MEDIUM-CHAIN LENGTH FATTY ACIDS, GLYCERIDES AND ANALOGUES AS NEUTROPHIL SURVIVAL AND ACTIVATION FACTORS

FIELD OF THE INVENTION

The present invention relates to the prevention and/or treatment of neutropenia. This includes the treatment of neutropenia associated with the use of chemotherapy and radiotherapy as well as treatment of neutropenia arising from infections, hematologic diseases and nutritional deficiencies. The present invention also relates generally to reducing drug toxicity and enhancing drug efficacy. In particular, the present invention relates to the use of medium-chain length fatty acids such as capric acid, caprylic acid, or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof as a neutrophil survival and activation factor or bone marrow stem cell proliferation factor.

BACKGROUND OF THE INVENTION

Chemotherapy refers to the use of cytotoxic agents such as, but not limited to, cyclophosphamide, doxorubicin, daunorubicin, vinblastine, vincristine, bleomycin, etoposide, topotecan, irinotecan, taxotere, taxol, 5-fluorouracil, methotrexate, gemcitabine, cisplatin, carboplatin or chlorambucil in order to eradicate cancer cells and tumors. However, these agents are non-specific and, particularly at high doses, they are toxic to normal and rapidly dividing cells. This often leads to various side effects in patients undergoing chemotherapy and radiation therapy. Myelosuppression, a severe reduction of blood cell production in bone marrow, is one such side effect. It is characterized by leukopenia, neutropenia and thrombocytopenia. Severe chronic neutropenia (idiopathic, cyclic, and congenital) is also characterized by a selective decrease in the number of circulating neutrophils and an enhanced susceptibility to bacterial infections.

The essence of treating cancer with chemotherapeutic drugs is to combine a mechanism of cytotoxicity with a mechanism of selectivity for highly proliferating tumor cells over host cells. However, it is rare for chemotherapeutic drugs to have such selectivity. The cytotoxicity of chemotherapeutic agents limits administrable doses, affects treatment cycles and seriously jeopardizes the quality of life of the oncologic patient.

Although other normal tissues may also be adversely affected, bone marrow is particularly sensitive to proliferation-specific treatments such as chemotherapy or radiation therapy. Acute and chronic bone marrow toxicity is a common side effect of cancer therapies which leads to decreases in blood cell counts and anemia, leukopenia, neutropenia, agranulocytosis and thrombocytopenia. One cause of such effects is a decrease in the number of hematopoietic cells (e.g., pluripotent stem cells and other progenitor cells) caused by both a lethal effect of cytotoxic agents or radiation on these cells and by differentiation of stem cells provoked by a feed-back mechanism induced by the depletion of more mature marrow compartments. The second cause is a reduction in self-renewal capacity of stem cells, which is also related to both direct (mutation) and indirect (aging of stem cell population) effects. (Tubiana, M., *et al.*, Radiotherapy and Oncology 29:1-17, 1993). Thus, cancer treatments often result in a decrease in Polymorphonuclear Neutrophils (PMN) or neutropenia. PMN are the first line of defense against invading pathogens and play a central role during acute inflammation, their primary function being the phagocytosis and killing of the infectious agents. To accomplish this role, PMN leave the circulation in response to chemotactic factors and enter in the affected area to exert their biological functions. In individuals exhibiting normal blood cell counts, neutrophils constitute approximately 60% of the total leukocytes. (SI Units Conversion Guide, 66-67 (1992), New England Journal of Medicine Books). However, as many as one in three patients receiving chemotherapy treatment for cancer may suffer from neutropenia. Mean normal neutrophil counts for healthy human adults are on the order of 4400 cells/μL, with a range of 1800-7700 cells/μL. A count of 1,000 cells to 500 cells/μL is moderate neutropenia and a count of 500 cells/μL or less is severe neutropenia. Patients in myelosuppressive states are prone to infection and frequently suffer from blood-clotting disorders, requiring hospitalization. Lack of neutrophils and platelets is the leading cause of morbidity and mortality following cancer treatments and contributes to the high cost of cancer therapy. In these above-mentioned conditions, the use of any agent capable of inhibiting neutrophil apoptosis or stimulating neutrophil activation and mobilization can be of therapeutic value. Efforts to restore the patient's immune system after chemotherapy involves the use of hematopoietic growth factors to stimulate remaining stem cells to proliferate and differentiate into mature infection fighting cells.

In bone marrow transplantation, a phenomenon known as "mobilization" has also been exploited to harvest greater numbers of stem/progenitor cells from peripheral blood. This method is currently used for autologous or allogeneic bone marrow transplantation. Growth factors are used to increase the number of peripheral progenitor stem cells to be harvested before myeloablative therapy and infusion of progenitor stem cells.

Post-therapy bone marrow transplantation can also counter neutropenia. However, these treatments require 10-15 days of treatment which leaves patients vulnerable to infection. Agents capable of stimulating bone marrow stem cells can facilitate and accelerate stem cells engraftment thus shortening the neutropenic window following bone marrow transplantation.

Although hematopoietic growth factors such as granulocyte-macrophage colony stimulating factor (GM-CSF) and granulocyte colony stimulating factor (G-CSF) can exert such actions, their use is expensive since they have to be produced by recombinant technology. Such post-therapeutic ameliorative treatments are unnecessary if patients are "chemoprotected" from immune suppression.

Therefore, there is a need for novel compositions and methods to reduce the undesirable side effects of myelosuppressive states induced by chemotherapy and radiation therapy.

SUMMARY OF THE INVENTION

The present invention satisfies the need for chemoprotective agents by providing a novel method for the stimulation of the hematopoietic system in a mammal, including a human. The present invention also provides a novel method for treating the myelosuppressive effects of chemotherapy and radiotherapy, and any other situation in which the stimulation of the hematopoietic system can be of therapeutic value such as, but not limited to, bone marrow transplantation and chronic neutropenia, as well as neutropenia resulting from infections, hematologic diseases and nutritional deficiencies. This method assists the hematopoietic system in countering myelosuppression, increasing neutrophil survival and activation, in patients undergoing such treatment.

In accordance with this method, a composition containing one or more medium-chain length fatty acids such as capric acid, caprylic acid, or salts or triglycerides thereof or mono- or diglycerides or other analogues in a

pharmaceutically acceptable carrier is administered to a mammal, particularly humans, in an amount effective to prevent or treat neutropenia such as for reducing the adverse effects of chemotherapy and radiation therapy and for treating neutropenia arising from infections, hematologic diseases and nutritional deficiencies.

Accordingly, it is an object of the present invention to provide compositions using capric acid, caprylic acid, lauric acid or metallic salts (sodium, potassium, calcium, magnesium) thereof, or triglycerides thereof, or mono- or diglycerides or other analogues thereof for the production of chemoprotective pharmaceutical compositions as a single agent or as a combination of two or more agents with and/or without other chemotherapeutic agents or such drugs which induce a state of myelosuppression.

Another object of the present invention relates to the use of capric acid, caprylic acid or sodium salts or triglycerides thereof or mono- or diglycerides thereof or related compounds as a hematopoiesis stimulating factor.

Furthermore, the present invention includes compositions containing capric acid, caprylic acid or sodium salts or triglycerides thereof or mono- or diglycerides or other analogues thereof and the use of such compounds for the treatment of myelosuppression and subsequent immunosuppression.

An object of the invention relates also to the use of capric acid, caprylic acid or sodium salts or triglycerides thereof or mono- or diglycerides or other analogues thereof for the treatment of patients with severe chronic neutropenia.

Yet another object of the present invention relates to the use of capric acid, caprylic acid or sodium salts or triglycerides thereof or mono- or diglycerides or other analogues thereof as a neutrophil survival and activation factor.

The present invention also relates to the use of capric acid, caprylic acid or sodium salts or triglycerides thereof or mono- or diglycerides or other analogues thereof in conditions where neutrophil mobilization can be of therapeutic value such as autologus or allogeneic bone marrow transplantation.

It is an object of the present invention to provide a method effective for providing chemoprotection of a mammal, including a human.

Another object of the present invention is to provide a method effective for increasing the effectiveness of chemotherapy and radiation therapy in a mammal, including a human.

Yet another object of the invention is to provide methods for using more usual dosages, or even increasing the dose of chemotherapeutic compositions necessary to achieve a better therapeutic benefit, while avoiding increased side-effects.

Another object of the present invention is to provide a method effective for reducing or eliminating chemotherapy-induced neutropenia in a mammal, including a human.

Still another object of the present invention is to provide a method for treating neutropenia arising from hematologic diseases such as chronic idiopathic neutropenias, cyclic neutropenia, lazy-leukocyte syndrome, Chédiak-Higashi syndrome leukemia and aplastic anemia.

Yet another object of the present invention is to provide a method for treating neutropenia arising from infections such as viral (for example, HIV, measles, hepatitis, yellow fever, mononucleosis) and bacterial (for example, typhoid, paratyphoid, brucellosis) infections.

Finally, another object of the present invention is to provide a method that causes minimal or no adverse side effects in the recipient.

These and other objects, features and advantages of the present invention will become apparent after a review of the following detailed description of the disclosed embodiment and the appended claims.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the effect of MCT on PMN apoptosis.

Figure 2 shows the effect of MCT on PMN phagocytosis.

Figures 3A and 3B show the effect of doxorubicin on PMN apoptosis.

Figure 4A represents a time-course response of MCT on doxorubicin-treated neutrophils.

Figure 4B represents a time-course response of doxorubicin on MCT-treated neutrophils.

Figure 5 shows the effect of MCT and tricaprin on bone marrow proliferation.

Figure 6 shows the effect of MCT on bone marrow cell count in immunosuppressed animals.

Figure 7 shows the effect of MCT on spleen cell count in immunosuppressed animals.

Figure 8 shows the effect of MCT and GM-CSF on thymus weight on normal mice.

Figure 9 shows the effect of MCT, sodium caprylate and sodium caprate on bone marrow cell count in immunosuppressed animals.

Figure 10 represents the chemoprotective effect and anti-tumor efficacy of MCT in combination with a sub-therapeutic concentration of doxorubicin in B16F10 melanoma model.

Figure 11 represents the chemoprotective effect and anti-tumor efficacy of MCT in combination with a sub-therapeutic concentration of cyclophosphamide or taxotere in DA-3 breast carcinoma model.

Figure 12 shows the chemoprotective effect and anti-tumor efficacy of MCT in combination with a therapeutic concentration of cyclophosphamide or taxotere in DA-3 breast carcinoma model.

DETAILED DESCRIPTION OF THE INVENTION

High-dose chemotherapy and radiation destroy hematopoietic cells in bone marrow, leaving the patients severely depleted in neutrophils and platelets. After such treatments, patients spend several weeks in intensive care units due to infections and fever resulting from neutropenia. Thrombocytopenia leads to prolonged clotting time and bleeding disorders requiring platelet transfusions. Myelosuppression is a dose-limiting factor in cancer treatment and lack of neutrophils and platelets is the leading cause of morbidity and mortality following these cancer treatments.

In bone marrow transplantation, two approaches may be used. Before transplantation, stimulation of the bone marrow may increase the number of peripheral progenitor stem cells. However, freshly transplanted bone marrow does not contain sufficient mature neutrophils or neutrophil intermediaries to restore a patient's immune system. This leaves the patient with a period of increased susceptibility to infections and prolonged clotting time. Therapy involving neutrophil stimulation and activation increases recovery following bone marrow transplantation, by reducing neutropenia and thrombocytopenia.

The present invention relates to a method of promoting neutrophil survival and activation in a subject. Current methods are directed towards restoring the subject's hematopoietic system. Hematopoietic growth factors presently used for such treatment are granulocyte colony-stimulating factor (G-CSF), stem cell

factor (SCF) and granulocyte-macrophage colony-stimulting factor (GM-CSF). G-CSF and GM-CSF can shorten the total period of neutropenia and thrombocytopenia but there still remains a significant window during which the patient is deficient in blood clotting and susceptible to infections.

