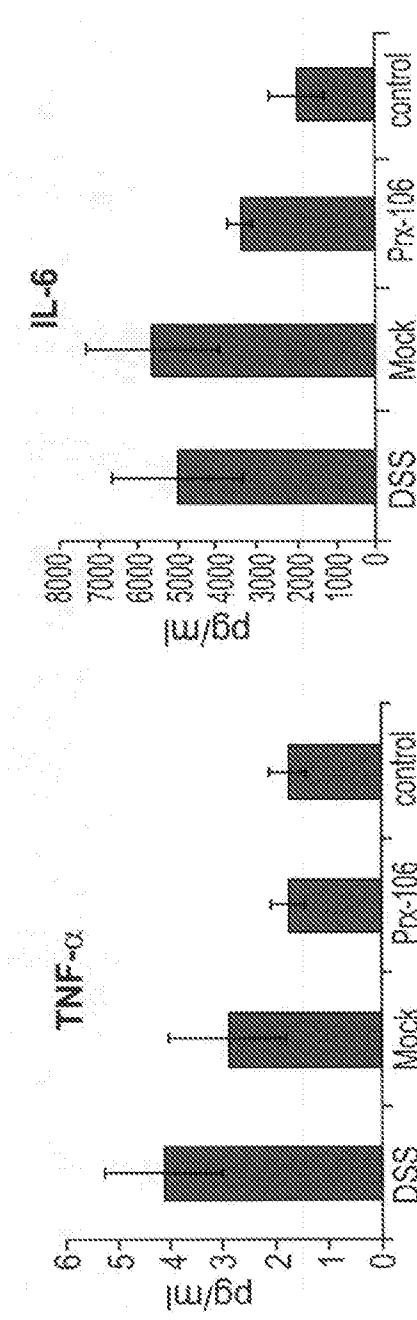


FIG. 15A

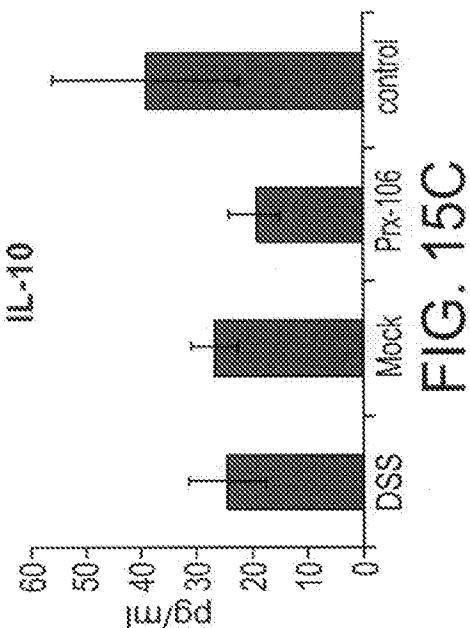


FIG. 15B

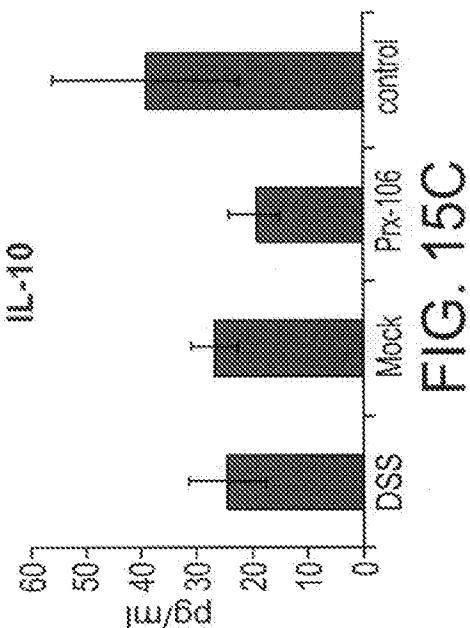


FIG. 15C

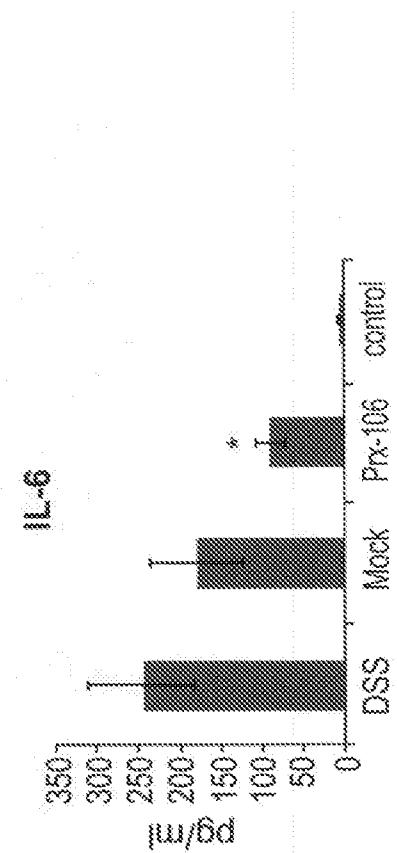


