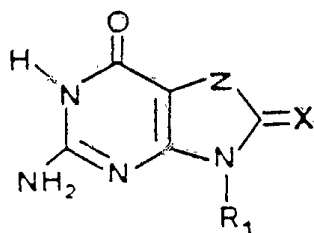


- (54) Title  
**IMMUNOSTIMULATING 7-DEAZA-7-OXA- AND 7-DEAZA-7-THIA- ANALOGS OF 8-SUBSTITUTED-GUANINE-9-(1'BETA-D-ALDOGLYCOSIDYL) DERIVATIVES, COMPOSITIONS AND METHODS**
- (51)<sup>4</sup> International Patent Classification(s)  
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- (56) Prior Art Documents  
AU 24860/88 C07H 19/24 A61K 31/70
- (57) Claim

1. A method of enhancing an immune response comprising contacting leukocytes in an aqueous medium with a composition containing a diluent amount of a physiologically tolerable carrier admixed with an immune response-effective amount of a guanosine analog derivative active ingredient whose structure conforms to that of the formula



wherein

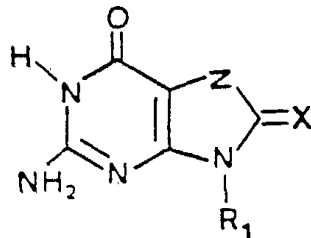
Z is O or S;

X is O, S, Se or NCN; and

R<sub>1</sub> is a beta-bonded D aldoglycoside radical selected from the group consisting of 1'-aldopentosidyl, 1'-aldohexosidyl, mono-deoxygenated-1'-aldopentosidyl, and mono-deoxygenated-1'-aldohexosidyl and their O-substituted lower alkyl, lower alkylidene, lower alkanoyl, benzyl and benzoyl derivatives, and the pharmaceutically acceptable non-toxic, base addition

salts of said guanosine analog derivative; and  
maintaining said contact for a time period  
sufficient for said cells to modulate their response.

9. A guanosine analog derivative whose  
structure conforms to that of the formula



wherein

Z is O or S;

X is O, S, Se or NCN;

R<sub>1</sub> is a beta-bonded D aldoglycoside radical  
selected from the group consisting of 1'-aldopentosidyl,  
1'-aldohexosidyl, mono-deoxygenated-1'-aldopentosidyl,  
and mono-deoxygenated-1'-aldohexosidyl and their  
O-substituted lower alkyl, lower alkanoyl, lower  
alkylidene, benzyl and benzoyl derivates, and the  
pharmaceutically acceptable non-toxic, base addition  
salts of said guanine analog derivative.

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COMMONWEALTH OF AUSTRALIA

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Form 10

COMPLETE SPECIFICATION

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TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:

"IMMUNOSTIMULATING 7-DEAZA-7-OXA- AND  
7-DEAZA-7-THIA-ANALOGS OF  
8-SUBSTITUTED-GUANINE-9-(1'-BETA-D-ALDOGL  
YCOSIDYL) DERIVATIVES, COMPOSITIONS AND  
METHODS"

5007456 15/05/89  
5007456 15/05/89  
The following statement is a full description of this invention,  
including the best method of performing it known to us:-

1193A/bm

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The present invention relates to immune response enhancing compounds (immunostimulants), and more particularly to guanine nucleoside derivatives that are substituted at the 7- and 8-positions of the guanine ring, as well as to compositions containing those derivatives and methods of their use.

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An animal's immune system is comprised of numerous elements that act separately and/or in concert to counteract, to eliminate, or to neutralize substances that are recognized by that system as foreign to the animal host. Generally, but not necessarily, the substance recognized as foreign by the immune system has its origin exogenous to the host. Exemplary of such exogenous substances are infectious bacteria and the by-products of their cellular activity, virus particles and their proteins, proteins injected by insect stings, and the like. In autoimmune diseases, such as rheumatoid arthritis, the host's immune system recognizes host-made proteins or self-made proteins as foreign.

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The principal effectors of the immune system are the leukocytes, which include lymphocytes of thymic origin (T cells), lymphocytes produced in bone marrow (B cells), neutrophils which, inter alia, produce enzymes that make oxidizing agents such as hydrogen peroxide that have cytotoxic effects upon bacteria, and macrophages which present the foreign substance or antigen to the T cells, as well as produce a protein designated interleukin-1 that assists T cell transformation into T helper cells. Complement which is a complex mixture of proteins that acts in an ordered, cascading manner upon the foreign substance also plays a major role in immune responses.

B cells can be distinguished from T cells, inter alia, by the presence of immunoglobulins on their membrane surfaces. The immunoglobulins function as antibodies.

There are five known classes of immunoglobulins, identified as IgA, IgD, IgE, IgG, and IgM on the basis of five antigenically different heavy chain proteins which in part make up the immunoglobulin molecule. B cells also bear non-immunoglobulin cell markers, including a complement receptor (CR), a receptor for the Fc portion of immunoglobulin (FCR), I-region associated antigens (Ia), and a set of differentiation antigens (Lya 1-7) which are identified by all antisera and are correlated with various aspects of B cell maturation and activation. These markers are useful in phenotypically identifying B cells.

While the B cell immunoglobulins act upon the foreign substance, or antigen, the T cells, and particularly helper T cells, are believed necessary to stimulate B cells to divide and to differentiate

into antibody secreting cells for humoral immunity. Suppressor T cells contribute to the regulation of humoral immunity, while cytotoxic T cells and T cell mediators of delayed-type hypersensitivity are the principal effectors of cell mediated immunity.

5

T cells include antigens designated CD4 and CD8 that are related to T cell functions. Helper T cell precursors are of the CD4<sup>+</sup>, CD8<sup>-</sup> phenotype. It is these cells which normally participate in the activation and regulation of B cells.

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Helper T cells are known to assist in activation and differentiation of immunoglobulin-secreting B cells after a first message is received by the B cells from the activating antigenic agent. However, the mode by which the T cells provide the second message for B cell proliferation (or activation) and differentiation to the B cells is a matter of controversy.

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Guanosine-3',5'-cyclic monophosphate (cGMP) has been implicated as a naturally occurring agent for providing the required second message for B cell proliferation. 8-Bromoguanosine-3',5'-cyclic monophosphate (8-BrcGMP) has been found to be a weak synthetic intracellular lymphocyte mitogen.

25

The immune response can be modified by artificial supression (immunosuppression) or enhancement (immunopotentialion or immunostimulation). Immunosuppression; i.e., artificially induced decreased responsiveness, can be achieved by six general methods: (1) administration of antigen, (2) administration of specific antisera or antibody, (3) use of other biologic reagents such as antilymphocyte antisera, (4) use of drugs or hormones, (5) radiation, and (6) surgical removal of

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lymphoid tissue. Immunopotentialion can include the administration of an agent effecting an increase in the rate at which the immune response develops, an increase in the intensity or level of the response, a prolongation of the response, or the development of a response to an otherwise non-immunogenic substance.

The agents that are known to enhance immune responses are generally termed adjuvants and can be placed into two general categories: (1) those providing general potentiation; i.e., substances that enhance both cellular and humoral immune responses for a wide variety of antigens, and (2) those providing specific potentiation, i.e., substances which enhance specific responses to certain antigens only.

Substances that can act as adjuvants can be grouped into the following categories: (1) water and oil emulsions, e.g., Freund's adjuvant, (2) synthetic polynucleotides, (3) hormones, drugs and cyclic nucleotides, (4) endotoxins, (5) proteinaceous lymphokines and monokines such as the interleukins.

A substance capable of specifically potentiating the immune response is transfer factor, a dialyzable leukocyte extract (DLE) obtained from human peripheral leukocytes. It has been reported that the transfer factor exhibits some effectiveness in patients with immunodeficiencies and possible effectiveness in cancer patients and in patients with limited immunodeficiencies. However, much remains to be learned about this particular substance.

In some diseases and physiological conditions such as AIDS, X-linked agammaglobulinemias, senescence and drug-induced-immunosuppression, B cell activation and differentiation is lacking and/or exists only at a

reduced level, thereby lessening the immune response of the host. These diseases and conditions are representative of immunosuppressed states. Here, enhanced activation and differentiation, if it can be effected, tends to beneficially lessen the disease manifestation and/or improve the patient's condition.

An immunopotentiated state can be illustrated by the bodily condition after vaccination. Here, the immune response is already enhanced due to an antigenic response, but could be beneficially enhanced still further to provide an improved degree and/or duration of immunity.

Co-assigned U.S. Patent No. 4,539,205 to Goodman and Weigle describes modulation of animal cellular responses with 8-substituted guanine derivatives bonded 9-1' to an aldose having 5 or 6 carbon atoms in the aldose chain (ring). The cellular modulations described in that patent relate mostly to immunomodulation such as adjuvanticity in producing primary and secondary immune responses. Activity against certain neoplastic conditions is also disclosed as are T cell-replacing activity, an IL-1 like activity on thymocytes, and induction of the release of lysosomal enzymes from neutrophils. The 8-substituents in those molecules have electron withdrawing inductive effects relative to hydrogen. Thus, halo, mercapto or its thioxo tautomer, acyl mercapto, alkyl sulfido, nitro, cyano, keto, halomethyl and methyleneoxy alkyl and the like were disclosed as useful, while electron donating substituents such as an amino group were found to be inactive.