In bone marrow transplantation, "mobilization" has also been used to harvest higher numbers of stem/progenitor cells from peripheral blood. Hematopoietic stem cells in the bone marrow are mobilized in the blood following treatment with growth factors. Growth factors used for such treatment include interleukin-3 (IL-3), G-CSF, GM-CSF, SCF and a recombinant fusion protein having the active moieties of both IL-3 and GM-CSF. Mobilized stem cells are then harvested after growth factor treatment and reinfused into the patient following the next round of high dose chemotherapy or irradiation, to restore the patient's neutrophils and platelets.

Medium-chain triglycerides (also referred to herein as "MCT") consist of glycerol esterified with fatty acids with carbon chain lengths of 8 (C8, octanoic acid or caprylic acid) and 10 (C10, decanoic acid or capric acid). MCT usually contain of a mixture of glycerol esters of C8 and C10 fatty acids. However, MCT can also contain small amounts (2±1% each) of glycerol esters of C6 (hexanoic acid or caproic acid) and C12 (dodecanoic acid or lauric acid). CRODAMOL™ is a commercially available MCT available from Croda Ltd., Toronto (Canada). As shown in example 1, CRODAMOL™ is an MCT which contains glycerol triesters of C8 and C10 fatty acids present in varying proportions. However, CRODAMOL™ does not contain any C6 or C12 fatty acid esters. Long-chain triglycerides (also referred to herein as "LCT"), on the other hand, consist of glycerol esterified with fatty acids with carbon chain lengths of greater than 12. Typical fatty acids present in LCT include palmitic (C16) and stearic (C18) acids. Unlike MCT, LCT is the primary component of dietary fats. Indeed, MCT and LCT have significantly different biological properties. Some of the physiological differences between MCT and LCT are described in Harrison's Principles of Internal Medicine, 8th Edition, 1520-1521 (1977), McGraw Hill Book Company or 15th Edition, 1668-1669 (2001). For example, MCT, in contrast to LCT, do not require hydrolysis by pancreatic lipase, since they can be absorbed by the intestinal epithelial cell.

MCT and their constituent medium-chain fatty acids are nontoxic materials which find use in the food and pharmaceutical industries. For example,

K.A. Traul *et al.* in Food and Chemical Toxicology 38:79-98 (2000) state that MCT have been utilized in an increasing number of food and nutrition applications because they offer a number of advantages over LCT. MCT are also used primarily as emulsifiers in various human and veterinary pharmaceutical preparations and in cosmetics. They refer to a number of toxicological studies which support the safety of MCT. For example, they note that the safety of human dietary consumption of MCT, up to levels of 1 g/kg, has been confirmed in clinical trials. C8 and C10 fatty acids possess similar safety and use. For example, in The Merck Index, 11th Edition, 266 (1989) caprylic acid is reported to have an LD_{50} (oral, rats) = 10.08 g/kg which is essentially nontoxic. In fact, according to section 184 of the Code of Federal Regulations (CFR), the U.S. Federal Drug Agency (FDA) has granted caprylic acid a GRAS (Generally Recognized As Safe) affirmation. Similarly, according to section 172 (CFR) free fatty acids (e.g. capric, caprylic) and their metallic salts are recognized as safe additives for use in food. As noted by D. Dimitrijevic *et al.* in Journal of Pharmacy and Pharmacology 53:149-154 (2001), capric acid (sodium salt) is approved for human use in Japan and Sweden as an absorption enhancer for rectal drug products. U.S. Patent 4,602,040 (1986) describes the use of MCT as a pharmaceutical excipient. More recently, PCT publication WO 01/97799 describes the use of medium-chain fatty acids, in particular caprylic and capric acids, as antimicrobial agents.

However, until the unexpected findings disclosed herein, the effectiveness of medium-chain fatty acids such as capric acid, caprylic acid or metallic salts or mono-, di- or triglycerides (MCT) thereof as a neutrophil survival and activation factor was not known. As described herein, MCT contain triglycerides of C8 (caprylic) and C10 (capric) fatty acids which constitute at least 98% of the activity pertaining to stimulation of hematopoiesis and maturation of neutrophils. D. Waitzberg *et al.* in Nutrition 13:128-132 (1997) state that lipid emulsions (LCT and MCT) only moderately decreases neutrophil bactericidal function and have no effect on monocytes. Indeed, the only publication which gives a vague indication that MCT may influence neutropenia describes clinical studies in which MCT are administered along with LCT and compared with LCT alone. No studies were undertaken with MCT alone and so the effect on immune function is not apparent. However, the results reported by S. Demirer *et al.* in Clinical Nutrition 19:253-258 (2000) teaches that MCT exacerbate neutropenia when MCT are combined

with LCT and relative to LCT alone. That is, it was suggested that MCT inhibit neutrophil function and/or survival. Somewhat supporting this suggestion, PCT publication WO 95/30413 asserts that unsaturated long chain fatty acids such as linolineic acid, as well as saturated long chain (C16 or longer) fatty acids, can function to enhance hematopoietic stem cell proliferation.

The present invention relates to the use of medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT as a hematopoiesis activation or growth factor and a neutrophil survival and activation factor. When used in chemotherapy and radiotherapy, a composition containing medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT is administered before, during and/or after the treatment in order to shorten the neutropenic window and to accelerate the replenishment of the hematopoietic system. Furthermore, it is possible to use a combination of medium-chain fatty acids along with their metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof and/or MCT at multiple points relative to treatment with chemotherapy and radiotherapy (e.g., fatty acids before treatment and MCT after). Alternatively, it is possible to administer the combination simultaneously: before, during and/or after treatment with chemotherapy and radiotherapy. In severe neutropenia, a composition containing medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT is used as the therapeutic agent. In bone marrow transplantation, medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT is used to increase the number of peripheral stem cells available for transplantation after ablative radiotherapy or chemotherapy. Medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT can also be used after bone marrow transplantation in order to stimulate bone marrow stem cells thus shortening the time period for recovery from neutropenia.

The method is therefore useful for stimulating hematopoiesis to treat myelosuppression arising from chemotherapy or radiotherapy; chronic or transient neutropenia neutropenia; drug-induced neutropenia; and neutropenia arising from a hematologic disease, nutritional deficiency, infection, or radiotherapy. Transient neutropenia may arise from stress due to shipping of an animal or travel of a human or animal. The method is also useful for stimulating hematopoiesis to heal

a wound in the patient, and to induce neutrophil mobilization to facilitate bone marrow transplantation in a patient.

As used herein, the terms "a" or "an" can mean one or more, depending on the context in which it is used.

As used herein, "medium-chain fatty acids such as capric acid or caprylic acid or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT composition" refers to a composition comprising said active ingredient and one or more pharmaceutically acceptable carriers.

As used herein, the term "pharmaceutically acceptable carrier" refers to a substance that does not interfere with the physiological effects of medium-chain fatty acids such as capric acid or caprylic acid or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT and that is not toxic to mammals including humans.

The capric or caprylic acid or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT compositions of the present invention are formulated using capric or caprylic acid or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT and pharmaceutically acceptable carriers by methods known to those skilled in the art (MERCK INDEX, Merck & Co., Rahway, NJ). These compositions include, but are not limited to, liquids, oils, emulsions, aerosols, inhalants, capsules, pills, patches and suppositories.

All methods include the step of bringing the active ingredient(s) into association with the carrier which constitutes one or more accessory ingredients.

As used herein, the term "chemotherapy" refers to a process of killing proliferating cells using a cytotoxic agent. The phrase "during the chemotherapy" refers to the period in which the effect of the administered cytotoxic agent lasts. On the other hand, the phrase "after the chemotherapy" is meant to cover all situations in which a composition is administered after the administration of a cytotoxic agent regardless of any prior administration of the same and also regardless of the persistence of the effect of the administered cytotoxic agent.

When the method of this invention is applied to chemotherapy, a capric or caprylic acid or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT composition can be administered prior to, during, or subsequent to the chemotherapy (i.e., prior to, during, or subsequent to the administration of a cytotoxic agent).

By "cytotoxic agent" is meant an agent which kills highly proliferating cells, e.g., tumor cells, virally infected cells, or hemopoietic cells. Examples of a cytotoxic agent which can be used to practice the invention include, but are not limited to, cyclophosphamide, doxorubicin, daunorubicin, vinblastine, vincristine, bleomycin, etoposide, topotecan, irinotecan, taxotere, taxol, 5-fluorouracil, methotrexate, gemcitabine, cisplatin, carboplatin or chlorambucil, and an agonist of any of the above compounds. A cytotoxic agent can also be an antiviral agent, e.g., AZT (i.e., 3'-azido-3'-deoxythymidine) or 3TC/lamivudine (i.e., 3-thiacytidine).

As used herein, the term "leukopenia" refers to an abnormal reduction in the number of leukocytes in the blood.

As used herein, the term "neutropenia" refers to the presence of abnormally small numbers of neutrophils in the blood.

In one preferred embodiment, the pharmaceutical composition is in the form of any suitable composition for oral, sublingual administration or inhalation (nasal spray), intravenous, intramuscular, subcutaneous, for use in the treatment of neutropenia, thrombocytopenia or as a neutrophil survival and activation factor.

It will be appreciated that the amount of a composition of the invention required for use in the treatment will vary with the route of administration, the nature of the condition being treated, the age and condition of the patient, and will be ultimately at the discretion of the attendant physician. The desired dose may conveniently be presented in a single dose or as divided doses taken at appropriate intervals, for example as two, three, four or more doses per day.

While it is possible that, for use in therapy, medium-chain fatty acids or metallic salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT may be administered as the raw chemical, it is preferable to present the active ingredient as a pharmaceutical formulation.

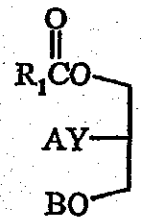
In a preferred embodiment of this invention, the amount of active ingredient administered is such that the concentration in the blood (free and/or bound to serum albumin) is greater than 1 μM. In a particularly preferred embodiment, the concentration in the blood is greater than 1 mM.

In another embodiment, the pharmaceutical composition is in the form of oral (including sublingual), or parental (including intramuscular, subcutaneous rectal and intravenous) administration. The formulations may, where appropriate, be conveniently presented in discrete dosage units and may be prepared by any of

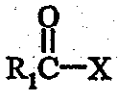
the methods well known in the art of pharmacy. All methods include the step of bringing into association the active compound with liquid carriers or finely divided solid carriers or both and then, if necessary, shaping the product into the desired formulation. When desired, the above-described formulations adapted to give sustained release of the active ingredient may be employed.

Medium-chain fatty acids or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT can also be used in combination with other therapeutically active agents such as cytotoxic anticancer agents or other anticancer agents (immune modulating or regulating drugs or therapeutic vaccines or antiangiogenesis drugs, etc.), immune suppressive drugs (including anti-inflammatory drugs), a growth factor such as a colony stimulating factor (preferably GM-CSF or G-CSF), a cytokine such as interleukin 2 or interleukin 15, or combinations thereof. The individual components of such combinations may be administered either sequentially (before or after) or simultaneously in separate or combined pharmaceutical formulations. The combination referred to above may conveniently be presented for use in the form of a pharmaceutical formulation and thus pharmaceutical formulations comprising a combination as defined above together with a pharmaceutically acceptable carrier thereof comprise a further aspect of the invention.

In a preferred embodiment of the method of stimulting hematopoiesis in a patient needing treatment, a pharmacologically effective amount of a composition containing one or more of the following compounds, or combinations thereof, are administered:



I Y = O, NH



II



III Z = O, NH, CH_2O = zero

wherein

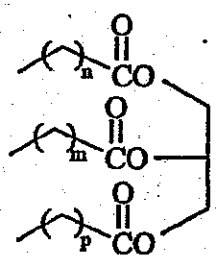
R_1 is a straight chained or branched, saturated or unsaturated C7-C11 alkyl group;

A and B are hydrogen or R_1-C(=O), independently; and

X is a hydroxyl group, an oxy anion with a metallic mono- or dicationic counterion, or an alkoxy group with a straight chained or branched C1-C4 alkyl moiety.