FIG. 16B

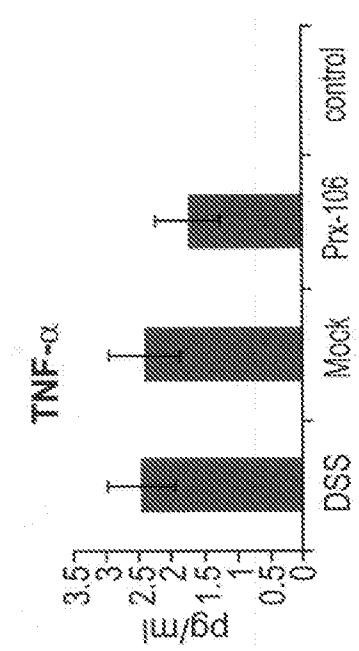


FIG. 16A

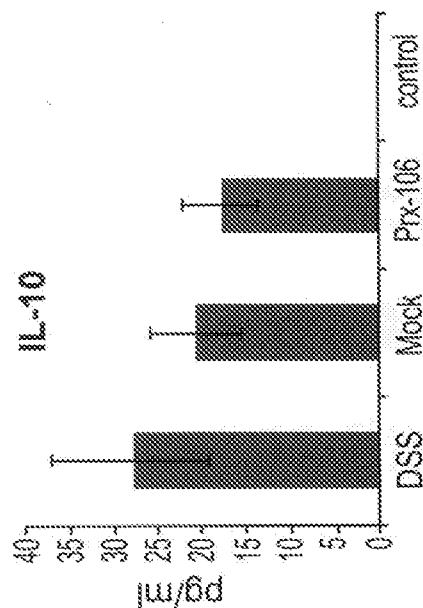


FIG. 16C

FIG. 17A

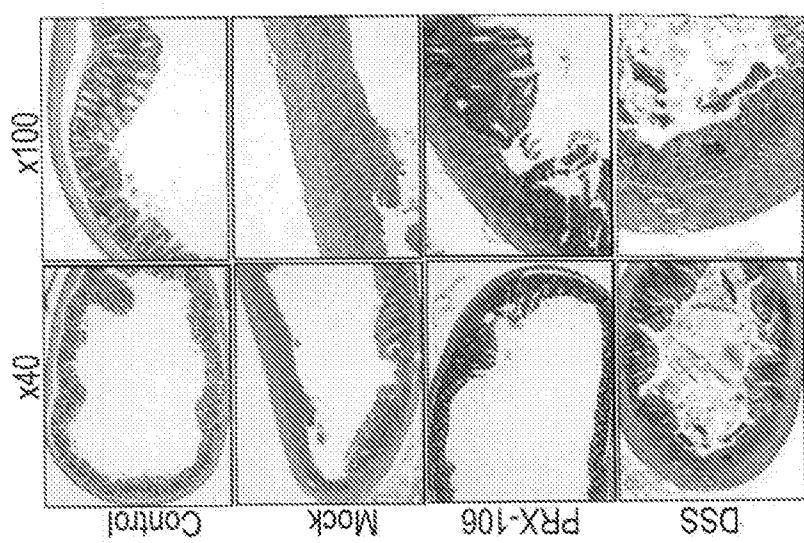
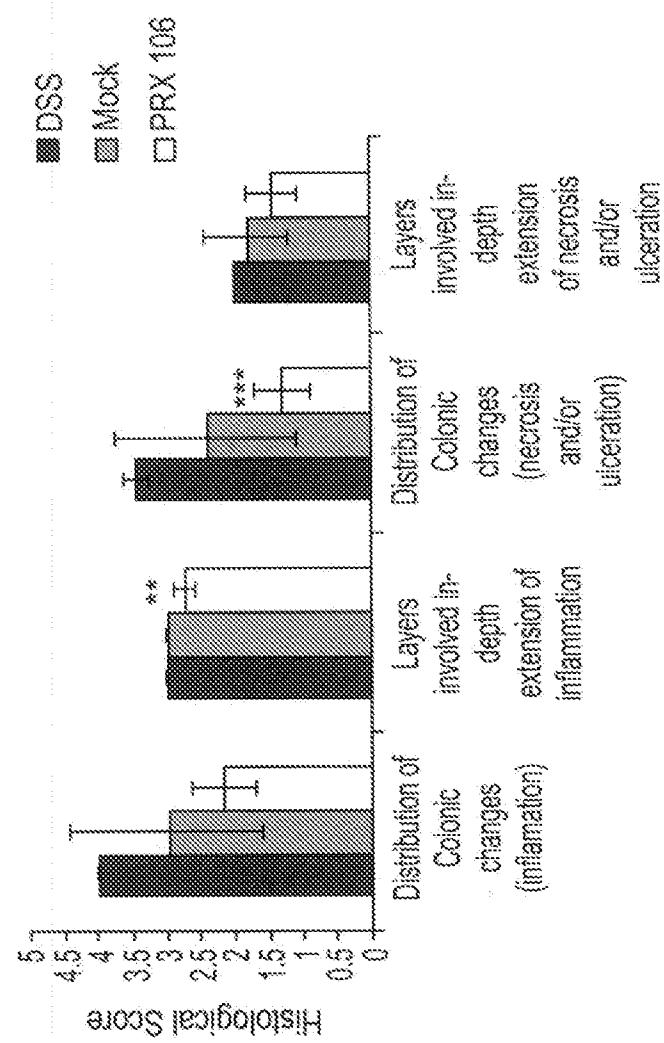