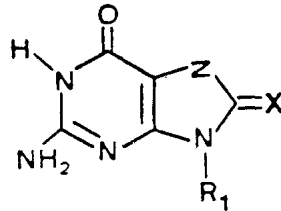
In addition, co-assigned U.S. Patent No. 4,643,992 and its corresponding published European patent application No. 83306791.1 further disclose

the use of derivatives of 8-hydroxyguanine (8-oxoguanine), 7-methyl-8-oxoguanine and 7-methyl-8-thioxoguanine in modulating animal cellular responses. Further results using guanine derivatives disclosed in U.S. Patent No. 4,539,205 are also disclosed in U.S. Patent No. 4,643,992, as are similar results using guanine derivatives disclosed for the first time in that patent.

Still further, several papers and book chapters have been published by some of the present inventors and their co-workers relating to still further effects of compounds disclosed and claimed in U.S. Patent No. 4,643,992. Exemplary of those published papers are Goodman, Proc. Soc. Exp. Biol. Med., 179:479 (1985); Goodman, J. Immunol., 136:3335 (1986); Goodman and Weigle in Purine Metabolism In Man, Part B, Nyhan and Thompson, eds., Plenum Press, New York, page 451 and 443 (1986); Goodman and Weigle, J. Immunol., 135:3284 (1985); Goodman, J. Immunol., 136:3335 (1986); Goodman, J. Immunol., 137:3753 (1986); and Goodman and Hennen, Cell. Immunol., 102:395 (1986).

Brief Summary of the Invention

The present invention contemplates compounds, compositions utilizing a compound, and methods using such a composition. The compounds are 7-deaza-7-oxa- or 7-deaza-7-thia-analogs of 8-substituted-guanine-9-(1'-beta-D-aldoglycosidyl) derivatives, aldoglycosidyl O-substituted lower alkyl, lower alkylidene, lower alkanoyl, benzyl and benzoyl derivatives, and their pharmaceutically acceptable, non-toxic base addition salts. The compounds have a structure that corresponds to Formula I, below.



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I

wherein Z is oxygen (O) or sulfur (S); X is oxygen (O), sulfur (S), selenium (Se) or cyanimino (NCN); and R<sub>1</sub> is an aldoglycoside or derivative that is described hereinafter, as well as the pharmaceutically acceptable, non-toxic base addition salts thereof.

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Animal immune responses are enhanced by contacting leukocytes in an aqueous medium with a composition containing a diluent amount of a physiologically tolerable carrier admixed with an effective amount of a compound of the invention. The contact between the cells and the composition is maintained for a period of time sufficient for the contacted leukocytes to manifest enhancement of their immune response.

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Enhancement of immunogen(antigen)-specific humoral immune responses resulting in adjuvanticity that provides enhanced antibody secretion in the presence of immunogen, is a particular example of an immune response that can be enhanced in accordance with the present invention.

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An immune response-enhancing composition of this invention can be used to provoke differing, although related results depending, inter alia, upon

the manner of administration, dosage and the cell population to which it is administered. The active ingredient guanosine analog derivative is present in the composition admixed in the carrier as a  
5 suspension of solid guanosine analog derivative in a solid or liquid carrier, or as a dissolved solute in the carrier.

Contacting leukocytes such as B lymphocytes with a composition of this invention and maintaining  
10 that contact for a predetermined period of time enhances the immune response of those leukocytes. Enhancement of B lymphocyte (B cell) responses can be effected by treating B cells with an effective amount of the immunogen to form immunogen-primed B cells,  
15 followed by contacting the B cells with the immune response-enhancing composition and a further effective amount of immunogen. B cell immune responses can also be modulated by contacting the B cells with a priming immunogen and an immune  
20 response-enhancing composition of this invention followed thereafter by contacting those cells with an additional effective amount of the immunogen alone, or with a further amount of immune response-enhancing composition. In addition, an immune  
25 response-enhancing composition can be administered to contact the animal cells and thereafter followed, while the guanosine analog derivative is in contact with the animal cells; i.e., present in vivo or in vitro, with one or more immunizing doses of an  
30 immunogen. These immune response enhancements are within those effects referred to as adjuvanticity; i.e., the guanosine analog derivative acts as an adjuvant for the immunogen, and thus provides an immunogen- or antigen-specific modulation.

The methods of this invention can be used on cells in vivo as well as in vitro to cell cultures. The compositions can be administered subcutaneously, intravenously intraperitoneally in a liquid form, or perorally as in pill or capsule form, or in liquid form as a slurry, suspension or solution.

The present invention has several benefits and advantages.

One benefit of the present invention is that its compounds are effective in providing an enhanced response at a given dose.

An advantage of the invention is that use of one of its compositions can provide the second message required for B lymphocyte activation and differentiation in response to a first (antigenic) message.

Another benefit of the invention is that an enhanced immune response can be effected in both the presence and absence of T helper cell activity. Thus, an enhanced immune response is noted in both T cell-dependent and T cell-independent systems.

Another advantage of this invention is that particular immune-suppressed or immune-deficient conditions and disease manifestations can be improved and/or lessened by use of the invention.

Still further benefits and advantages of the invention will be apparent to those skilled in the art from the discussion that follows.

Anthropomorphic descriptions such as the sending and receiving of messages by and to chemicals and cells are used herein for descriptive purposes as aids to the understanding of observed phenomena.

Detailed Description of the Invention

I. Introduction

The present invention contemplates an immune response-enhancing agent (immunostimulator) that stimulates the immune system of the host mammal to which it is administered as well as stimulating leukocytes in cell culture. The immunostimulation particularly contemplated is predominantly antigen-specific for the immunizing antigen.

In studying the effects of some reportedly mitogenic guanosine derivatives, e.g., guanosine 3',5'-cyclic monophosphate and its 8-bromo derivative, it was found that a new class of low molecular weight guanine nucleoside derivatives, when present in an effective amount as the active ingredient of a composition containing a diluent amount of a physiologically tolerable carrier, provided remarkable effects in modulating responses of mammalian cells. Enhancement of antigen-specific humoral immune responses, which resulted in potent adjuvanticity, T cell replacing factor-like activity and immunoreconstitution activity are particular examples of the cellular responses that were found to be modulated. Those compounds and their methods of use are disclosed in U.S. Patents No. 4,539,205 and No. 4,643,992.

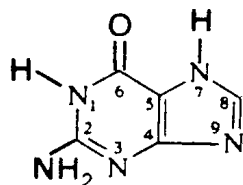
II. The Compounds

7-Deaza-7-thia- and 7-deaza-7-oxa-analogs of 8-substituted-guanosine Derivatives

1. Guanosine Analogues

A compound of the present invention is a derivative of an analog of guanine. Guanine is itself a purine derivative that has a structure that corresponds to formula II, below, wherein the numerals identify ring numbering positions.

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A compound of the present invention contains an oxygen or sulfur atom (O or S) substituted for the 7-position imino nitrogen of a guanine, and therefore can be referred to as a guanine analog. Such compounds can also be referred to as 7-deaza-7-oxa- and 7-deaza-7-thiaguanines, respectively.

20

A compound of the present invention also contains a divalent radical (=O, =S, =Se or =N-CN) substituted for the hydrogen (H) at the 8-position of guanine, and further includes an aldoglycoside bonded to the 9-position. A guanine analog bonded 9,1'-beta to a ribosyl group can be referred to as a guanosine analog derivative.

25

The phrase "guanosine analog derivative" is used herein generically to include compounds that have aldoglycoside radicals in place of ribosyl radicals, as well as those that contain ribosyl radicals. Specific compounds are given appropriate names.

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## 2. Aldoglycosides

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The 9-aldoglycoside portion (R<sub>1</sub>) of the useful guanosine analog derivatives are cyclic, contain 5 or 6 carbon atoms, and are selected from the group consisting of 1'-aldopentosidyl,

1'-aldohexosidyl, mono-deoxygenated-  
1'-aldopentosidyl, and mono-deoxygenated-1'-  
aldohexosidyl radicals. The useful aldoglycosides  
are bonded to the 9-position of the guanine analog,  
5 respectively, and are of the D configuration. The  
aldoglycosides are free from electric charge at  
physiological pH values and are therefore free from  
carboxy, phosphate and quaternary ammonium  
substituents.

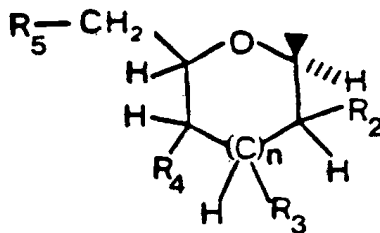
10 Exemplary 1'-aldopentosidyl radicals are the  
1'-radicals of ribose, arabinose, lyxose and xylose  
that are named 1'-ribofuranosidyl,  
1'-arabinofuranosidyl, 1'-lyxofuranosidyl, and  
1'-xylofuranosidyl radicals, respectively. Exemplary  
15 1'-aldohexosidyl radicals are the 1'-radicals of  
glucose, galactose, mannose, gulose, allose, altrose,  
and rhamnose that are named 1'-glucopyranosidyl,  
1'-galactopyranosidyl, 1'-mannopyranosidyl  
1'-gulopyranosidyl, 1'-allopyranosidyl,  
20 1'-altropyranosidyl, 1'-rhamnopyranosidyl, radicals,  
respectively. An exemplary mono-deoxygenated  
1'-aldopentosidyl radical is that of deoxyribose that  
is named the 1'-(2'-deoxy)-ribofuranosidyl radical.  
An exemplary mono-deoxygenated 1'-aldohexosidyl  
25 radical is that of deoxyglucose, named the  
1'-(2'-deoxy)glucopyranosidyl radical.