It will be understood by those skilled in the art that, in formula III, the term "Z= zero" indicates that the variable Z is optional and may be eliminated or replaced with a hydrogen.

In an alternative preferred embodiment, the composition contains a mixture of at least two compounds described by formula I, which are Medium Chain Triglycerides (MCTs) wherein A, B and R_1 are the same and are straight chained or branched, saturated or unsaturated C7 and C9 alkyl groups, respectively. Alternatively, the composition contains a mixture of two triglycerides wherein a first MCT is described by formula I, wherein A, B and R_1 are $CH_3(CH_2)_6$, and a second MCT is described by formula I, wherein A, B and R_1 are $CH_3(CH_2)_8$. Alternatively, the composition further contains from 0.1% to 3% each of a third compound described by formula I, wherein A, B and R_1 are $CH_3(CH_2)_4$, and a fourth compound described by formula I, wherein A, B and R_1 are $CH_3(CH_2)_{10}$. Alternatively, the composition is a mixture containing four geometric isomers of C8 and C10 fatty acid triglycerides described by the following formula:



	1	2	3	4
n =	6	6	6	8
m =	6	6	8	8
p =	6	8	8	8

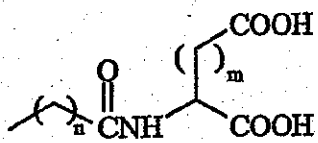
In an alternative preferred embodiment, the composition contains one or more compounds described by formula II or formula III, wherein X is OH or X is an oxy anion with a metallic counterion such as calcium, magnesium, potassium, and sodium.

In a more preferred embodiment, the composition is caprylic acid, capric acid, sodium caprylate, sodium caprate, calcium caprylate, calcium caprate, caprylic acid triglyceride, or capric acid triglyceride.

The compositions and methods described herein include the following analogues and compounds:

aza analogues of caprylic acid triglyceride or capric acid triglyceride, preferably where the aza analogue is 1,2,3-O,N,O-trioctanoyl serinol or 1,2,3-O,N,O-tridecanoyl serinol;

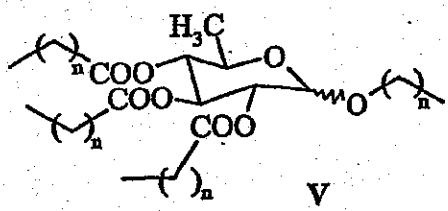
the compound described by formula IV



n = 6, 8
m = 1, 2

IV ;

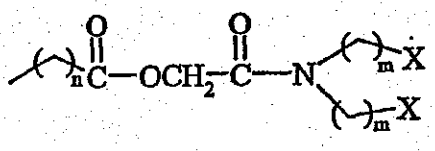
the compound described by formula V



n = 6, 8

V ;

the compound described by formula VI, which provide a pharmaceutical formulation by degradation *in vivo* to release active substances described above



n = 6, 8
m = 1, 2
X = H, OH, O C—NH2

VI ;

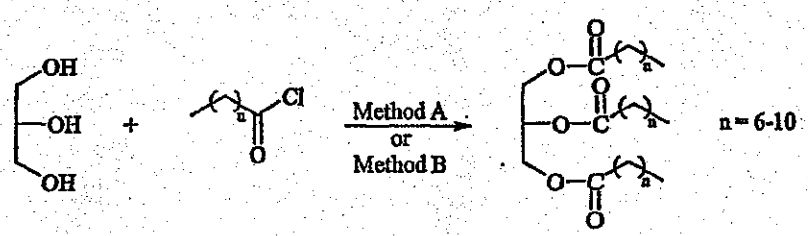
The following examples further illustrate the practice of this invention, but are not intended to be limiting thereof. It will be appreciated that the selection of the dose of medium-chain fatty acids or salts or triglycerides thereof or mono- or diglycerides or other analogues thereof or MCT and related pharmaceutical formulations to be administered to any individual patient (human or animal) will fall within the discretion of the attending physician, will be prescribed in a manner commensurate with the appropriate dosages and will depend on the stage of the disease and like factors uniquely within the purview of the attending physician.

Example 1: Analysis of CRODAMOL™ (MCT: Caprylic/Capric Triglyceride)

CRODAMOL™ GTCC lot #T1033-1299 from Croda Ltd. (Toronto, Canada) was analyzed by gas chromatography. GC FID-analysis, conditions of the gradient: 100°C-250°C in 10 minutes, then 250°C for 25 minutes; FID 250°C. Four peaks were observed: 22.04 minutes (26%), 25.07 minutes (43%), 29.16 minutes (25%) and 34.75 minutes (5%).

A sample of caprylic triglyceride (tricaprylin), obtained from Sigma-Aldrich lot #079H1212, was analyzed by gas chromatography. GC FID-analysis, conditions of the gradient: 100°C-250°C in 10 minutes, then 250°C for 25 minutes; FID 250°C. Mainly one peak at 22.31 minutes (98%).

Example 2: Acylation of alcohol using acid chloride and pyridine base



Method A: Pyridine, CH_2Cl_2
Method B: DMAP, CH_2Cl_2

General Method A (Pyridine)

A solution of the alcohol (~0.1 M) in dry CH_2Cl_2 and pyridine (4:1), was cooled to 0°C under nitrogen, and treated with the acid chloride (1.2 equivalent). The

reaction was allowed to warm slowly to ambient temperature, and stirred overnight. TLC analysis (SiO_2, EtOAc 1:9 hexane) showed no remaining alcohol. The reaction mixture was diluted with CH_2Cl_2, and washed with saturated aqueous NH_4Cl solution. The aqueous phase was extracted with CH_2Cl_2 (x 1) and hexane (x 1), and combined organic phases were washed with saturated aqueous NaCl solution, dried over Na_2SO_4, filtered and evaporated *in vacuo* to give the crude product.

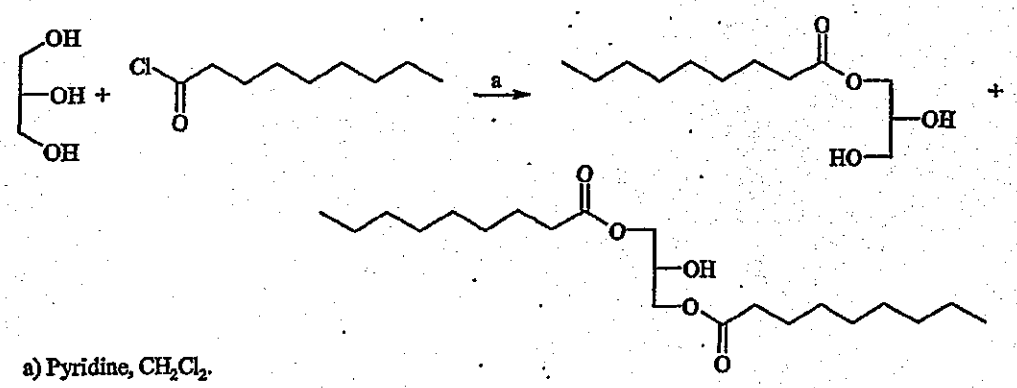
General Method B (DMAP)

A solution of the alcohol (~0.1 M) in dry CH_2Cl_2 was cooled to 0°C under nitrogen, and treated with DMAP (1.3 equivalent) and the acid chloride (1.2 equivalent). The reaction was allowed to warm slowly to ambient temperature, and was stirred overnight. TLC analysis (SiO_2, EtOAc 1:9 hexane) showed no remaining alcohol. The reaction mixture was diluted with CH_2Cl_2, and washed with saturated aqueous NH_4Cl solution. The aqueous phase was extracted with CH_2Cl_2 (x1) and hexane (x1), and combined organic phases were washed with saturated aqueous NaCl solution, dried over Na_2SO_4, filtered and evaporated *in vacuo* to give the crude product.

Example 3: Nonanoic Acid Triglyceride

Glycerol (120 mg, 1.30 mmol) was acylated with nonanoyl chloride (751 µl, 4.16 mmol) according to General Method A, example 2. Purification by column chromatography (Isolute™ SiO_2, eluting with 0-5% EtOAc in hexane) gave two product containing fractions, which were evaporated *in vacuo* to give the desired product as a colourless liquid, in 89% (127 mg, 19%) and 93% (475 mg, 71%) purity respectively (GC/FID). R_f 0.46 (SiO_2, 10% ethyl acetate in hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H = 5.27 (m, 1H), 4.29 (dd, 2H), 4.14 (dd, 2H), 2.31 (m, 6H), 1.61 (m, 6H), 1.27 (m, 30H), 0.88 (t, 9H); MS (FAB^+) *m/z* = 510($M\text{-}H^+$); GC FID-analysis, conditions: gradient 100°C-250°C in 10 minutes, then 250°C for 25 minutes; FID 250°C; 27.25 minutes.

Example 4: Nonanoic acid Diglyceride and Monoglyceride



a) Pyridine, CH_2Cl_2.

Glycerol (100 mg, 1.09 mmol) was acylated with one equivalent of nonanoyl chloride (205 µl, 1.09 mmol) according to General Method A, example 2. Purification by Biotage™ (40S, SiO_2, eluting with 10% ethyl acetate in hexane-100% ethyl acetate) gave a colorless oil. Two different compounds were obtained:

Nonanoic acid Diglyceride was obtained (73 mg, 18%) as a white solid. mp 24-26°C; R_f 0.52 (SiO_2 pretreated with Et_3N, 30% ethyl acetate in hexane); ^1H NMR ($CDCl_3$, 300 MHz) $\delta_H = 4.17$ (m, 5H), 2.35 (t, 4H), 1.63 (m, 4H), 1.27 (m, 20H), 0.88 (t, 6H); MS (FAB^+) $m/z = 373$ ($M+H^+$).

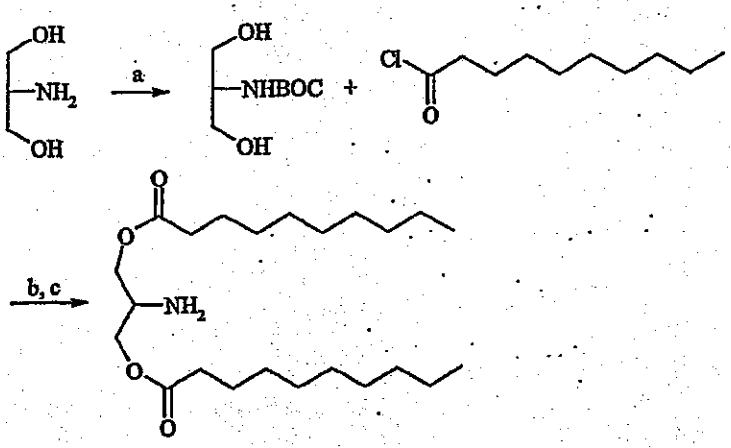
Nonanoic acid Monoglyceride was obtained (85 mg, 34%) as a white solid. mp 37-38.5°C; R_f 0.08 (SiO_2 pretreated with Et_3N, 30% ethyl acetate in hexane); ^1H NMR ($CDCl_3$, 300 MHz) $\delta_H = 4.18$ (m, 2H), 3.94 (m, 1H), 3.69 (m, 1H), 3.62 (m, 1H), 2.36 (t, 2H), 1.62 (m, 2H), 1.28 (m, 10H), 0.88 (t, 3H); MS (FAB^+) m/z = 233 ($M+H^+$).