FIG. 17B



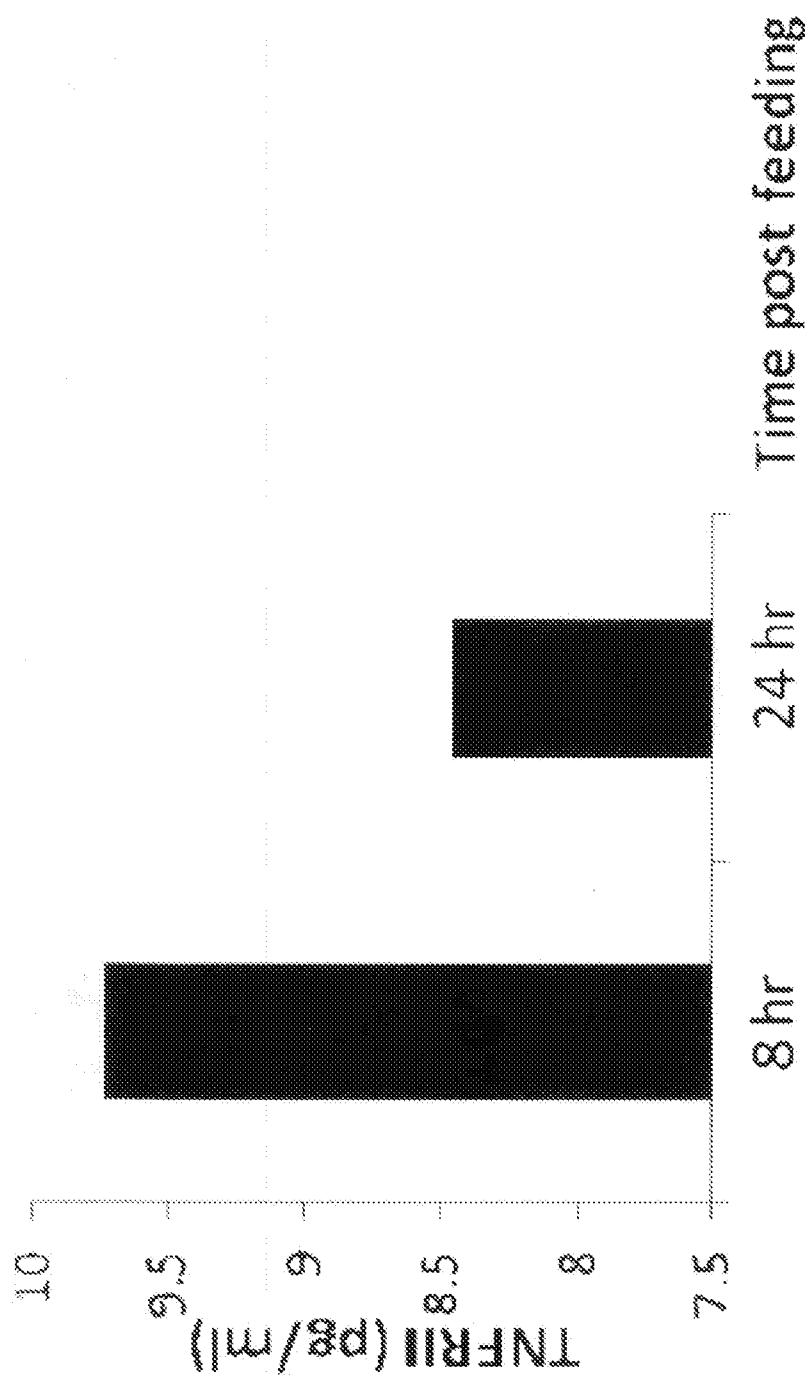


FIG. 18