Useful aldoglycosidyl radicals can have one  
or more hydroxyl groups esterified by a lower  
alkanoyl radical such as formyl, acetyl, propionyl or  
30 hexanoyl (lower alkanoyloxy radicals), and also by a  
benzoyl radical. Aldoglycosidyl radicals are also  
useful when etherified by lower alkyl, especially  
methyl and ethyl radicals (lower alkoxy), benzyl  
radicals, and lower alkylidene radicals.

35 2'-Deoxyaldoglycosides are also useful as esters and  
ethers.

Suitable aldoglycosidyl radicals conform to the formula

5



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wherein n is one or zero, such that when n is zero the =CHR<sub>3</sub> group is absent and the aldoglycoside is an aldopentosidyl radical, whereas when n is one, the aldoglycoside is an aldohexosidyl radical;

R<sub>2</sub> is hydrogen, hydroxy, lower alkoxy such as methoxy, ethoxy and the like, benzyloxy, lower alkanoyloxy such as formyloxy, acetoxy (and the like, or benzoxy.

R<sub>3</sub> when present, as well as R<sub>4</sub> and R<sub>5</sub>, all are preferably the same. These radicals can be hydroxy, a lower alkyl ether (lower alkoxy) such as methoxy and ethoxy, a benzyl ether (benzyloxy), a lower alkanoyl radical (lower alkanoyloxy) such as formyloxy, acetoxy, or a benzoate ester (benzoxy). When R<sub>2</sub> is other than hydrogen, it is preferred that R<sub>2</sub> = R<sub>3</sub> (when present) = R<sub>4</sub> = R<sub>5</sub>. Thus, an O-substituent, (when present on one oxygen is preferably present on all available ring substituent oxygens.

In another embodiment, when n = 0 (R<sub>3</sub> is absent) and R<sub>2</sub> and R<sub>4</sub> are in a cis configuration, as in ribose, R<sub>2</sub> and R<sub>4</sub> can together form a lower

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alkylidenedioxy radical. A lower alkylidenedioxy radical is a ketal or acetal formed from a lower alkyl ( $C_1-C_6$ ) ketone or aldehyde, respectively. A particularly preferred lower alkylidenedioxy radical is formed from acetone and is referred to as isopropylidene. When  $R_2$  and  $R_4$  together form a lower alkylidenedioxy radical,  $R_5$  is preferably hydroxy, lower alkanoyloxy or benzoxy.

As used herein, the term "lower" used in conjunction with "lower alkoxy", "lower alkyl", "lower alkanoyloxy" or "lower alkanoyl" relates to a  $C_1-C_6$  alkyl derivative. Lower alkoxy radicals include methoxy, ethoxy, iso-propoxy, cyclopentoxy, hexyloxy and the like, whereas lower alkanoyloxy radicals include formyloxy, acetoxy, propionyloxy, butanoyl, cyclopentanoyloxy, hexanoyloxy, and the like.

The bonds of the above formula are not intended to convey any particular stereo specific configuration, except at the 1'-position at which the beta anomer is indicated, and that the D form of the aldoglycoside is contemplated.

In preferred practice, the aldoglycosidyl radical is selected from the group consisting of 1'-ribofuranosidyl, 1'-glucopyranosidyl, and 1'-(2'-deoxy)ribofuranosidyl radicals. Thus, preferably, when  $n$  is zero and  $R_2$ ,  $R_4$  and  $R_5$  are all hydroxy,  $R_3$  is absent, the aldoglycosidyl radical is selected from the group consisting of 1'-ribofuranosidyl; when  $n$  is zero,  $R_2$  is hydrogen and  $R_4$  and  $R_5$  are hydroxy,  $R_3$  is absent, the aldoglycosidyl radical is 2'-deoxy-1'-ribofuranosidyl; and when  $n$  is 1, and  $R_2 = R_3 = R_4 = R_5 =$  hydroxy, 1'-glucopyranosidyl is an aldoglycosidyl radical.

As already noted, the aldoglycoside is bonded from its 1'-position to the 9-position of a guanosine analog derivative. When named as a guanosine analog derivative, that bonding can be described as a 9-1' bond. The beta anomer of the aldoglycoside is that preferred herein, although mixtures of alpha and beta anomers are also useful.

3. Exemplary Immune Response-Enhancing Agents

Structural formulas of exemplary immune response-enhancing agents of the invention that are useful in a composition and method of this invention are shown below, wherein X, Z and R<sub>1</sub> are as shown in Table 1 following the structural formulas.

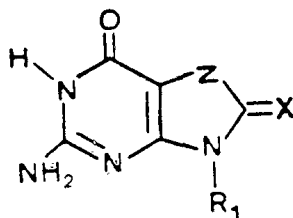


Table 1

	<u>Z</u>	<u>X</u>	<u>R<sub>1</sub></u>
	O	O	1'-ribofuranosidyl
	O	O	1'-lyxofuranosidyl
	O	O	1'-glucopyranosidyl
	O	O	1'-(2'-deoxy)ribofuranosidyl
30	S	O	1'-gulopyranosidyl
	S	O	1'-allopyranosidyl
	S	O	1'-xylofuranosidyl
	S	O	1'-(2',3',4',6'-tetra-O-methyl)gulopyranosidyl
35	S	S	1'-ribofuranosidyl

	S	S	1'-allopyranosidyl
	S	S	1'-(2',3',5'-tri-O-benzoyl)- galactopyranosidyl
	O	S	1'-mannopyranosidyl
5	O	S	1'-ribofuranosidyl
	O	S	1'-(2',3',4',6'-tetra-O- benzyl)altropyranosidyl
	O	Se	1'-ribofuranosidyl
	O	Se	1'-lyxofuranosidyl
10	O	Se	1'-glucopyranosidyl
	O	Se	1'-(2'-deoxy)ribofuranosidyl
	S	Se	1'-gulopyranosidyl
	S	Se	1'-allopyranosidyl
	S	Se	1'-xylofuranosidyl
15	S	Se	1'-(2',3',4',6'-tetra-O- methyl)gulopyranosidyl
	O	NCN	1'-ribofuranosidyl
	O	NCN	1'-allopyranosidyl
	O	NCN	1'-(2',3',5'-tri-O-benzoyl)- galactopyranosidyl
20	O	O	1'-(2',3'-isopropylidenyl)- ribofuranosidyl
	S	O	1'-(2',3'-isopropylidenyl)- ribofuranosidyl
25			

The 8-substituent of 7-deaza-7-oxa- and 7-deaza-7-thiaguanosine analog derivatives is preferably oxo, whereas a 7-deaza-7-oxaguanosine analog derivative is preferred over a 7-deaza-7-thiaguanosine analog derivative.

Particularly preferred compounds include 7-deaza-7-oxa-8-oxoguanosine or 7-deaza-7-oxa-8-oxo-9-(1'-beta-D-ribofuranosidyl)guanine; 7-deaza-7-oxa-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine; 7-deaza-7-oxa-8-oxo-9-(1'-beta-D-glucopyranosidyl)guanine;

7-deaza-7-thia-8-oxoguanosine or 7-deaza-7-thia-8-oxo-9-(1'-beta-D-ribofuranosidyl)guanine; 7-deaza-7-thia-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine; and 7-deaza-7-thia-8-oxo-9-(1'-beta-D-glucopyranosidyl)guanine.

5           A useful guanosine analog derivative is substantially free from ionic charge at physiological pH values; i.e., about pH 7.0 to about pH 7.5, except for the ionic charges that might be provided by the relatively acidic 1-position ring nitrogen atom.

10          Thus, a useful molecule is free of acid and base-containing moieties that are not present in guanosine. That freedom from acidic and basic groups extends from the R<sub>1</sub> radical, and throughout the whole guanosine molecule.

15           The guanosine analog derivatives are acids, and as such can form base addition salts. Such salts are useful in providing storage stability and do not provide an added ionic charge to a guanosine analog derivative used in a method of the invention because  
20          of the buffering effect provided by the host's blood and lymph systems or the buffer of a culture medium.

            Pharmaceutically acceptable, non-toxic base addition salts of guanosine analog derivatives are useful herein, and can be formed by treatment of the  
25          immune response-enhancing agent with an appropriate base, in a suitable solvent such as water or a lower alkyl alcohol such as methanol or ethanol. Exemplary inorganic bases include sodium hydroxide, potassium hydroxide, ammonium hydroxide and the like.

30          Exemplary organic bases include tris-(hydroxymethyl)-aminomethane (TRIS), 4-(2-hydroxyethyl)-1-piperazine-ethanesulfonic acid (HEPES) and the like bases. Conversely, the base addition salt form can be converted to the free guanosine form by treatment  
35          with acid.

#### 4. Syntheses

The substituted guanosine analog derivatives useful herein are readily prepared by procedures analogous to those published in the chemical literature. Exemplary syntheses are provided hereinafter in the Materials and Methods Section.

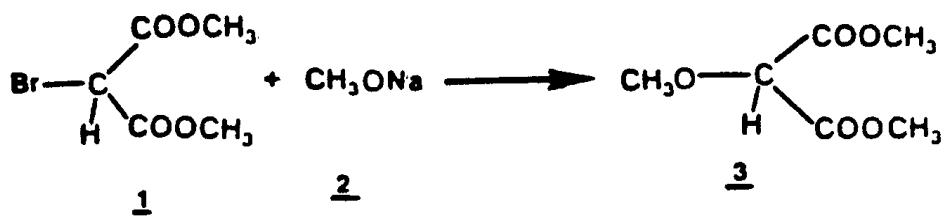
Those exemplary reactions follow the course of reaction Schemes I and II that are pictured below. It is noted that abbreviated structures are utilized in those schemes for added clarity in presentation. However, those abbreviated structures are well known by those skilled in the art of organic synthesis.