Example 5: 1,2,3-*O*,*N*,*O*-Tridecanoyl serinol

Serinol (51 mg, 0.56 mmol) was acylated with decanoyl chloride (372 µl, 1.76 mmol) according to General Method B, example 2. Purification by MPLC (SiO_2, eluting with 0 then 10% EtOAc in hexane) gave the desired product as a white solid (301 mg, 97%). mp 54°C; TLC, R_f 0.85 (SiO_2, EtOAc 2:3 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 0.84 (9H, t), 1.20-1.27 (36H, m), 1.52-1.60 (6H, m), 2.13 (2H, t), 2.28 (4H, t), 4.03 (2H, 2 x A of 2 x ABX), 4.19 (2H, 2 x B of 2 x ABX,), 4.41-4.46 (1H, m), 5.70 (1H, d); HRMS m/e calcd for $C_{33}H_{63}NO_5$ 553.4706 Found 553.4713. GC-FID analysis, conditions of the gradient: 100°C-

250°C in 10 minutes, then 250°C for 25 minutes; FID 250°C. Mainly one peak at 14.80 minutes (98%).

Example 6: 1,3-*O*,*O*-Didecanoyl serinol



a) BOC-ON, Et_3N; b) DMAP, CH_2Cl_2; c) HCl.

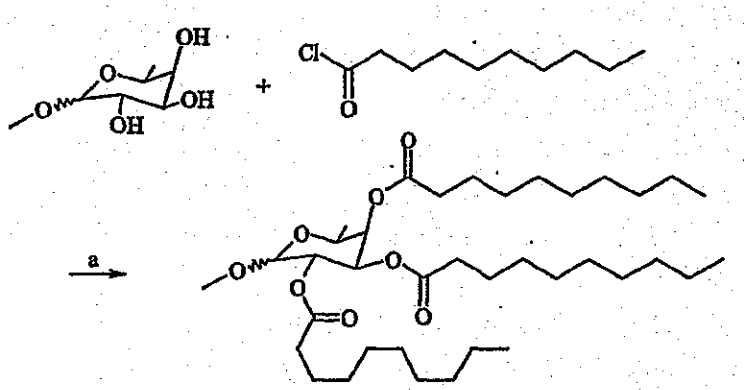
A solution of serinol (1.57 gm, 17.2 mmol) in acetone (17 ml) and water (17 ml), was treated with triethylamine (3.60 ml, 25.9 mmol) and BOC-ON (4.67 gm, 19.0 mmol), and the reaction was stirred under nitrogen overnight. Acetone was evaporated *in vacuo*, and the crude mixture was partitioned between EtOAc and water. The aqueous phase was extracted with EtOAc (x 3), and combined organic extracts were dried over Na_2SO_4, filtered and evaporated *in vacuo*, to give a yellow solid. Purification by MPLC (SiO_2, eluting with 40 to 80% EtOAc in hexane) gave the *N*-BOC-diol intermediate as a white crystalline solid (2.10 gm, 64%). TLC, R_f 0.15 (SiO_2, EtOAc 4:1 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 1.40 (9H, s), 3.54-3.56 (5H, m).

The *N*-BOC-diol intermediate (50 mg, 0.26 mmol) was acylated with decanoyl chloride (173 µl, 0.83 mmol) according to General Method B. Purification by MPLC (SiO_2, eluting with 0 then 10% EtOAc in hexane) gave the *N*-BOC-diacyl intermediate as a colourless oil (115 mg, 88%). TLC, R_f 0.80 (SiO_2, EtOAc 2:3 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 0.87 (6H, t), 1.23-1.30 (24H, m), 1.44 (9H, s), 1.56-1.70 (4H, m), 2.31 (4H, t), 4.04-4.21 (4H, m), 4.77-4.80 (1H, m), 6.73 (1H, d).

A solution of the *N*-BOC-diacyl intermediate (76 mg, 0.15 mmol) in dry CH_2Cl_2 (1.5 ml) was cooled to 0°C, and treated with a solution of 4.0 M anhydrous HCl in

1,4-dioxane (375 µl, 1.50 mmol; final concentration 0.8 M). The reaction was allowed to warm to room temperature, and stirred for 3 hr at the same temperature. A further portion of 4.0 M anhydrous HCl in 1,4-dioxane (375 µl, 1.50 mmol) was added, and the reaction was stirred for a further 2 hr. Evaporation of solvents gave the desired product, as a white solid (69 mg, 100%). mp 101°C; TLC, R_f 0.40 (SiO_2, EtOAc 2:3 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 0.88 (6H, t), 1.20-1.29 (24H, m), 1.55-1.65 (4H, m), 2.45-2.52 (4H, m), 3.72-3.80 (1H, m), 4.30-4.51 (2H, m), 8.6-9.0 (3H, br m); HRMS m/e calcd for (M-HCl), $C_{23}H_{45}NO_4$ 339.3348 Found 339.3340; GC-FID analysis, conditions of the gradient: 100°C-250°C in 10 minutes, then 250°C for 25 minutes; FID 250°C. Mainly one peak at 17.14 minutes (94%).

Example 7: α- and β-1-*O*-Methyl-2,3,4,-*O*,*O*,*O*-tridecanoyl-L-fucopyranose



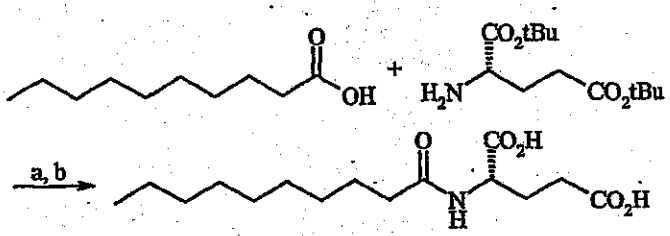
a) DMAP, CH_2Cl_2.

1-*O*-Methyl-L-fucopyranose (593 mg, 3.33 mmol) was synthesised according to the method of Levene & Muskat (J. Biol. Chem. 105:431-441, 1934) and was acylated with decanoyl chloride (2.90 ml, 14.0 mmol) according to General Method B, example 2. Purification by MPLC (SiO_2, eluting with 0 to 5% EtOAc in hexane) gave the α (1.18 gm, 55%) and β (0.52 gm, 24%) of the desired product as a colourless oil.

Data for α anomer: TLC, R_f 0.45 (SiO_2, EtOAc 1:9 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 0.87 (9H, t), 1.14 (3H, d), 1.20-1.35 (36H, m), 1.52-1.68 (4H, m), 2.18 (2H, t), 2.29 (1H, A of ABX_2), 2.32 (1H, B of ABX_2), 2.41 (2H, t), 3.38 (3H, s), 4.13 (1H, qd, *J* 6.5), 4.93 (1H, d), 5.15 (1H, dd, 5.30 (1H, dd), 5.36 (1H, dd); HRMS m/e calcd for (M-CH_3O) $C_{36}H_{65}O_7$ 609.4730 Found 609.4720.

Data for β anomer: TLC, R_f 0.40 (SiO_2, EtOAc 1:9 hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H 0.87 (9H, t, *J* 6.5Hz), 1.22 (3H, d), 1.20-1.35 (36H, m), 1.49-1.67 (4H, m), 2.18 (2H, t), 2.25 (1H, A of ABX_2), 2.29 (1H, B of ABX_2), 2.34 (2H, t), 3.50 (3H, s), 3.81 (1H, qd), 4.35 (1H, d), 5.03 (1H, dd), 5.19 (1H, dd), 5.24 (1H, dd).

Example 8: L-glutamate capramide



a) EDCI, DMAP, iPr_2EtN, CH_2Cl_2; b) HCl/1,4-Dioxane, CH_2Cl_2.

To a solution of capric acid (7.30 mmol, 1.26g) in dry CH_2Cl_2 (60 ml) was added under nitrogen L-glutamic acid di-*t*-butyl ester HCl salt (6.09 mmol, 1.80 gm), DMAP (1.8 mmol, 0.22g), diisopropylethylamine (18 mmol, 3 ml) and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide HCl salt (EDCI) (7.30 mmol, 1.40 gm). The resulting colorless solution was stirred at room temperature for 24 hr. The solvent was then removed under reduced pressure to give a white oily residue. Purification by Biotage™ (40S SiO_2, eluting with 5% ethyl acetate in hexane-30% ethyl acetate in hexane) gave a colorless oil, which was L-glutamate di-*t*-butylester capramide (2.47 gm, 98%). R_f 0.56 (SiO_2, 30% ethylacetate in hexane); ^1H NMR ($CDCl_3$, 300 MHz) δ_H = 6.05 (d, 1H), 4.45 (m, 1H), 2.30 (m, 2H), 2.27 (m, 2H), 2.16 (t, 2H), 2.07 (m, 1H), 1.87 (m, 1H), 1.58 (m, 2H), 1.43 (s, 9H), 1.41 (s, 9H), 1.23 (m, 12H), 0.84 (t, 3H).

Deprotection of the BOC group was achieved by a slow addition of a solution 4.0 M HCl in 1,4-dioxane (23 ml) to a solution of the di-*t*-butyl ester derivative (5.75 mmol, 2.38 gm) in CH_2Cl_2 (35 ml) at 0°C. The colorless solution was allowed to warm to room temperature and stirred for an additional 20 hr. The solvent was then removed under reduced pressure and the resulting white solid was dried to yield L-glutamate capramide (1.71 gm, 99%). mp 95-96.5°C; ^1H NMR (CD_3OD, 300 MHz) δ_H = 4.39 (m, 1H), 3.27 (d, 1H), 2.36 (t, 2H), 2.20 (t, 2H), 2.13 (m, 1H), 1.90 (m, 1H), 1.58 (m, 2H), 1.27 (m 12H), 0.86 (t, 3H); MS (ES^+) *m/z* = 324 ($M+Na^+$), 302 ($M+H^+$); MS (ES^-) *m/z* = 300 ($M-H^+$); HPLC

analysis, conditions: gradient 0.01%TFA in 10%-70% acetonitrile in 10 minutes; flow 1.0 ml/min; 210 nm; 8.93 minutes.

Example 9: Capric Acid N,N-dimethylacetamide ester

To a solution of capric acid (8.7 mmol, 1.5g) in anhydrous DMF (80 ml) under nitrogen was added sodium iodide (0.87 mmol, 130 mg) followed by dimethylchloroacetamide (9.6 mmol, 985 µl). Potassium carbonate (9.6 mmol, 1.3 g) was then added and the resulting suspension stirred at 90°C for 5 days. The reaction was allowed to cool at room temperature, and then was mixed with distilled water. The product was extracted with ethyl acetate (x3). The combined organic phases were washed with aqueous solution of $NaHCO_3$, dried with Na_2SO_4, filtered, and concentrated under reduced pressure. The yellow liquid obtained was purified by Biotage™ (40M, SiO_2, eluting with 25% ethyl acetate in hexane-50% ethyl acetate in hexane). Capric acid N,N-dimethylacetamide ester was obtained (2.03 gm, 92%) as a white powder. mp 42-42.5°C; R_f 0.55 (SiO_2, ethyl acetate); ^1H NMR ($CDCl_3$, 300 MHz) δ_H = 4.64 (s, 2H), 2.92 (s, 3H), 2.91 (s, 3H), 2.38 (t, 2H), 1.62 (qt, 2H), 1.22 (m, 12H), 0.83 (t, 3H); MS (ES^+) m/z = 537 ($2M+Na^+$), 280 ($M+Na^+$), 258 ($M+H^+$).

Example 10: *In vitro* assays of neutrophil apoptosis and survival

Neutrophil survival was measured as described by Lagraoui and Gagnon (Cell. Mol. Biol. 43:313-318, 1997). Neutrophils were obtained from the peripheral blood of healthy volunteers. Blood was submitted to gradient centrifugation with Lympholyte-poly (Cedarlane, Hornby, Canada) followed by hypotonic lysis of contaminating erythrocytes. Cells were suspended in RPMI (Gibco, Burlington, Canada) supplemented with 10% FBS (Hyclone, Logan USA). Final cell preparations consisted of >95% neutrophils as determined by Wright Giemsa staining. Viability was greater than 97% as determined by trypan blue exclusion. Polymorphonuclear leukocytes (PMN) have a short half-life and rapidly undergo characteristic changes indicative of apoptosis. Apoptosis was assessed according to the method described by Nicoletti *et al.*, J. Immunol. Meth. 139:271-279 (1991). Briefly, freshly isolated neutrophils were incubated for 24 hr at 37°C with different concentrations of MCT. After incubation, cells were stained with propidium iodide (PI, Sigma) and analyzed for apoptosis using an XL Flow Cytometer (Coulter). Data were then expressed as the percent of apoptotic cells.