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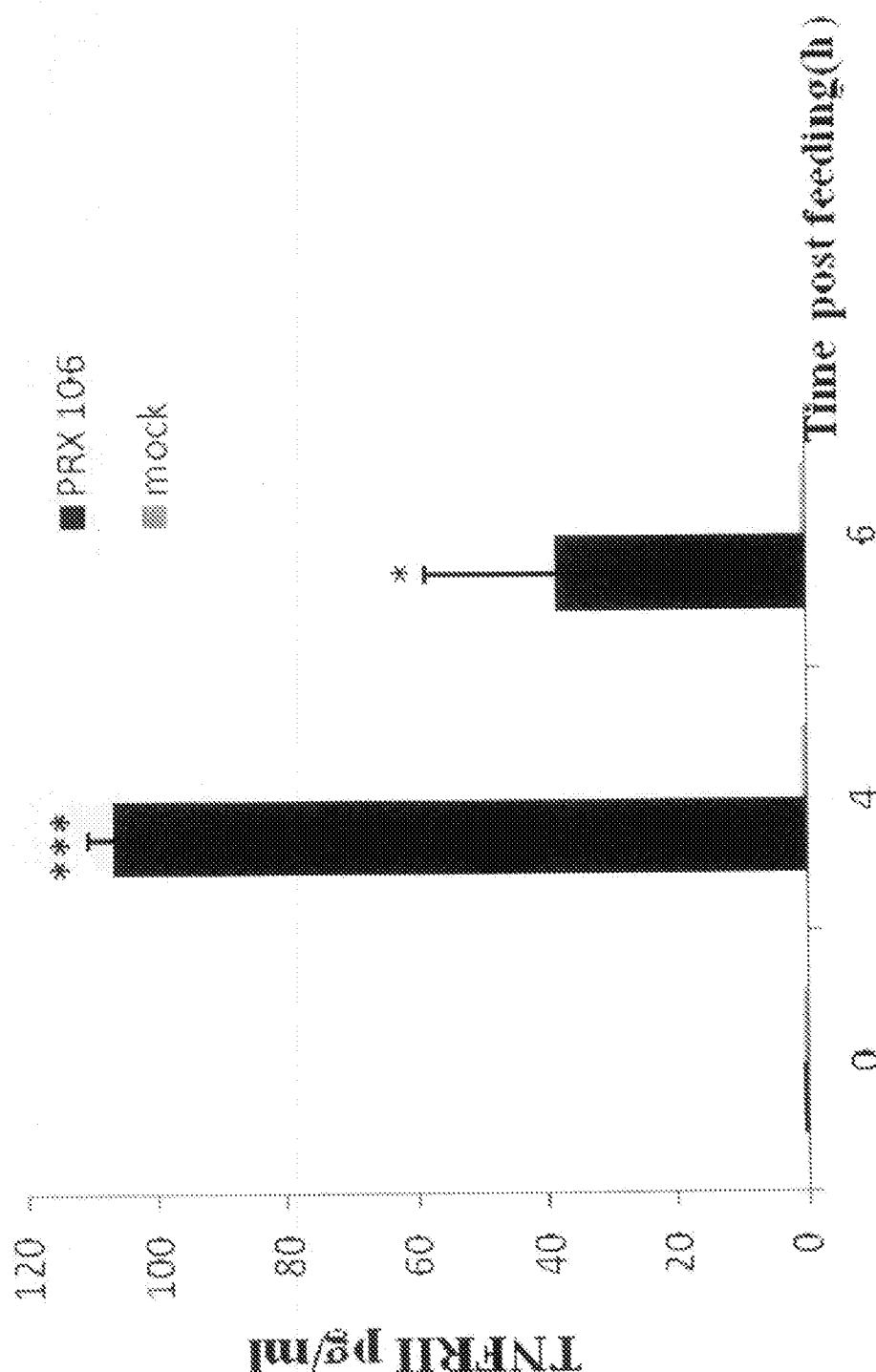