In addition, the reaction closing the 5-membered ring to form an 8-oxo or 8-thioxo derivative is shown for the oxo derivative with the reagent for forming the thioxo substituent shown in parentheses. Once the 5-membered ring is shown as closed, the sulfur atom, S, that could alternatively occupy the 8-position is shown in brackets.

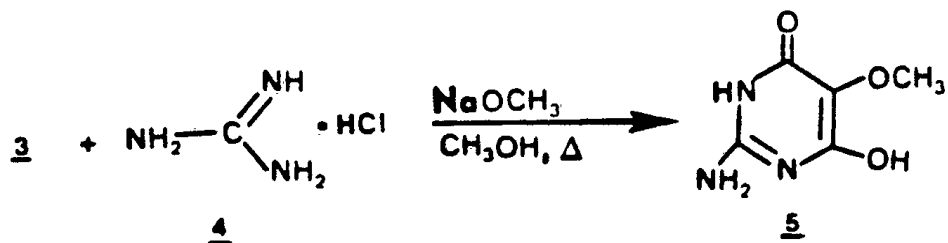
Still further, compounds whose synthesis are not specifically discussed in the Materials and Methods section are either commercially available or their syntheses are discussed in one or more publications.

Scheme I

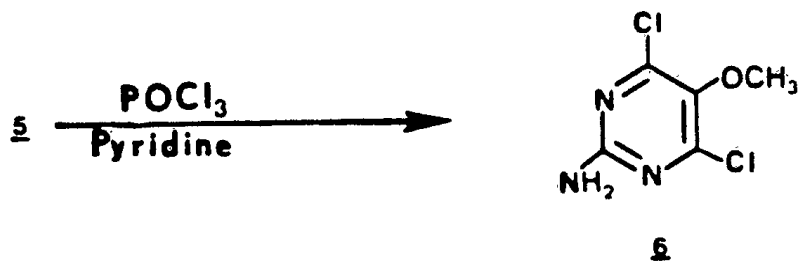
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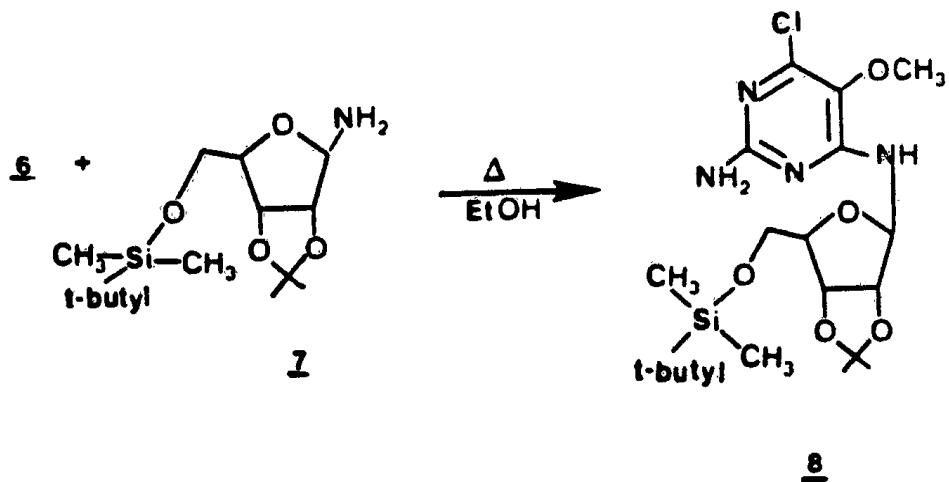
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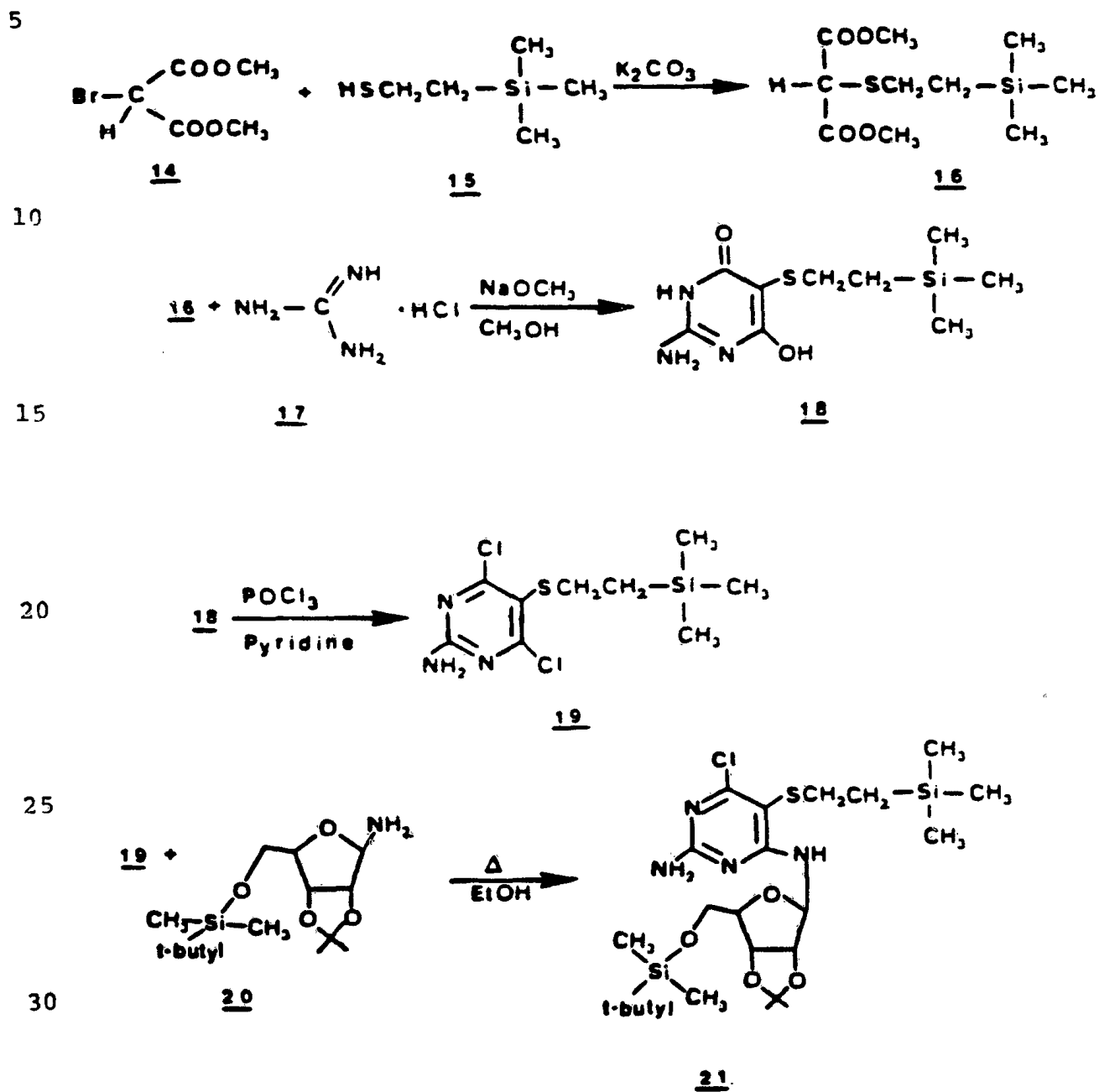
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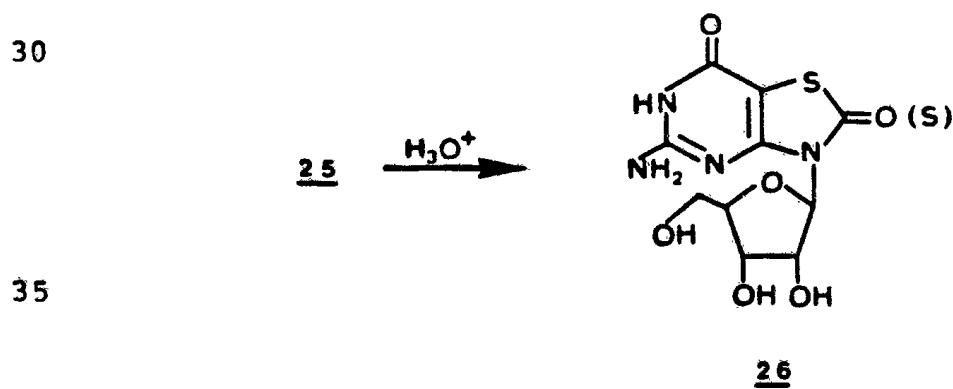
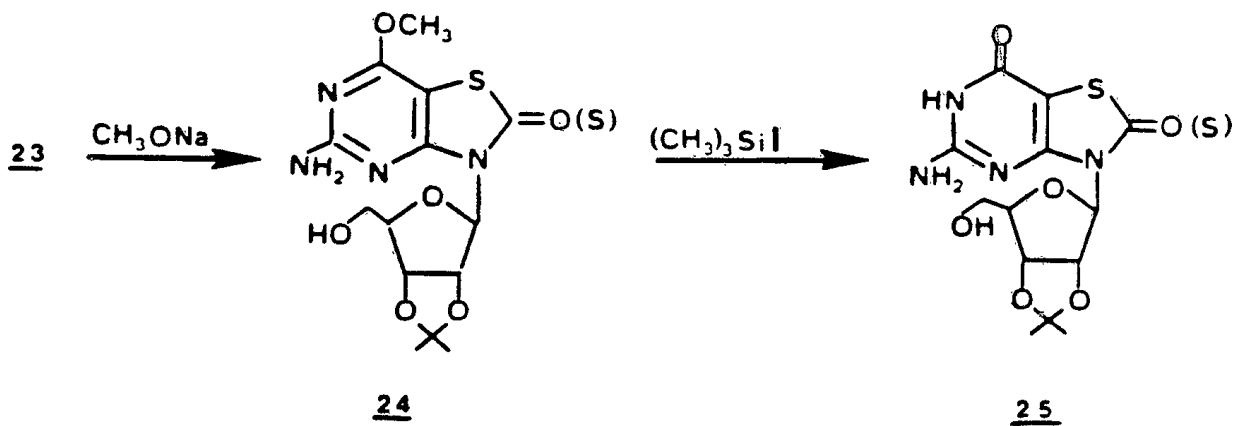
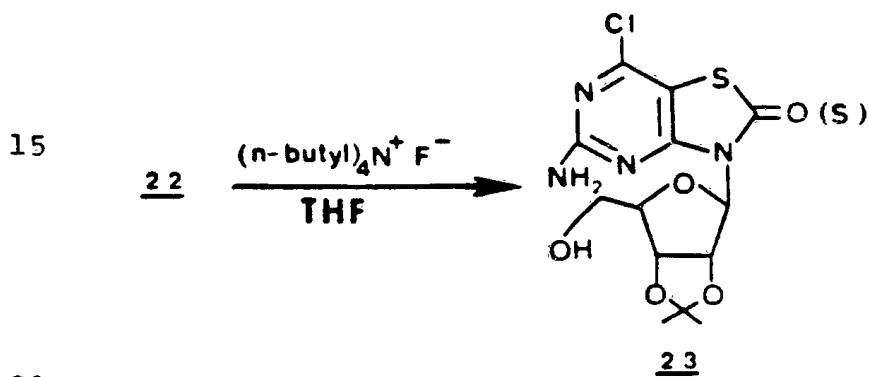
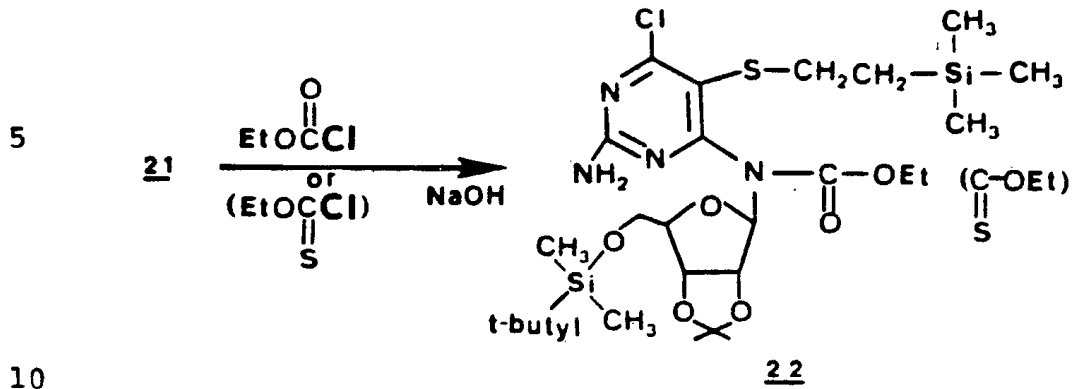
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35