Figure 1 represents a compilation of several experiments in which neutrophil apoptosis was measured in the absence (control) or the presence of various concentrations of MCT. The results indicate that in the presence of MCT *in vitro*, neutrophil apoptosis is inhibited by up to 90% and that the inhibition is dose-dependent. Thus, MCT can increase neutrophil survival and can be used as a neutrophil survival factor.

Example 11: *In vitro* assays of PMN phagocytosis

Neutrophils (2 x 10^6/ml) were incubated for 24 hr, at 37°C in 5% CO_2 and 95% humidity with various concentrations of MCT. After 24 hr, viability was determined by trypan blue exclusion and cells were washed three times with PBS containing 2 mM glucose, 1 mM $MgCl_2$ and 1 mM $CaCl_2$. The cell concentration was then adjusted to 1 x 10^6 cells/ml and then incubated with fluoresbrite carboxylate microspheres (1/10 dilution). After 30 minutes of incubation, neutrophils were washed and fixed in 2% paraformaldehyde. Fixed neutrophils were analyzed for microspheres ingestion using XL Flow Cytometer (Coulter). Data were then expressed as the percent of phagocytic cells.

Figure 2 represents a compilation of several experiments which measure PMN phagocytic activity in the absence (control) or the presence of various concentrations of MCT. The results indicate that MCT enhances the phagocytic activity of human PMN. The phagocytic activity is enhanced up to two to three times from the control values and the extent of the stimulation depends on the immune status of the donor.

Example 12: Effect of Doxorubicin on neutrophil apoptosis

PMN were isolated as described in example 10. Cells (2 x 10^6/ml) were incubated for 4 hr, at 37°C in 5% CO_2 and 95% humidity in the presence of various concentrations of a chemotherapeutic agent, doxorubicin. Apoptotic cells were evaluated as described in example 10. Data are expressed in percent of apoptotic cells. Figure 3A and 3B indicate that doxorubicin induces PMN apoptosis.

Example 13: MCT rescues the doxorubicin-induced apoptosis of neutrophils

PMN were isolated as described in example 10. Cells (2 x 10^6/ml) were incubated for 4 hr, at 37°C in 5% CO_2 and 95% humidity in the presence of various concentrations of doxorubicin with or without MCT (2.5% and 5.0%).

Apoptotic cells were evaluated as described in example 10. Data are expressed in percent of apoptotic cells.

Table 1 represents two experiments measuring the chemoprotective effects of MCT on PMN. Results are expressed in percent of apoptotic cells after 4 hr of incubation in the presence or the absence of doxorubicin with or without MCT. As in example 12, doxorubicin induces PMN apoptosis *in vitro*. However, in the presence of MCT, at a concentration of 2.5% and 5% (v/v), the apoptotic effects of doxorubicin are inhibited. Thus, MCT exerts an anti-apoptotic action on PMN.

Apoptosis was also studied using the annexin V-FITC/PI (propidium iodide) method according to the manufacturer's Biosources recommendations (Apotarget Annexin-VFITC Apoptosis Kit #PHN 1018). Annexin V binds to phosphatidylserine which is transferred from the internal to external membrane in early to late phase apoptosis. Briefly, neutrophils are incubated in the presence or absence of varying concentrations of doxorubicin and MCT. After 24 hr, neutrophils are washed with PBS and stained with 2 µl of Annexin V-FITC and 10 µl of PI (Sigma, 1 mg/ml) for 20 minutes. After incubation, stained cells were fixed in paraformaldehyde (1%) and analyzed for apoptosis using an XL Flow Cytometer (Coulter). Data were then expressed as the percent of apoptotic cells.

Figure 4A represents a time-course response of MCT on doxorubicin-treated neutrophils. MCT rescues human neutrophil doxorubicin-induced apoptosis in a time- and dose-dependent manner.

Figure 4B represents a time-course response of doxorubicin on MCT-treated neutrophils. MCT protects, in a dose-dependent manner, neutrophils against doxorubicin-induced apoptosis up to 4 hr before the introduction of the toxic agent (doxorubicin).

Table 1

Protective effect of MCT on doxorubicin-induced neutrophil apoptosis

Doxorubicin Concentration	% Apoptosis of neutrophils (PMN)					
	Experiment 1			Experiment 2		
	Control	MCT 2.5% (v/v)	MCT 5% (v/v)	Control	MCT 2.5% (v/v)	MCT 5% (v/v)
0	12.4	9.5	12.3	49.6	23.6	4.6
10^{-10} M	9.3	11.7	7.4	60.6	14.7	23.9
10^{-8} M	18.7	14.2	8.3	59.2	32.5	14.8
10^{-6} M	23.2	12.7	3.5	55.0	21.6	16.9
10^{-5} M	23.8	12.3	8.3	66.2	74.7	12.1
10^{-4} M	27.5	35.2	17.1	53.2	58.6	55.7

Example 14: MCT rescues the doxorubicin-induced apoptosis of neutrophils: Comparison to GM-CSF

Table 2 represents the effect of GM-CSF, MCT and tricaprylin on doxorubicin-induced human neutrophil apoptosis. GM-CSF and MCT are able to rescue or protect human neutrophils against doxorubicin-induced apoptosis. Tricaprylin rescues doxorubin-induced apoptosis and further enhances the viability of human neutrophils to a higher extent than that observed in the non-treated neutrophils (control, absence of doxorubicin).

Table 2

Protective effect of MCT and GM-CSF on doxorubicin-induced neutrophil apoptosis

	% PMN Viability
Control	35.9 ± 0.71
Doxorubicin (DOX) (10^{-5} M)	6.82 ± 0.5
GM-CSF (10^{-7} M) + DOX	16.75 ± 2.05
GM-CSF (10^{-8} M) + DOX	6.99 ± 0.23
MCT (24 mM) + DOX	14.20 ± 1.98
MCT (12 mM) + DOX	12.37 ± 1.72
Tricaprylin (24 mM) + DOX	12.13 ± 1.25
Tricaprylin (12 mM) + DOX	42.95 ± 6.15

Example 15: MCT and tricaprin increase *in vitro* murine bone marrow proliferation

Bone marrow cells were obtained from the femur of female C57BL/6 mice (6- to 8-weeks old). Cells were flushed and washed with PBS. Collected cells are centrifuged and resuspended at 2×10^6 cells/ml. 100 µl of cells (2×10^5 cells) are incubated in a 96-well microtiter plate for 48 hr in the presence or absence of MCT or tricaprin. After incubation, cells are pulsed with 1 µCi of [^{3}H]-thymidine for 6 hr. Plates are harvested on a Tomteck and counted on a Microbeta β-counter. Incorporation of [^{3}H]-thymidine in the DNA is a direct indication of the cell proliferation.

Figure 5 represents a typical experiment on the effect of MCT and tricaprin on bone marrow proliferation. MCT and tricaprin increase bone marrow proliferation by 3- to 5-fold relative to the control.

Example 16: Chemoprotection studies: *In vivo* induction of immune cells proliferation or protection by MCT

Female C57BL/6 mice, 6 to 8 week old, were immunosuppressed by treatment with 80 mg 5-fluorouracil (5-FU) or 100-200 mg of cyclophosphamide (CY) or 12 mg of taxotere (TX) administered intravenously at day 0. To examine the immunoprotective effect of MCT or other compounds, mice were pre-treated orally at day -3, -2 and -1 or treated intravenously at day 0 with the test compound. Mice were sacrificed at day +5 by cardiac puncture and cervical dislocation. Then, cell suspensions were prepared from thymus, spleen and bone marrow as follow.

Tissues were crushed in PBS buffer and contaminating erythrocytes were lysed in ACK buffer (155 mM NH_4Cl, 12 mM $NaHCO_3$, 0.1 mM EDTA, pH 7.3) for 5 minutes. Cells were then collected by centrifugation and washed three times in PBS and resuspended in tissue culture medium. Cells were counted on a hemacytometer.

Results show that MCT significantly increases the number of cells in immune tissues of normal and immunosuppressed animals compared to the vehicle alone as shown in the following tables and figures. Depending on the experiments and the immune status of the mice, MCT can increase the bone marrow cell and/or the spleen cell and/or the thymus cell counts.

Figure 6 shows the effect of MCT on bone marrow cell count in immunosuppressed animals. Only CY and 5-FU depressed the bone marrow cell count compared to the control (no cytotoxic treatment). In mouse, taxotere treatment has no significant effect on bone marrow cell count. In suppressed bone marrow, administration of MCT (6.25 µMole per mouse) at day -3, -2 and -1 enhanced significantly the bone cell marrow count.

Figure 7 represents the effect of MCT on spleen cell count in immunosuppressed mice which received the pre-treatment regimen of MCT per o.s. All cytotoxic drugs (CY, 5-FU and TX) reduce significantly the spleen cell count compared to the control. Administration of MCT (6.25 µMole per mouse) at day -3, -2 and -1 significantly increases spleen cell count with "P" less than 0.0017, 0.009 and 0.0036 for CY, 5-FU and TX respectively.

Furthermore, MCT significantly enhances bone marrow cell count in normal mice when administered i.v. at day 0 (table 3). However, one i.v. injection of MCT is not sufficient to improve the spleen cell count in both normal and immunosuppressed mice.

Table 3

Effect of cyclophosphamide (CY) and CY + MCT on bone marrow and spleen cells (normal mice)

	Bone Marrow		Spleen	
	# Cells ($x10^6$)	P	# Cells ($x10^6$)	P
Control	16 ± 3.94		94 ± 11	
CY	13 ± 3.92	0.17	60 ± 12	0.0014
CY + MCT (50 µMole)	17 ± 4.28	0.87	53 ± 10	0.0003
CY + MCT (12.5 µMole)	17 ± 6.15	0.95	51 ± 10	0.0002
MCT (50 µMole)	41 ± 6.11	>0.0001	103 ± 7	0.19
MCT (12.5 µMole)	27 ± 4.19	0.0018	101 ± 11	0.31

Example 17: Chemoprotection studies: *In vivo* dose-response of MCT induction of immune cell proliferation when administered at day-3, -2 and -1 in normal mice

In vivo dose-response of MCT induction of immune cell proliferation in normal mice was assessed by the protocol described in example 16.

Table 4 represents the dose-response on treatment of MCT orally administered at day -3, -2 and -1 in normal mice. MCT significantly increases the bone marrow and spleen cell counts.

Table 4
Effect of MCT on normal mice

	Bone Marrow		Spleen	
	# Cells ($x10^6$)	P	# Cells ($x10^6$)	P
Control	45 ± 7.3		120 ± 12.9	
MCT (3.15 µMole)	52 ± 4.3	0.10	144 ± 15.8	0.018
MCT (6.25 µMole)	59 ± 11.3	0.05	134 ± 13.9	0.129
MCT (12.5 µMole)	54 ± 6	0.04	144 ± 19.8	0.04
MCT (25 µMole)	56 ± 3.9	0.01	127 ± 17.0	0.48

Example 18: Chemoprotection studies: *In vivo* induction of immune cells proliferation or protection: Comparison of the effect of MCT versus GM-CSF

In vivo comparison on the induction of immune cell proliferation/regeneration or protection was undertaken following the protocol described in example 16.

Comparative studies of MCT and GM-CSF were performed on normal and immunosuppressed animals. Compared to MCT, GM-CSF has no significant activity on bone marrow and spleen cell counts in immunosuppressed animals. A significant effect of GM-CSF was observed only on thymus weight in normal mice (figure 8). In this case, MCT displayed a similar effect to GM-CSF.