FIG. 19

	144	21	31	41	51	61	71	81	91	101
WATERMARKS: SUBSTITUTED LUMINESCENT POLY(1,3-BUTYLENE TEREPHTHALATE)										
144	C	0	C	C	0	C	C	0	C	C
21	D	0	D	0	C	C	0	C	0	C
31	D	0	D	0	C	D	0	D	0	D
41	D	0	D	0	C	D	0	D	0	D
51	D	0	D	0	C	D	0	D	0	D
61	D	0	D	0	C	D	0	D	0	D
71	D	0	D	0	C	D	0	D	0	D
81	D	0	D	0	C	D	0	D	0	D
91	D	0	D	0	C	D	0	D	0	D
101	D	0	D	0	C	D	0	D	0	D

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2014/050228

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K14/525 C12N15/82
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, BIOSIS, Sequence Search, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>WINICHAYAKUL SOMRUTAI ET AL: "Head-to-tail fusions of camelid antibodies can be expressed in planta and bind in rumen fluid.", BIOTECHNOLOGY AND APPLIED BIOCHEMISTRY JUN 2009, vol. 53, no. Pt 2, June 2009 (2009-06), pages 111-122, XP002725894, ISSN: 1470-8744 the whole document</p> <p>-----</p> <p style="text-align: center;">-/-</p>	1-3, 22-55

Further documents are listed in the continuation of Box C.

See patent family annex.

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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 2014	04/07/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Kania, Thomas

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2014/050228

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>WILSON SARAH A ET AL: "Recent advances towards development and commercialization of plant cell culture processes for the synthesis of biomolecules", PLANT BIOTECHNOLOGY JOURNAL, vol. 10, no. 3, April 2012 (2012-04), pages 249-268, XP002725895, page 261, left-hand column, last paragraph - page 262, left-hand column, paragraph 1 page 262, right-hand column, paragraph 2 table 1</p> <p>-----</p>	1-55
X	<p>US 2003/135887 A1 (BRANDLE JIM [CA] ET AL) 17 July 2003 (2003-07-17)</p>	1,23-25,
	<p>paragraph [0216]; claims; example 3</p> <p>-----</p>	27-30,
X	<p>MENASSA RIMA ET AL: "Therapeutic effectiveness of orally administered transgenic low-alkaloid tobacco expressing human interleukin-10 in a mouse model of colitis.", PLANT BIOTECHNOLOGY JOURNAL JAN 2007, vol. 5, no. 1, January 2007 (2007-01), pages 50-59, XP002725896, ISSN: 1467-7652 the whole document</p> <p>-----</p>	1,23-25,
X	<p>WO 02/12502 A2 (CENTOCOR INC [US]) 14 February 2002 (2002-02-14)</p>	27-30,
	<p>page 20, lines 9-28 page 48, lines 18-36 claims</p> <p>-----</p>	34-36,
A	<p>WO 2012/170938 A1 (ACCELERON PHARMA INC [US]; SEEHRA JASBIR [US]; KNOPF JOHN [US]; KUMAR) 13 December 2012 (2012-12-13)</p> <p>-----</p>	38,40,
		42-50,
		52,53

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2014/050228

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P	<p>SHAALTIEL YOSEPH ET AL: "Oral administration of a plant cell-expressed recombinant anti-TNF fusion protein is biologically active in the gut and alleviates immune mediated hepatitis", HEPATOLOGY, vol. 58, no. Suppl. 1, Sp. Iss. SI, October 2013 (2013-10), page 564A, XP002725897, & 64TH ANNUAL MEETING AND POSTGRADUATE COURSE OF THE AMERICAN-ASSOCIATION-FOR-THE-STUDY-OF-LIVE R-DISEA; WASHINGTON, DC, USA; NOVEMBER 01-05, 2013 abstract</p> <p>-----</p>	1-29, 32-55

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IL2014/050228

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			US	2007003548 A1		04-01-2007
			WO	0212502 A2		14-02-2002
			YU	9103 A		25-05-2006
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			WO	2012170938 A1		13-12-2012
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