Scheme II





$\Delta$  = heat to reflux;

t-butyl = tertiary-butyl;

 = isopropylidenedioxy;

Et = ethyl;

5 EtOH = ethanol;

THF = tetrahydrofuran; and

nBu = normal butyl.

10 The 8-selenoxo and 8-cyanimino derivatives  
are prepared from the corresponding 8-thioxo  
derivatives. Here, the 8-thioxo compound is first  
alkylated as with methyl iodide, and the thionium  
salt so formed is thereafter reacted with sodium  
selenide or with cyanamide and sodium hydride to form  
15 the respective 8-selenoxo or 8-cyanimino  
derivatives.

### III. The Compositions

20 A composition of this invention comprises a  
diluent amount of a physiologically tolerable carrier  
(also referred to herein as a vehicle or diluent)  
admixed with an immunopotentiating (immune  
response-enhancing or immunostimulating) effective  
amount of a guanosine analog derivative or salt of  
25 this invention described before.

A composition for in vivo administration is  
typically provided for per oral or parenteral  
administration in customary unit dosage  
compositions. The term "unit dosage" and its  
30 grammatical equivalents as used herein refer to  
physically discrete units suitable as unitary dosages  
for human patients and other mammals, each unit  
containing a predetermined effective amount of the  
guanosine analog derivative active ingredient  
35 calculated to produce the desired therapeutic effect

in association with the required physiologically tolerable carrier, e.g. a diluent or a vehicle. The specifications for the novel unit dosage forms of this invention are dictated by and are directly dependent on (a) the unique characteristics of the active guanosine derivative ingredient and the particular therapeutic effect to be achieved, and (b) the limitations inherent in the art of compounding such an active ingredient for therapeutic use in vitro, as well as in vivo in humans and other animals.

Examples of suitable unit dosage forms in accord with this invention are tablets, capsules, pills, powder packets, granules, wafers, and the like, segregated multiples of any of the foregoing, as well as liquid solutions, emulsions and suspensions. Liquid compositions can be administered in usual manners such as subcutaneously, intraperitoneally, intramuscularly, perorally or the like.

The amount of active ingredient that is administered in vivo as an effective immunostimulating amount depends on the age and weight of the patient, the particular condition to be treated, the frequency of administration, and the route of administration. The total daily dose range can be about 0.01 to about 200 milligrams per kilogram of body weight, more preferably about 0.1 to about 25 milligrams per kilogram of body weight, and most preferably about 1 to about 15 milligrams per kilogram of body weight. The human adult dose is in the range of about 5 to about 1400 milligrams daily, given either as a single dose or in 3 or 4 divided doses. Veterinary dosages correspond to human dosages with the amounts administered being in

proportion to the weight and metabolic rate of the animal as compared to adult humans.

5 It will be appreciated by those skilled in the art that useful in vivo concentrations can vary from animal species to animal species. Those skilled workers also know that appropriate concentrations can be readily determined.

10 Concentrations for the in vitro contacting of animal cells are about  $1 \times 10^{-6}$  molar to about  $3 \times 10^{-4}$  molar for cell concentrations of about  $10^6$ - $10^7$  cells per milliliter. More preferably, the concentration is about  $1 \times 10^{-5}$  molar to about  $1 \times 10^{-4}$  molar. The peak concentration; i.e., the concentration that provides the greatest  
15 adjuvanticity, for a given guanosine analog nucleoside can vary when studied in mouse and human lymphocyte systems.

20 A composition can be a solid or a liquid. Physiologically tolerable carriers are well known in the art. Exemplary of liquid carriers are sterile aqueous solutions that contain no materials in addition to the active ingredient guanosine derivative and water, or contain a buffer such as sodium phosphate at physiological pH value,  
25 physiological saline or both, such as phosphate-buffered saline. Still further, aqueous carriers can contain more than one buffer salt, as well as salts such as sodium and potassium chlorides, dextrose and other solutes. The latter carriers are  
30 exemplified by Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection and Lactated Ringer's Injection.

35 Liquid compositions can also contain liquid phases in addition to and to the exclusion of water. Exemplary of such additional phases are glycerin,

vegetable oils, such as cotton seed oil, sesame oil and water-oil emulsions.

Exemplary solid carriers include those materials usually used in the manufacture of pills or tablets, and include corn starch, lactose, dicalcium phosphate, thickeners such as tragacanth gum and methylcellulose U.S.P., finely divided SiO<sub>2</sub> polyvinylpyrrolidone, magnesium stearate and the like. Additionally, the solid carrier can include biodegradable and non-biodegradable polymers, polypeptide carriers, affinity carriers such as AFFI-GEL 601 (phenyl boronate resin available from BIO-RAD Laboratories, Richmond, California), liposomes and synthetic polymers, as are known in the art. Antioxidants such as methylparaben and propylparaben can be present in both solid and liquid compositions, as can sweeteners such as cane or beet sugar, sodium saccharin, sodium cyclamate and the dipeptide aspartic-phenylalanine methyl ester sweetener sold under the tradename NUTRASWEET (aspartame) by G. D. Searle Co.

#### IV. Method of Immunostimulation

A method of enhancing the immune response of leukocytes is also contemplated. Preferably, the immune response is an antigen-specific response. In accordance with this method, leukocytes such as lymphocyte preparations, B cells, T cells, neutrophils and macrophages are contacted separately or in combination in an aqueous medium with a before-described composition containing an immunostimulating effective amount of a before-described guanosine analog derivative.

The method can be practiced in vivo in humans, laboratory mammals such as mice, rats and guinea pigs or in veterinary animals and pets such as

pigs, horses, cattle, dogs and cats. The method can also be practiced in vitro in cell cultures such as in hybridoma culture for the production of monoclonal antibodies.

5                   The leukocytes are contacted in an aqueous medium regardless of whether the composition of guanosine analog derivative is itself a solid or liquid, or whether or not the liquid of the composition is aqueous. For the in vivo method, the  
10                   aqueous medium is supplied at least in part by the water of the blood or lymph. For in vitro methods, the aqueous medium is supplied at least in part by the culture medium used.

                  Contact between the composition and  
15                   leukocytes is maintained for a time period sufficient for the contacted cells to manifest the enhancement of their immune response. That immunostimulation can itself be manifest in cellular proliferation,  
                  enhanced antibody secretion, enhanced T helper  
20                   activity, enhanced cytokine production from T cells and macrophages, enzyme secretion from neutrophils, and the like.