Example 19: Chemoprotection studies

The effect of caprylic acid and capric acid on *in vivo* induction of immune cell proliferation or protection was assessed by the protocol described in example 16.

As shown in table 5, only capric acid significantly enhances the bone marrow cell counts. No significant effect was demonstrated on spleen cell counts, compared to cyclophosphamide treated mice.

Table 5
Effect of cyclophosphamide (CY), CY + caprylic acid and CY + capric acid on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	54 ± 5.9			66 ± 7.3		
CY	22 ± 5.7	>0.0001		23 ± 4.0	>0.0001	
CY + caprylic acid	26 ± 3.58	0.001	0.21	28 ± 6.4	>0.0001	0.17
CY + capric acid	32 ± 2.71	0.0004	0.006	27 ± 8.4	>0.0001	0.27

Example 20: Chemoprotection studies

The effect of tricaprylin and tricaprin on *in vivo* induction of immune cell proliferation or protection assessed by the protocol described in example 16.

Tricaprylin and tricaprin are both efficacious in the proliferation or protection of bone marrow cell counts in CY-treated mice (table 6). No significant effect was observed on the spleen cell count, compared to cyclophosphamide treated mice.

Table 6
Effect of cyclophosphamide (CY), CY + tricaprylin and CY + tricaprin on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	55 ± 9.3			113 ± 15.9		
CY	22 ± 5.8	0.0001		36 ± 13.6	>0.0001	
CY + tricaprylin	34 ± 7.8	0.0033	0.022	37 ± 12.6	>0.0001	0.8
CY + tricaprin	31 ± 3.8	0.0008	0.012	38 ± 6.8	>0.0001	0.7

Example 21: Chemoprotection studies

The effect of nonanoic acid and lauric acid on in vivo induction of immune cell proliferation or protection assessed by the protocol described in example 16.

Significant increases in proliferation or protection of bone marrow and spleen cell counts were observed with the pre-treatment of lauric acid in CY-treated mice. However, nonanoic acid demonstrates weak (not significant) activity on immune cell counts (table 7) compared to cyclophosphamide treated mice.

Table 7
Effect of cyclophosphamide (CY), CY + nonanoic acid and CY + lauric acid on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	58 ± 11.8			99 ± 22		
CY	32 ± 6.3	0.0016	1.0	24 ± 6	0.0002	
CY + nonanoic acid (6.25 µMole)	36 ± 5.6	0.0044	0.26	28 ± 4	0.0004	0.27
CY + lauric acid (6.25 µMole)	42 ± 7.8	0.0185	0.04	32 ± 5	0.0005	0.03

Example 22: Chemoprotection studies

The effect of trilaurin and trimyristin on *in vivo* induction of immune cell proliferation or protection assessed by the protocol described in example 16. Trilaurin and trimyristin have weak (not significant) activity on bone marrow and spleen cell counts on CY-immunosuppressed mice (table 8).

Table 8
Effect of cyclophosphamide (CY), CY + trilaurin and CY + trimyristin on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	49 ± 7.3			105 ± 23		
CY	27 ± 2.8	0.0014		19 ± 6.5	0.0007	
CY + trilaurin (6.25 µM)	31 ± 6.8	0.0028	0.219	28 ± 19.5	0.0004	0.302
CY + trimyristin (6.25 µM)	31 ± 9.9	0.0067	0.402	15 ± 4.6	0.0007	0.314

Example 23: Chemoprotection studies

The effect of tricaproin and sodium caproate on *in vivo* induction of immune cell proliferation or protection assessed by the protocol described in example 16. Tricaproin and sodium caproate have a weak (not significant) activity on bone marrow and spleen cell counts on CY-immunosuppressed mice (table 9).

Table 9
Effect of cyclophosphamide (CY), CY + tricaproin and CY + sodium caproate on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	48 ± 4.9			98 ± 24.2		
CY	25 ± 4.9	>0.0001		33 ± 13.2	0.0018	
CY + tricaproin (6.25 µMole)	29 ± 4.1	0.0001	0.17	37 ± 8.7	0.0035	0.51
CY + sodium caproate (6.25 µMole)	39 ± 17.9	0.2403	0.09	35 ± 10.6	0.0026	0.77

Example 24: Chemoprotection studies

The effect of sodium caprylate and sodium caprate on *in vivo* induction of immune cell proliferation or protection assessed by the protocol described in example 16.

A significant increase in proliferation or protection of bone marrow cell count was observed with pre-treatment with sodium caprylate and sodium caprate in CY-treated mice (figure 9).

Example 25: Chemoprotection studies: Post-treatment regimens

Chemoprotection studies were performed as described in example 16 except that mice were (post)-treated with MCT, sodium caprylate, sodium caprate or capric acid per o.s. on day 1, 2, 3 and 4.

A significant increase in bone marrow cell count was observed with the post-treatment of MCT, sodium caprylate and sodium caprate in CY-treated mice (table 10). When used as post-treatment, capric acid induces a significant increase in spleen cell count and a weak increase in bone marrow cell count (table 11).

Table 10
Effect of cyclophosphamide (CY), CY + MCT, CY + sodium caprylate and CY + sodium caprate post-treatment on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P	P/CY	# Cells ($x10^6$)	P	P/CY
Control	52 ± 6.17			110 ± 29.3		
CY	19 ± 4.99	>0.0001		30 ± 9.5	0.0007	
CY + MCT (12.5 µM)	26 ± 3.70	>0.0001	0.0189	38 ± 7.2	0.0014	0.163
CY + sodium caprylate (12.5 µM)	26 ± 5.33	>0.0001	0.0455	36 ± 12.5	0.0009	0.394
CY + sodium caprate (12.5 µM)	29 ± 4.45	0.0001	0.0140	28 ± 6.3	0.0007	0.696

Table 11
Effect of cyclophosphamide (CY), CY + capric acid post-treatment on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	48 ± 7.9			88 ± 15.9		
CY	31 ± 6.7	0.0026		21 ± 4.3	0.0001	
CY + capric acid (3.125 µMole)	37 ± 7.8	0.0326	0.209	31 ± 8.7	0.0001	0.035
CY + capric acid (6.25 µMole)	38 ± 4.6	0.0274	0.066	25 ± 6.3	0.0001	0.187
CY + capric acid (12.5 µMole)	38 ± 7.4	0.0412	0.134	36 ± 7.8	0.0002	0.003

Example 26: Chemoprotection studies: Immunophenotyping assay

Female, 6- to 8-week old, C57BL/6 mice were pre-treated on day -3,-2 and -1 per o.s. or intravenously at day 0 with different concentrations of MCT. Immunophenotyping was also performed on immunosuppressed animals. Immunosuppression was achieved with 80 mg/kg of 5-fluorouracil (5-FU) or 100 to 200 mg/kg of cyclophosphamide (CY) or 12 mg/kg of taxotere (TX) injected i.v. on day 0. Mice were sacrificed on day 5 by cardiac puncture. Blood and spleens were collected and cell suspensions prepared and erythrocytes lysed in ACK buffer (155 mM NH_4Cl, 12 mM $NaHCO_3$, 0.1 mM EDTA, pH 7.3) for 5

minutes. The cells were washed three times in PBS, pH 7.4 and resuspended in tissue culture medium. The cells were then incubated for 45 minutes on ice with fluorescein isothiocyanate (FITC) or phycoerythrin (PE) conjugated cell surface marker according to the manufacturer's (Gibco/BRL, Cedarlane, Boehringer Mannheim) recommendation. The cells were then washed in PBS, fixed with 1% paraformaldehyde and analyzed with a Coulter XL flow cytometer. Analysis of the cell subsets was undertaken by determination of standard cell surface markers which were as follows: TCR (T-cell receptor), CD4 (T helper), CD8 (T cytotoxic/suppressor), CD11b (macrophage), NK (NK cells) and Ly5 (B-cells).

Bone marrow cells were obtained as described in example 15. Cells were stained by a 45 minutes incubation of FITC or PE conjugated cell surface marker according to the manufacturer's recommendation. The cells were then washed in PBS, fixed with 1% paraformaldehyde and analyzed with a Coulter XL flow cytometer. Analysis of the cell subsets was undertaken by determination of standard cell surface markers which were as follows: CD34 (hematopoietic progenitor cells), CD41 (platelets, megakaryocytes), CD13 (myelomonocytic stem cells, myelocytes, promonocytes) and CD38 (lymphoid stem cells, pro-B, pre-B). Table 12 represents the effect of MCT on blood and spleen immunophenotyping in normal mice. On blood immunophenotyping, MCT increase CD8+ and LY5+ cell subsets. In some experiments, MCT increases weakly the LY5-TCR- subset (data not shown). On spleen immunophenotyping, MCT increases significantly the relative percentage of LY5+TCR+ and CD4+ cells. LY5-TCR- are non B-non T-cells that may represent the neutrophils.

When administered to immunosuppressed mice, MCT increases the relative percentage of LY5-TCR- (probably neutrophils) and CD11+ (macrophage) cells on blood and spleen immunophenotyping compared to cyclophosphamide alone. These cell subsets originate from the myeloid cell precursor (table 13).

Table 12

Effect of MCT on blood and spleen immunophenotyping in normal mice

Cell subsets	Control	6.25 µM	12.5 µM	50 µM
Blood Immunophenotyping				
CD8+	12.76 ± 1.23	16.41 ± 1.16 p≤ 0.0004	–	13.18 ± 2.08 p = 0.68
LY5+	15.57 ± 6.91	24.0 ± 4.92 p < 0.037	–	26.75 ± 4.11 p < 0.01
Spleen Immunophenotyping				
LY5-TCR-	13.02 ± 2.54	–	16.84 ± 0.83 p < 0.0257	–
CD4+	19.9 ± 1.09	22.25 ± 1.64 p ≤ 0.013	–	22 ± 0.47 p < 0.091

Table 13

Effect of MCT on blood and spleen immunophenotyping in cyclophosphamide (CY, 200 mg/kg) immunosuppressed mice

Cell subsets	CY	6.25 µM	12.5 µM	50 µM
Blood Immunophenotyping				
LY5-TCR-	36.82 ± 9.93	–	51.67 ± 11.10 p≤ 0.05	46.32 ± 5.63 p = 0.1254
CD11+	26.41 ± 4.54	–	42.12 ± 8.77 p < 0.0119	42.56 ± 8.62 p < 0.0098
Spleen Immunophenotyping				
LY5-TCR-	20.2 ± 4.05	23.92 ± 1.61 p < 0.07 (weak)	–	–
CD11+	16.31 ± 4.85	27.47 ± 11.48 p ≤ 0.06 (weak)	–	–

Example 27: Chemoprotection studies: Immunophenotyping assay

Immunophenotyping of trimyristin, trilaurin, capric acid and sodium caproate was undertaken following the protocol described in example 26.

Table 14 represents the effect of these MCT analogues on blood and spleen immunophenotyping. On blood, trimyristin and trilaurin have no significant effect compared to cyclophosphamide alone. However on spleen, trimyristin and trilaurin enhance the relative percentage of CD11+. Furthermore, trilaurin induces a significant increase in the LY5-TCR- and NK+ cell subsets.

Interestingly, capric acid and sodium caproate significantly increase the relative percentage of LY5-TCR- on blood. On spleen, capric acid has no significant effect compared to cyclophosphamide alone.