                  An antigen-specific response of B cells is a usual and preferred result of immunoenhancement.  
25                   Additional illustrative antigen-specific immunoenhancements that can be achieved using a method of the invention include enhanced  
                  proliferation of T cells, the in vitro reconstitution of the primary immune response in immunodeficient B  
30                   cells, T cell-replacing activity in B cells, and an in vivo enhancement of antibody production, enhanced T helper cell activity, and increased cytokine secretion.

                  For use in vivo, contact between leukocytes  
35                   and a composition is typically maintained for a time period sufficient for the animal to clear the

guanosine analog derivative from its body as by metabolism, excretion or both processes. That time period can be longer than that required for immunostimulation to be manifest. Contact with an individual unit dose is typically maintained for a time period of hours to about a week or more, depending, for a given compound, upon the carrier or vehicle used. Continual contact can be advantageous for an immunodeficient animal host.

Contact in vitro can be maintained for a period of time sufficient for one of the before-described immunostimulations to become manifest as determined by standard assay techniques such as a plaque-forming assay for B cells. Such maintenance times typically take about one to about seven days of time, and more usually about 2 to about 6 days.

## V. Treatments

### A. In Vitro Adjuvanticity

Contacting animal antibody-producing cells with a composition useful herein provides an adjuvant effect on the primary antibody response to SRBC and other immunogens when evaluated in vitro. The immune response-modulating composition and effective amount of immunogen (sheep red blood cells; SRBC) are typically admixed to contact the cells substantially simultaneously. The words "antigen" and "immunogen" are used interchangeably.

At optimal concentration, a composition containing an effective amount of a useful guanosine analog derivative enhances the response to SRBC by at least about 2-to 6-fold. The effect is dose dependent. Enhancement of the antibody response cannot be accounted for by the additive effects of

the specific response to SRBC and the polyclonal response to the guanosine analog derivative.

The adjuvant effect of compositions containing a useful guanosine analog derivative is exerted on immunogen-experienced (primed) as well as on naive cells. Both responses are enhanced by contacting the cells with compositions containing an effective amount of guanosine analog derivative. This adjuvant effect is dependent upon the concentration of immunogen added to culture. Thus, the primary IgM as well as the secondary IgM and IgG responses to immunogen (antigen) are augmented by contacting B cells with a composition containing an effective amount of an guanosine analog derivative as active ingredient, and maintaining that contact as discussed herein.

While immune responses; i.e., responses of B lymphocytes or B cells, are observed to be enhanced at all immunologically effective doses of immunogen, the degree of enhancement is usually greatest at optimal or near optimal immunogen concentrations. Additionally, adjuvanticity of guanosine analog derivatives is synergistic with immunogen and not just due to the sum of independent immunogen-specific and polyclonal (nonspecific) responses.

For memory responses, B cells are primed by treatment with an effective, priming, amount of an immunogen, as is well known. That priming treatment can be in the presence or absence of an immune response-modulating composition. When contacted in the presence of such a composition, treatment of the B cells with a priming amount of immunogen is preferably substantially simultaneous; i.e., within about 12 hours, with contacting of the cells with a composition useful in this invention. More

preferably, the immunogen is included in the immune response-enhancing composition, unless its effect is impaired by being in that composition, as by denaturation.

5                    In summary, an enhanced immune response can thus be obtained by contacting B cells substantially simultaneously with an effective, priming amount of immunogen and an immune response-enhancing composition useful herein, followed, after a primary  
10 immune response is obtained, by an additional contacting of the primed cells with a further effective amount of immunogen (antigen) alone or substantially simultaneously with a further amount of immune response-enhancing composition.

15                    Guanosine analog derivative-containing compositions useful herein are thought to enhance the primary humoral immune response by acting directly upon the B cell and/or the immunogen-presenting cell. Thus, use of these derivatives enhances the  
20 antibody response mounted against T-independent antigens; i.e., responses that involve B cells and immunogen-presenting cells. In addition, compositions containing an guanosine analog derivative can replace the need of B cells for T  
25 helper cells, as discussed hereinafter, and therefore exert their adjuvant effect in cultures initiated in the absence of intact, functional T cells. A replacement of T cells with T cell helper activity contained in mixed lymphocyte culture (MLC)  
30 supernates does not diminish the ability of an guanosine analog derivative to augment the antibody response.

                    Still further, the synergy observed between the soluble T cell signal contained in MLC supernate  
35 and the guanosine analog derivative-containing

composition indicates that the signal supplied by each is qualitatively distinct. This synergy is observed over a range of supernate concentrations, indicating that the guanosine analog derivative is not simply providing more of the same "signal" that T cells provide. A comparable degree of synergy can be observed when such B cell cultures are supplemented with T cells rather than with T cell-like supernates (which are in fact T cell derived), and are contacted in the presence of immunogen with an guanosine analog derivative-containing composition useful in this invention.

T cell-mediated effects of the adjuvanticity of guanosine analog derivatives are not ruled out by the observation of T-independence for that adjuvanticity; i.e., the existence of a T cell-independent facet does not bear upon the existence of a T cell-dependent phase. Thus, more substantial enhancement can be observed from a composition containing the guanosine analog derivative under conditions of stimulation with low doses of T-dependent and T-independent type 2 antigens (T cell dependent situations) than with T-independent type 1 antigens (more completely T cell-independent), which suggests the presence of a T cell-dependent component. Moreover, guanosine analog derivatives are thought to act (either directly or indirectly) on precursors of T helper cells to increase the ability of a population of such cells to support (i.e., help) an antibody response to immunogen.

B. In Vivo Enhancement Of Immune Response  
Immunopotentiating effects on the primary antibody (B cell) response to SRBC in vivo are

observed when a liquid composition containing a guanosine analog derivative useful herein is contacted with animal cells as by injecting the composition into CBA/CaJ mice about thirty minutes after injection of the SRBC immunogen; i.e., substantially simultaneously. Relatively high dosages, e.g., about 2.5 milligrams per animal (about one-tenth gram per kilogram), are tolerated by the animals.

10 Immunogen dose dependency is observed in the above mice in the presence or absence of adjuvant. A much higher response level is seen in animals injected i.p. with a guanosine analog derivative compared with normal saline (NS) i.p. injections as a control. Whereas there is an enhancement in the immune response at all useful (effective) levels of immunogen injection, typically, the enhancement becomes greater as the magnitude of the underlying response increases.

15  
20 In vivo enhancement of animal cellular responses as in the above-described primary immunization can also be effected as described before in relation to in vitro modulation of secondary immune responses of B cells.

25 CBA/CaJ mice are immunized intraperitoneally (i.p.) using a conjugate (TNP-BSA) prepared by the reaction of 2,4,6-trinitrobenzene sulfonic acid (TNBS) and bovine serum albumin (BSA) in a 0.28 molar cacodylate buffer, at pH 6.9. Each animal receives an intraperitoneal (i.p.) injection containing 50 micrograms (ug) of the immunizing conjugate. One group of mice thereafter (within about 30 minutes) receives another i.p. injection that contains a guanosine analog derivative of the invention in either 100 percent sesame seed oil or an aqueous composition containing 2 volume percent sesame oil

sonicated with saline. Each animal receives 0.2 ml of the guanosine analog derivative from the compositions each of whose concentration of guanosine analog derivative is 5 mg/ml. A third group of mice receives the immunization but no composition of this invention and serve as a control. Anti-TNP-BSA antibody secretion from each group is thereafter monitored over a period of about 30 days using standard enzyme-linked immunosorbant assay (ELISA) techniques using TNP-BSA as antigen.

The results of such a study indicate that animals receiving a guanosine analog derivative of the invention exhibit enhanced anti-TNP-BSA antibody titers as compared to titers from animals that do not receive the guanosine analog derivative.

#### C. T Cell-Replacing Activity

A composition of this invention can be used to substitute for T cells in the antibody response to a T-dependent antigen. Here, murine B cells generated in vitro by treatment with monoclonal anti-thy 1.2 plus complement are cultured with or without SRBC as antigen in the presence of compositions containing incremental concentrations of a guanosine analog derivative.

Under these conditions, isolated B cell cultures respond poorly to T-dependent antigens unless supplemented with a guanosine analog derivative of the invention. The guanosine analog derivative-enhanced response is dose-dependent as well as antigen-dependent. Thus, contacting B cells in vitro with a composition of this invention provides a T cell-like signal to those contacted cells.

D. In Vitro Reconstitution of the  
Primary Humoral Immune Response

CBA/N mice possess an X-chromosome linked  
(X-linked) primary B cell immunodeficiency, and  
5 thereby can provide a murine model for sex-linked  
immunodeficiency. The CBA/N strain is thought to be  
deficient in the functional activity of a  
subpopulation of mature B lymphocytes bearing the Lyb  
3/5/7 antigens. See, Huber et al., J. Exp. Med.,  
10 145:1(1977); Ahmed et al., J. Exp. Med., 145:101  
(1977); and Subbaro, J. Immunol., 122:2279 (1979).

Cultures of spleen cells from male and  
female homozygous CBA/N mice and male mice  
heterozygous for the CBA/N gene, called the xid gene,  
15 (male mice bear the X chromosome) is prepared as  
described in the Materials and Methods section. 0.1  
Milliliters of a 0.1 percent (v/v) SRBC suspension  
alone or the SRBC suspension plus incremental amounts  
of a guanosine analog derivative of the invention are  
20 added to the cultures, using  $5 \times 10^6$  cells/ml.  
Direct anti-SRBC plaque-forming cultures per culture  
are assessed after 4 days of culture.