Table 14

Effect of trimyristin, trilaurin, capric acid and sodium caproate on blood and spleen immunophenotyping in cyclophosphamide (CY, 200 mg/kg) immunosuppressed mice

Compounds	Cell subsets	CY	6.25 μM	12.5 μM
Blood Immunophenotyping				
Trimyristin	No significant effect			
Trilaurin	No significant effect			
Capric acid	LY5-TCR-	56.36 ± 7.26	61.52 ± 5.16 p = 0.189	70.79 ± 3.95 p < 0.0029
Sodium caproate	LY5-TCR-	40.91 ± 8.84	52.43 ± 10.16 p = 0.063 (weak)	–
Spleen Immunophenotyping				
Trimyristin	CD11+	16.31 ± 4.85	42.94 ± 8.45 p ≤ 0.0002	–
Trilaurin	CD11+	16.31 ± 4.85	43.94 ± 4.78 p < 0.0001	–
	LY5-TCR-	73.17 ± 1.41	77.86 ± 2.94 p < 0.0097	–
	NK+	7.53 ± 2.52	17.46 ± 5.80 p < 0.0067	–
Capric acid	No significant effect			
Sodium caproate	Not performed			

Example 28: Chemoprotection studies: Bone marrow immunophenotyping

The effect of MCT, sodium caprylate, sodium caprate on bone marrow immunophenotyping was assessed by the protocol described in example 26. Treatment with cyclophosphamide induces a significant increase in all studied subsets (CD34+, CD13+, CD41+ and CD38+). Addition of MCT or sodium caprylate or sodium caprate amplifies the number of CD13+ lineage which are myelomonocytic stem cells, myelocytes and promonocytes. This increase in the relative percentage of CD13+ is significant compared to cyclophosphamide alone. The results clearly demonstrate that MCT and other related compounds induce a significant increase in the number of bone marrow cells (as exemplified in the previous examples) and further enhance the relative percentage of precursor of

phagocytic cells (PMN and monocytes). This may result in a better recovery from cytotoxic treatment or protection against infectious agents (table 15).

Table 15

Effect of MCT, sodium caprylate and sodium caprate on bone marrow immunophenotyping in cyclophosphamide (CY, 200 mg/kg) immunosuppressed mice

% Cells	CD34+	CD13+	CD41+	CD38+
Control	1.1 ± 0.3	0.8 ± 0.2	1.6 ± 0.2	29.8 ± 6.5
Cyclophosphamide (CY)	10 ± 1.0	3.2 ± 0.5	4.2 ± 0.6	39.6 ± 13.6
CY + MCT	11.2 ± 1.3	4.5 ± 0.5 p<0.001	4.5 ± 0.4	42 ± 15.7
CY + Sodium caprylate	11.2 ±1.3	4.9 ± 1.2 p<0.017	4.6 ± 1.3	36 ± 9.7
CY + Sodium caprate	9.1 ± 3.1	4.7 ± 1.7 p<0.06	3.7 ± 0.7	44.3 ± 22.8

Example 29: Chemoprotection studies

The effect of tridecanoyl serinol and didecanoyl serinol on in vivo induction of immune cell proliferation or protection was assessed by the protocol described in example 16.

As shown in table 16, tridecanoyl serinol significantly enhances the spleen cell counts. No significant effect was demonstrated on bone marrow cell counts.

Table 16

Effect of cyclophosphamide (CY), CY + tridecanoyl serinol and CY + didecanoyl serinol on bone marrow and spleen cells

	Bone Marrow			Spleen		
	# Cells ($x10^6$)	P/Control	P/CY	# Cells ($x10^6$)	P/Control	P/CY
Control	53 ± 4.8			113±15.5		
CY	28 ± 3.4	>0.0001		29 ± 9.2	>0.0001	
CY + tridecanoyl serinol	28 ± 4.6	>0.0001	0.95	42 ± 8.4	>0.0001	0.035
CY + didecanoyl serinol	30 ± 3.8	>0.0001	0.54	36 ± 9.9	>0.0001	0.27

Example 30: Chemoprotection studies

The effect of α-methyl tridecanoyl-L-fucopyranose and β-methyl tridecanoyl-L-fucopyranose on *in vivo* induction of immune cell proliferation or protection was assessed by the protocol described in example 16.

As shown in table 17, β–methyl tridecanoyl-L-fucopyranose demonstrated weak (not significant) activity on bone marrow cell counts compared to cyclophosphamide treated mice. The lack of activity of the α-methyl anomer is expected in view of the known instability of α-alkyl pyranosides.

Table 17
Effect of cyclophosphamide (CY), CY + α-methyl tridecanoyl-L-fucopyranose and CY + β-methyl tridecanoyl-L-fucopyranose on bone marrow

	Bone Marrow		
	# Cells ($x10^6$)	P/Control	P/CY
Control	53 ± 8.0		
CY	26.2± 2.6	0.0058	
CY + α-methyl tridecanoyl-L-fucopyranose	30.4± 9.3	0.0133	0.334
CY + β-methyl tridecanoyl-L-fucopyranose	34.6± 8.5	0.0068	0.061

Example 31: Chemoprotection studies

The effect of ethyl caprate and capric acid N,N-dimethylacetamide ester on *in vivo* induction of immune cell proliferation or protection was assessed by the protocol described in example 16.

As shown in table 18, only capric acid N,N-dimethylacetamide significantly enhances the bone marrow cell count. No significant effect was demonstrated on spleen cell counts.

Table 18
Effect of cyclophosphamide (CY), CY + ethyl caprate and CY + capric acid N,N-dimethylacetamide on bone marrow

	Bone Marrow		
	# Cells ($x10^6$)	P/Control	P/CY
Control	50.2± 4.8		
CY	27.5± 8.0	0.0031	
CY + ethyl caprate	27.5± 4.4	0.0032	1.0
CY + capric acid N,N-dimethyl-acetamide	37.4± 5.9	0.042	0.036

Example 32: Antitumor activity

Female 6-8-week old C57BL/6 mice were injected intravenously on day 0 with 1 x 10^5 B16F10 melanoma cells from ATCC (source of cell culture, Dr. I. J. Fidler). Animals were then injected i.v. with or without MCT (25 µMole/mouse) on day 7, 9, 14 and 16 and 10 mg/kg Doxorubicin on day 10 and 17. Mice were sacrificed on day 22. Body weight and tumor volume were recorded. Serial tumor volume was obtained by bi-dimensional diameter measurements with calipers, using the formula 0.4 (a x b^2) where "a" was the major tumor diameter and "b" the minor perpendicular diameter.

This experiment was conducted to verify if MCT is not exacerbating or protecting the cancer cells rather than immune cells.

Figure 10 represents the chemoprotective effect and anti-tumor efficacy of MCT in combination with a sub-therapeutic concentration of doxorubicin in B16F10 melanoma model. MCT induces a weak reduction (T/C around 20%) of the tumor volume as close as the sub-therapeutic concentration of doxorubicin (T/C around 25% reduction) when used alone. An additive effect is observed when MCT is used in combination with doxorubicin (T/C around 45 to 50%). These results indicate that it is possible to attain therapeutic activity when MCT is combined with a sub-therapeutic concentration of cytotoxic drugs.

Example 33: Antitumor activity

The syngeneic tumor DMBA3 (DA-3, breast carcinoma model) arose from a preneoplastic lesion treated with 7,12-dimethylbenzanthracene in female BALB/c mice. DA-3 cells were grown as monolayer cultures in plastic flasks in RPMI-1640 containing 0.1 mM nonessential amino acids, 0.1 µM sodium pyruvate, 2 mM L-glutamine and 100 µg/ml gentamycin sulfate. This was further

supplemented with 50 μM 2-mercaptoethanol and 10% fetal bovine serum. The DA-3 tumors were serially passage *in vivo* by s.c. inoculation of $5x10^5$ viable tumor cells to produce localized tumors in 6- to 8-week old BALB/c mice. The animals were then serially monitored by manual palpation for evidence of tumor. Serial tumor volume was obtained by bi-dimensional diameter measurements with calipers, using the formula 0.4 ($a \times b^2$) where "a" was the major tumor diameter and "b" the minor perpendicular diameter. Tumors were palpable, in general, 7-10 days post-inoculation.

Two treatment regimens were used for anti-tumor efficacy and protection evaluation of MCT in combination with cyclophosphamide (CY, 100 mg/kg) and taxotere (TX, 20 mg/kg) in the DA-3 tumor model. BABL/c mice were injected with tumor cells on day 0. Treatment with MCT was done per os on day 6, 7 and 8; day 13, 14 and 15; day 20, 21 and 23 followed by treatment with CY or TX administered i.v. as single bolus injection on day 9 and 16. Body weights and tumor volumes were monitored from day 4 until day 23. At day 23, all animals were sacrificed. The % T/C (treatment over control) was calculated as the ratio of tumor volumes at termination date in the treatment group divided by the respective volumes in the control group multiplied by 100. By the NCI criteria the product is considered effective if % T/C is ≤ 40%.

This experiment was performed to verify if MCT is not exacerbating or protecting the cancer cells rather than immune cells. Figure 11 shows the chemoprotective effect and anti-tumor efficacy of MCT in combination with sub-therapeutic concentration of CY and TX in DA-3 breast carcinoma model. MCT induces a weak reduction (T/C around 18%) of the tumor volume compared to the control. When MCT is used in combination with CY or TX, no exacerbation of the tumor volume is observed. However, when used in combination with CY, a therapeutic response is observed (T/C = 39.4%). These results indicate that therapeutic activity may be attained when MCT is combined with a sub-therapeutic concentration of CY. This effect may be due to an overall increase in immune cell efficiency in MCT-treated animals (figure 11 and table 19).

Table 19
Effect of MCT on tumor volume in combination with a sub-therapeutic concentration of cyclophosphamide (CY, 100 mg/kg) and taxotere (TX, 20 mg/kg)

	Tumor volume	Treated/Control (%)
Control	58.8 ± 60.1	
CY	27.5 ± 15.9	46.8
TX	37.9 ± 41.5	64.5
CY + MCT	23.2 ± 13.1	39.4
TX + MCT	38.8 ± 31.0	66.1
MCT	48.5 ± 35.2	82.5

Example 34: Antitumor activity

Antitumor and chemoprotection efficacy were assessed by the protocol described in example 30, with the exception of use of a therapeutic concentration of cytotoxic drugs (cyclophosphamide, 200 mg/kg; taxotere, 30 mg/kg).

This experiment was conducted to verify if MCT is not exacerbating or protecting the cancer cells rather than immune cells. Figure 12 shows the chemoprotective effect and anti-tumor efficacy of MCT in combination with therapeutic concentration of CY and TX in DA-3 breast carcinoma model. MCT induces a weak reduction of the tumor volume compared to the control. When MCT is used in combination with CY or TX, no exacerbation of the tumor volume is observed. When treated with CY or CY+MCT, a significant reduction of the tumor volume is observed. Futhermore, a significant response in reduction of tumor volume is attained with the treatment of MCT combined to TX ($p < 0.0327$) compared to TX alone which is not significant compared to the control mice ($p = 0.1211$) (table 20). These results indicate that a therapeutic activity may be attained when MCT is combined with a non-significant therapeutic concentration of TX. This effect may be due to an overall increase in immune cell efficiency in MCT-treated animals.

Table 20
Effect of MCT on tumor volume in combination with a therapeutic concentration of cyclophosphamide (CY, 200 mg/kg) and taxotere (TX, 30 mg/kg)

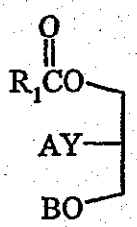
Treatment	T/C (%)	P/Control	P/CY	P/TX
Control				
MCT		0.4299		
CY	18.8	0.0337		
CY-MCT	22.1	0.0022	0.2928	
TX	64.7	0.1211		
TX-MCT	46.7	0.0327		0.5468

All references cited in this document are hereby incorporated by reference herein in their entireties.

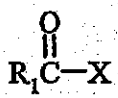
Modifications and variations of the compositions and methods described herein will be obvious to those skilled in the art from the foregoing description. Such modifications and variations are intended to come within the scope of the appended claims.

WHAT IS CLAIMED IS:

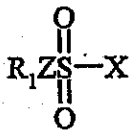
1. A method of stimulating hematopoiesis in a patient in need of treatment, said method comprising administration to said patient of a pharmacologically effective amount of a composition comprising one or more compounds described by formula I, one or more compounds described by formula II, one or more compounds described by formula III, or combinations thereof



I Y = O, NH



II



III Z = O, NH, CH_2O = zero

wherein

R_1 is a straight chained or branched, saturated or unsaturated C7-C11 alkyl group;

A and B are hydrogen or R_1-C(=O)-, and A is not necessarily identical to B; and

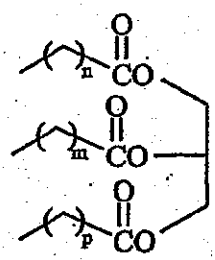
X is a hydroxyl group, an oxy anion with a metallic mono- or dicationic counterion, or an alkoxy group with a straight chained or branched C1-C4 alkyl moiety.

2. The method of claim 1 wherein said composition comprises a mixture of at least two compounds described by formula I, which are Medium Chain Triglycerides (MCTs) wherein A = B = R_1 are straight chained or branched, saturated or unsaturated C7 and C9 alkyl groups, respectively.

3. The method of claim 2 wherein said mixture consists of two triglycerides wherein a first MCT is described by formula I and A = B = R_1 = $CH_3(CH_2)_6$–, and a second MCT is described by formula I and A = B = R_1 = $CH_3(CH_2)_8$–.

4. The method of claim 2 wherein said composition further comprises from 0.1% to 3% each of a third compound described by formula I and A = B = R_1 = $CH_3(CH_2)_4$– and a fourth compound described by formula I and A = B = R_1 = $CH_3(CH_2)_{10}$–.

5. The method of claim 2 wherein said mixture comprises four geometric isomers of C8 and C10 fatty acid triglycerides described by the following formula:



	1	2	3	4
n =	6	6	6	8
m =	6	6	8	8
p =	6	8	8	8

6. The method of claim 1 wherein said composition comprises one or more compounds described by formula II and X is OH, which is a medium-chain fatty acid.

7. The method of claim 1 wherein said composition comprises one or more compounds described by formula III and X is OH.

8. The method of claim 1 wherein said composition comprises one or more compounds described by formula II and X is an oxy anion with a metallic counterion selected from the group consisting of calcium, magnesium, potassium, and sodium.

9. The method of claim 1 wherein said composition comprises one or more compounds described by formula III and X is an oxy anion with a metallic counterion selected from the group consisting of calcium, magnesium, potassium, and sodium.

10. The method of claim 6 wherein said one or more compounds is caprylic acid or capric acid.

11. The method of claim 8 wherein said one or more compounds is sodium caprylate or sodium caprate.

12. The method of claim 8 wherein said one or more compounds is calcium caprylate or calcium caprate.

13. The method of claim 1 wherein said one or more compounds is caprylic acid triglyceride or capric acid triglyceride.

14. The method of claim 1 wherein said one or more compounds has a concentration greater than 1 μM in blood.

15. The method of claim 1 wherein stimulating hematopoiesis treats myelosuppression arising from chemotherapy in said patient.

16. The method of claim 1 wherein stimulating hematopoiesis treats myelosuppression arising from radiotherapy in said patient.

17. The method of claim 1 wherein stimulating hematopoiesis treats chronic neutropenia in said patient.

18. The method of claim 1 wherein stimulating hematopoiesis treats transient neutropenia in said patient.

19. The method of claim 1 wherein stimulating hematopoiesis treats neutropenia in said patient arising from a hematologic disease.

20. The method of claim 1 wherein stimulating hematopoiesis treats drug-induced neutropenia in said patient.

21. The method of claim 1 wherein stimulating hematopoiesis treats neutropenia in said patient arising from a nutritional deficiency.

22. The method of claim 1 wherein stimulating hematopoiesis treats neutropenia in said patient arising from infection.

23. The method of claim 1 wherein stimulating hematopoiesis treats neutropenia in said patient arising from radiotherapy.

24. The method of claim 1 wherein stimulating hematopoiesis heals a wound in said patient.

25. The method of claim 1 wherein stimulating hematopoiesis induces neutrophil mobilization to facilitate bone marrow transplantation in said patient.

26. The method of claim 1 further comprising simultaneous administration of a pharmacologically effective amount of a human colony stimulating factor, wherein the pharmacologically effective amount is reduced in the presence of the one or more compounds.

27. The method of claim 26 wherein the colony stimulating factor is G-CSF or GM-CSF.

28. The method of claim 1 further comprising separate administration of a pharmacologically effective amount of a human colony stimulating factor before and/or after administration of the one or more compounds, but not simultaneous administration.

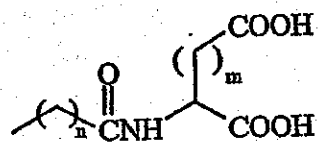
29. The method of claim 28 wherein the colony stimulating factor is G-CSF or GM-CSF.

30. The method of claim 1 further comprising simultaneous administration of a pharmacologically effective amount of a human cytokine.

31. The method of claim 30 wherein the cytokine is interleukin 2 or interleukin 15.

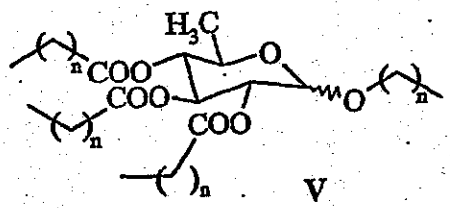
32. A compound comprising an aza analogue of caprylic acid triglyceride or capric acid triglyceride, wherein the aza analogue is 1,2,3-O,N,O-trioctanoyl serinol or 1,2,3-O,N,O-tridecanoyl serinol.

33. A compound described by formula IV in association with one or more optional diluents, carriers and/or excipients and in an amount or dosage sufficient to provide a pharmaceutical formulation



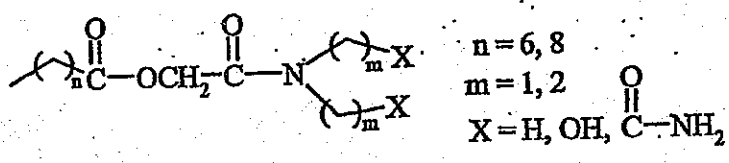
IV

34. A compound described by formula V in association with one or more optional diluents, carriers and/or excipients and in an amount or dosage sufficient to provide a pharmaceutical formulation



V

35. A compound described by formula VI in association with one or more optional diluents, carriers and/or excipients and in an amount or dosage sufficient to provide a pharmaceutical formulation by degradation *in vivo* to release drugs described in claim 1



VI

36. A method of stimulating hematopoiesis in a patient in need of such treatment, said method comprising administration of a pharmacologically effective amount of one or more compounds in accordance with any one of claims 32-35.

37. The method of claim 36 wherein stimulating hematopoiesis treats myelosuppression arising from chemotherapy in said patient.

38. The method of claim 36 wherein stimulating hematopoiesis treats myelosuppression arising from radiotherapy in said patient.

39. The method of claim 36 wherein stimulating hematopoiesis treats chronic neutropenia in said patient.

40. The method of claim 36 wherein stimulating hematopoiesis treats transient neutropenia in said patient.

41. The method of claim 36 wherein stimulating hematopoiesis treats neutropenia in said patient arising from a hematologic disease.

42. The method of claim 36 wherein stimulating hematopoiesis treats drug-induced neutropenia in said patient.

43. The method of claim 36 wherein stimulating hematopoiesis treats neutropenia in said patient arising from a nutritional deficiency.

44. The method of claim 36 wherein stimulating hematopoiesis treats neutropenia in said patient arising from infection.

45. The method of claim 36 wherein stimulating hematopoiesis treats neutropenia in said patient arising from radiotherapy.

46. The method of claim 36 wherein stimulating hematopoiesis heals a wound in said patient.

47. The method of claim 36 wherein stimulating hematopoiesis induces neutrophil mobilization to facilitate bone marrow transplantation in said patient.

48. The method of claim 36 further comprising simultaneous administration of a pharmacologically effective amount of a human colony stimulating factor, wherein the pharmacologically effective amount is reduced in the presence of the one or more compounds.

49. The method of claim 48 wherein the colony stimulating factor is G-CSF or GM-CSF.

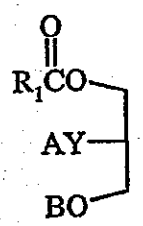
50. The method of claim 36 further comprising separate administration of a pharmacologically effective amount of a human colony stimulating factor before and/or after administration of said one or more compounds, but not simultaneous administration.

51. The method of claim 50 wherein the colony stimulating factor is G-CSF or GM-CSF.

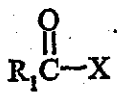
52. The method of claim 36 further comprising simultaneous administration of a pharmacologically effective amount of a human cytokine.

53. The method of claim 52 wherein the cytokine is interleukin 2 or interleukin 15.

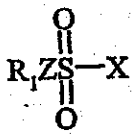
54. Use of one or more compounds for the manufacture of a medicament for stimulating hematopoiesis, said one or more compounds being selected from the group consisting of compounds described by formulae I, II, III and combinations thereof



I Y = O, NH



II



III Z = O, NH, CH_2O = zero

wherein

R_1 is a straight chained or branched, saturated or unsaturated C7-C11 alkyl group;

A and B are hydrogen or R_1-C(=O), and A is not necessarily identical to B; and

X is a hydroxyl group, an oxy anion with a metallic mono- or dicationic counterion, or an alkoxy group with a straight chained or branched C1-C4 alkyl moiety.

55. The method of claim 1 wherein stimulating hematopoiesis treats transient neutropenia in animals arising from stress due to shipping or travel.

56. The method of claim 36 wherein stimulating hematopoiesis treats transient neutropenia in animals arising from stress due to shipping or travel.

57. The use of claim 54, wherein the one or more compounds is a compound of formula II.

58. The use of claim 57, wherein X is OH.

59. The use of claim 57, wherein X is an oxy anion with a metallic counterion selected from calcium, magnesium, potassium and sodium.

60. The use of claim 57, wherein the compound is caprylic acid.

61. The use of claim 57, wherein the compound is capric acid.

62. The use of claim 57, wherein the compound is sodium caprylate or sodium caprate.

63. The use of claim 57, wherein the compound is calcium caprylate or calcium caprate.

64. The use of any of claims 57 to 63, which provides the compound in a concentration greater than 1 μM in blood.

65. The use of claim 64, wherein the concentration is greater than 1 mM.

66. The use of any of claims 57 to 65, wherein the haematopoiesis is in a human patient.

67. The use of claim 66, wherein stimulating haematopoiesis treats myelosuppression arising from chemotherapy in the human patient.

68. The use of claim 66, wherein stimulating haematopoiesis treats myelosuppression arising from radiotherapy in the human patient.

69. The use of claim 66, wherein stimulating haematopoiesis treats chronic neutropenia in the human patient.

70. The use of claim 66, wherein stimulating haematopoiesis treats transient neutropenia in the human patient.

71. The use of claim 66, wherein stimulating haematopoiesis treats neutropenia arising from a haematologic disease in the human patient.

72. The use of claim 66, wherein stimulating haematopoiesis treats drug-induced neutropenia in the human patient.

73. The use of claim 66, wherein stimulating haematopoiesis treats neutropenia arising from a nutritional deficiency in the human patient.

74. The use of claim 66, wherein stimulating haematopoiesis treats neutropenia arising from infection in the human patient.

75. The use of claim 66, wherein stimulating haematopoiesis treats neutropenia arising from radiotherapy in the human patient.

76. The use of claim 66, wherein stimulating haematopoiesis heals a wound in the human patient

77. The use of claim 66, wherein stimulating haematopoiesis induces neutrophil mobilisation to facilitate bone marrow transplantation in the human patient.

78. The use of any of claims 58 to 77, for use with separate or simultaneous administration of a human colony-stimulating factor.

79. The use of claim 78, wherein the colony-stimulating factor is G-CSF or GM-CSF.

80. The use of any of claims 58 to 77, for use with simultaneous administration of a human cytokine.

81. The use of claim 80, wherein the cytokine is interleukin 2 or interleukin 15.