Using a similar preparation of spleen cells  
from immunocompetent CBA/CaJ mice shows that at the  
25 zero guanosine analog derivative concentration level  
there is substantially no response for the CBA/N  
cells, as compared to a positive PFC/culture response  
for the immunocompetent CBA/CaJ cells.

At concentrations of about  $10^{-4}$ - $10^{-5}$   
30 molar guanosine analog derivative, both the  
immunocompetent CBA/CaJ cells and originally  
immunoincompetent CBA/N cells are made capable of  
producing significant numbers of PFC/culture. Thus,  
contacting X-linked immunodeficient splenocytes with  
35 a composition of this invention can reconstitute the

primary humoral immune response to SRBC of those otherwise immunodeficient cells.

Immunodeficiency in mice as well as other mammals can come from old age or senescence as well as by genetic defect as discussed above. Thus, animals that were immunocompetent as juveniles or adults can become immunodeficient as they reach old age. That is the case for the inbred CBA/CaJ mouse strain.

A further study of the reconstitution of a primary humoral antibody response to SRBC is carried out using spleen cells from senescent, 156-week old, CBA/CaJ mice that have become immunodeficient through age. The in vitro responses of those spleen cells to SRBC in a plaque-forming assay are compared to similar responses from cells of another group of healthy, adult 8-week old, CBA/CaJ mice. This comparison is carried out as described above, again using a composition containing a guanosine analog derivative of the invention to contact the splenocytes.

The PFC/culture for the healthy, adult mice controls containing SRBC but no guanosine analog derivative are several times the number formed in the absence of both SRBC and guanosine analog derivative. The PFC/culture for the controls for the senescent mice are about equal for both controls, and elevated compared to those of healthy adults. Those relatively elevated and similar responses are thought to reflect the process that culminates in formation of autoantibody-producing clones.

A guanosine analog derivative dose-related response is observed in the presence of SRBC. That response is observed for both the immunocompetent healthy adult splenocytes and the previously

immunodeficient, but now primary humoral  
response-reconstituted senescent splenocytes. Such  
results thereby illustrate that contacting  
immunodeficient senescent splenocytes with a  
5 composition of this invention can reconstitute this  
deficient immune response.

Having generally described this invention, a  
further understanding can be obtained by reference to  
syntheses and procedures that are provided  
10 hereinafter below for purposes of illustration.

## VI. Materials and Methods

### A. Syntheses

In the syntheses described below, compound  
15 numbers identified by an underlined numeral  
correspond to the similarly numbered compounds shown  
in Schemes I and II. Again, syntheses are discussed  
here for those compounds that are not commercially  
available or that are key intermediates in the  
20 reaction sequence. Those skilled in the art will be  
able to produce or purchase the remaining compounds.

### Scheme I Preparations

#### 25 Example 1: Preparation of compound 3

To a solution of sodium methoxide 2 in  
methanol is added a solution of 1 (1 equivalent; eq.)  
in CH<sub>3</sub>OH at zero degrees C under N<sub>2</sub>. After  
addition, the mixture is allowed to warm to room  
30 temperature (about 22 degrees C) and stirred for 2  
hours. Most of the methanol is removed in vacuo, the  
residue is treated with water, and extracted with  
methylene chloride. The organic layer is dried over  
Na<sub>2</sub>SO<sub>4</sub> and the solvent is removed in vacuo to  
35 provide the title compound 3.

Example 2: Preparation of compound 5

A mixture of 3 and 4 (1.1 eq.), sodium methoxide (1.1 eq.) and methanol is heated to reflux under nitrogen for 16 hours. After cooling, most of methanol is removed in vacuo, and the residue is  
5 treated with cold water. The white solid is filtered and washed with cold water to provide the title compound 5.

10 Example 3: Preparation of compound 6

To a mixture of 5, pyridine (20 eq.) and acetonitrile is added  $\text{POCl}_3$  (5 eq.) at zero degrees C under  $\text{N}_2$ . After addition, the mixture is heated to reflux for two hours. The mixture is cooled to  
15 room temperature, and the solvent is removed in vacuo. The residue is treated with methylene chloride and washed with saturated  $\text{NaHCO}_3$ , then water, and is thereafter dried over  $\text{Na}_2\text{SO}_4$ . The solvent is removed in vacuo to provide the title  
20 compound 6.

Example 4: Preparation of compound 8

A mixture of 6 (1 eq.), 7 (1 eq.), potassium carbonate and absolute ethanol is heated to reflux  
25 under nitrogen for 16 hours. The mixture is cooled to room temperature and filtered. The filtrate is concentrated in vacuo and the residue is purified by column chromatography on silica gel to provide the title compound 8.

30 Example 5: Preparation of compound 9

To a solution of 8 (1 eq.) in methylene chloride is added trimethylsilyl iodide (1 eq.) at zero degrees C under  $\text{N}_2$ , and the resulting mixture  
35 is stirred for 3 hours. The mixture is poured into

sodium bicarbonate solution. The organic layer is separated and dried over  $\text{Na}_2\text{SO}_4$ . The solvent is removed in vacuo and the residue is purified by column chromatography on silica gel to provide the title compound 9.

Example 6: Preparation of compound 10

To a mixture of 9 (1 eq.), potassium carbonate (2.5 eq.) and tetrahydrofuran is added a solution of phosgene in xylene (1 eq.) [or thiophosgene (neat) (1 eq.)] at zero degrees C under nitrogen. After addition, the mixture is allowed to warm to room temperature and stirred for about 18 hours. The mixture is filtered, and the filtrate is concentrated in vacuo. The residue is purified by column chromatography on silica gel to provide the title compound 10.

Example 7: Preparation of compound 11

To a solution of 10 (1 eq.) in dimethyl formamide (DMF) is added sodium methoxide (1.1 eq) at zero degrees C under  $\text{N}_2$ . After addition, the mixture is allowed to warm to room temperature, and stirred for 3 hours. Most of solvent is removed in vacuo and the residue is purified by column chromatography on silica gel to provide the title compound 11.

Example 8: Preparation of compound 12

To a solution of 11 (1 eq.) in methylene chloride is added trimethylsilyl iodide (1 eq.) at zero degrees C, and the resulting mixture is stirred for 2 hours. The mixture is poured into dilute sodium bicarbonate solution. The organic layer is separated and dried over  $\text{Na}_2\text{SO}_4$ . The solvent is

removed in vacuo, and the residue is purified by column chromatography on silica gel to provide the title compound 12.

5 Example 9: Preparation of compound 13

A mixture of 12 (eq.), methanesulfuric acid (catalytic amount) and tetrahydrofuran-water (1:1; v/v) is stirred at room temperature under nitrogen for three days. Most of solvent is removed  
10 in vacuo, and the residue is purified by reverse phase HPLC (C<sub>18</sub>-column) to provide the title compound 13.

Scheme II Preparations

15

Example 10: Preparation of compound 16

To a mixture of 15 (1 eq.), K<sub>2</sub>CO<sub>3</sub> (1.1 eq.) and tetrahydrofuran is added a solution of 14 in tetrahydrofuran at room temperature under nitrogen.  
20 The resulting mixture is stirred for 2 hours. Most of solvent is removed in vacuo and the residue is purified by column chromatography on silica gel to provide the title compound 16.

25 Example 11: Preparation of compound 18

The title compound is prepared in a manner analogous to the preparation of compound 5.

Example 12: Preparation of compound 19

30 The title compound is prepared in a manner analogous to the preparation of compound 6.

Example 13: Preparation of compound 21

35 The title compound is prepared in a manner analogous to the preparation of compound 10.

Example 14: Preparation of compound 22

To a mixture of 21 (1 eq.), sodium hydroxide pellets and acetonitrile is added ethyl chloroformate (27) [or ethyl chlorothioformate (27')] at zero  
5 degrees C under nitrogen. After addition, the mixture is allowed to warm to room temperature, and is stirred for 3 hours. The resulting mixture is filtered, and the filtrate is concentrated in vacuo. The residue is purified by column chromatography on  
10 silica gel to provide the title compound 22.

Example 15: Preparation of compound 23

To a solution of 22 (1 eq.) in tetrahydrofuran is added a solution of  
15 tetra-n-butylammonium fluoride (2.1 eq.) at zero degrees C, and the resulting mixture is stirred for 3 hours. Most of solvent is removed in vacuo and the residue is purified by column chromatography on  
20 silica gel to provide the title compound 23.

Example 16: Preparation of compound 24

The title compound is prepared in a manner analogous to the preparation of compound 11.

25 Example 17: Preparation of compound 25

The title compound is prepared in a manner analogous to the preparation of compound 12.

30 Example 18: Preparation of compound 26

The title compound is prepared in a manner analogous to the preparation of compound 13.

Example 19: 7-Deaza-7-oxa- or 7-deaza-7-thia-8-selenoxoguanosine Derivatives

35 7-Deaza-7-oxa- or 7-deaza-7-thia-8-selenoxoguanosine analog derivatives are prepared from

suitably protected, corresponding 7-deaza-7-oxa- or 7-deaza-7-thia-8-thioxo derivatives whose preparations are discussed previously. Thus, the 7-deaza-7-oxa- or 7-deaza-7-thia-8-thioxoguanosine is  
5 reacted with an S-alkylating agent such as methyl iodide in a solvent such as DMSO. The S-alkylated product so obtained is thereafter reacted with sodium selenide to form the 7-deaza-7-oxa- or 7-deaza-7-thia-8-selenoxo derivative. The desired  
10 product can thereafter be obtained from the reaction mixture by reverse phase HPLC.

Example 20: 7-Deaza-7-oxa- or 7-deaza-7-thia-8-cyanoimino  
guanosine Derivatives

15 Corresponding 7-deaza-7-oxa- or 7-deaza-7-thia-8-thioxoguanosine derivatives are utilized as the starting materials for these derivatives. In a typical preparation, methyl iodide [42 millimoles (mM)] is added to 28 mM of the starting 8-thioxoguanosine analog  
20 derivative dissolved in dimethyl sulfoxide (DMSO). The addition takes place at room temperature and under nitrogen. The resulting admixture is stirred for about three hours and then cooled to about zero degrees C. Cyanamide (about 57 mM) is added followed by sodium  
25 hydride (60% oil dispersion; 5mM). That reaction mixture is permitted to warm to room temperature and is stirred for about one hour.

The reaction mixture is then poured into about 1.5 liters of diethyl ether and stirred for  
30 about 10 minutes. The ether layer is decanted, the residue extracted with a further 1.5 liters of diethyl ether additionally containing about 50 ml of acetic acid. The ether layer is again decanted and the residue is dissolved in water (about 500 ml).  
35 The desired compound is purified from the water layer by reverse phase HPLC (C-18).

Example 21: Lower Alkylidenedioxy Derivatives

A lower alkylidenedioxy derivative of one of the before-described compounds is exemplified by the following synthesis of an isopropylidene derivative.

5           A mixture of 7-deaza-7-oxa-8-oxoguanosine (17 mM), 2,2-dimethoxypropane (41 mM), acetone (200 ml) and concentrated sulfuric acid (10 drops) are stirred under N<sub>2</sub> at ambient room temperature for a time period of 52 hours. The mixture is cooled to  
10 zero degrees C and treated with concentrated ammonium hydroxide (5 ml). The majority of the liquid is removed in vacuo, and the resulting solid is filtered. The filtered solid is washed with water, acetone, and then diethyl ether, followed by drying  
15 in a vacuum oven at 60 degrees C to provide the desired derivative. Similar procedures are followed for the 8-thioxo, 8-selenoxo and 8-cyanoimino derivatives.

20 Example 22: 7-Deaza-7-oxa- or 7-deaza-7-thia-8-oxo-2',3'-O-isopropylidene-5'-benzoylguanosine

A mixture containing an isopropylidene derivative as described in Example 21 (3mM), triethylamine (3 ml), benzoyl chloride (3 mM) and  
25 methylene chloride (100 ml) is stirred at ambient room temperature for a period of 16 hours. The mixture is thereafter poured into water, the methylene chloride layer separated, and the water layer extracted further with methylene chloride  
30 (2x150 ml).

The methylene chloride layers are combined, dried over NaSO<sub>4</sub>, and the solvent is removed in vacuo. The residue is purified by column chromatography on silica gel.

5'-Acetyl derivatives are prepared by substituting acetic anhydride for benzoyl chloride. 8-Thioxo, 8-selenoxo and 8-cyanimino derivatives are similarly prepared.

5

Example 23: 7-Deaza-7-oxa- or 7-deaza-7-thia-8-thioxo-2',3',5'-triacetylguanosine

This preparation is exemplary of acylation procedures for the aldoglycosidyl portion of the molecule such as a ribosyl ring. Here, 4-N,N-dimethylaminopyridine (10 mg) is added to a mixture of the 7-deaza-7-oxa- or 7-deaza-7-thia-8-thioxoguanosine (3 mM), triethylamine (2 ml), acetic anhydride (15 mM; lower acyl chlorides or benzoyl chloride can be used in the alternative to prepare the corresponding tri-lower acyl or tribenzyoyl derivatives) and methylene chloride (50 ml). The resulting reaction mixture is stirred under N<sub>2</sub> for 16 hours at room temperature.

Further methylene chloride (50 ml) is thereafter added, and the solution is washed with 1N HCl, brine, and then water. The solution is thereafter dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent is removed in vacuo, and the residue is purified by column chromatography on silica gel.

Similar procedures are followed for the 8-oxo, 8-selenoxo and 8-cyanimino derivatives.

#### B. Exemplary Compositions For Administration

Exemplary solid and liquid compositions suitable for administering the compounds of the present invention are described below using five of the more preferred guanine nucleoside derivatives as exemplary active ingredients.

35

Tablets

Tablets are compounded from the following ingredients:

		<u>Parts by Weight</u>
5	7-Deaza-7-oxa-8-oxoguanosine	2.5
	Lactose, powdered	36.4
	Corn starch, dry	34.5
	Finely divided SiO <sub>2</sub>	5.6
	Polyvinylpyrrolidone	0.6
10	Magnesium stearate	0.4
		<hr/>
		80.0

The guanosine analog derivative is thoroughly admixed with the lactose, 25.0 parts by weight of the corn starch, and 4.0 parts by weight of the SiO<sub>2</sub>. The resulting admixture is then uniformly moistened with a 5% ethanolic solution of polyvinylpyrrolidone. The moist mass is then passed through a one-millimeter mesh screen to produce a granulate. The produced granulate is dried for about 24 hours at 60°C. in a drying chamber. The dried granulate is again passed through a one-millimeter mesh screen. 70.0 Parts of the obtained granulate are admixed in a suitable mixer with a mixture consisting of the remainder of the SiO<sub>2</sub>, the remainder of the corn starch and all of the magnesium stearate, which mixture previously had been passed through a one-millimeter mesh screen. The thus-obtained admixture is then pressed into tablets weighing 800 milligrams each and containing 25 milligrams of the guanosine analog derivative.

Starch Capsules

Capsule contents are compounded from the following ingredients:

		<u>Parts by Weight</u>
	7-Deaza-7-oxa-8-oxo-9-(1'-beta-D-2'- deoxyribofuranosidyl)guanosine	10.0
	Lactose	450.0
5	Corn Starch	540.0
		<hr/> 1000.0

10 The guanosine analog derivative is gradually admixed with the lactose. When all of the lactose has been admixed, the obtained admixture is blended with the corn starch. The resulting blend is then filled into capsules holding 10 gram of the blend. Each capsule contains 1.0 milligram of the guanosine analog derivative.

15 Tablets

20 A lot consisting of 10,000 tablets, each containing 50 milligrams of 7-deaza-7-oxa-8-oxo-9-(1'-beta-D-glucopyranosidyl)guanosine is prepared from the following types and amounts of ingredients:

	7-Deaza-7-oxa-8-oxo-9-(1'-beta-D- glucopyranosidyl)guanosine	500 grams
25	Dicalcium Phosphate	1000 grams
	Methyl cellulose, U.S.P. (15 cps)	75 grams
	Talc	150 grams
	Corn Starch	250 grams
	Magnesium stearate	25 grams
30		<hr/> 2000 grams

35 The guanosine analog derivative and dicalcium phosphate are mixed well, granulated with 7.5 percent solution of methyl cellulose in water,

passed through a No. 8 screen (U.S. Standard Sieve Series) and dried carefully. The dried granules are passed through a No. 12 screen (U.S. Standard Sieve Series), mixed thoroughly with the talc, starch and magnesium stearate, and compressed into tablets.

Injectable Preparation

A sterile preparation suitable for subcutaneous or intracavitary injection and containing 50 milligrams of 7-deaza-7-thia-8-oxoguanosine in each milliliter of ingredients is prepared from the following types and amounts of ingredients:

15	7-Deaza-7-thia-8-oxoguanosine	5 grams
	Physiological saline	98 milliliters
	Sesame oil	2 milliliters

The guanosine analog derivative and saline are admixed and sonicated for a period of time sufficient to provide a substantially homogenous dispersion. The sesame oil is thereafter admixed and the new admixture is similarly homogenized to provide an emulsion. After emulsification, five to fifteen percent of the final volume of this sterile preparation are injected subcutaneously or intraperitoneally once a week to enhance humoral immunity.

Aqueous Preparation for Oral Use

An aqueous preparation for oral use containing in each 5 milliliters (1 teaspoon) 25 milligrams of 7-deaza-7-thia-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine is prepared from the following ingredients:

	7-Deaza-7-thia-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine	5.0 grams
	Methylparaben, U.S.P.	0.75 grams
	Propylparaben, U.S.P.	0.25 grams
5	Saccharin sodium	1.25 grams
	Cyclamate sodium	0.25 grams
	Glycerin	300 milliliters
	Tragacanth powder	1.0 grams
	Orange oil flavor	1.0 grams
10	F.D. and C. orange dye	0.75 grams
	Deionized water, q.s. to	1000 milliliters

C. Methods

15 Lymphocyte cultures. The serum-containing culture medium is prepared to contain the following per 100 milliliters: 91.9 milliliters RPMI 1640 (Flow Laboratories, Inc., Rockville, MD), 0.1 milliliters of 100 x glutamine, 1.0 milliliter of 100 x sodium pyruvate, 1.0 milliliter of 50 x nonessential amino acids, 1.0 milliliter of water containing 10<sup>4</sup> units of penicillin G and 10<sup>4</sup> micrograms of streptomycin, and 5.0 milliliters of a supportive lot of fetal calf serum (FCS). These ingredients are admixed to apparent homogeneity.

20 Spleen cell suspensions and populations enriched for splenic B cells are prepared as described in Goodman et al., J. Immunol., 121:1905 (1978).

25 For evaluation of the primary humoral immune response to sheep erythrocytes (SRBC), 5x10<sup>6</sup> to 30 10<sup>7</sup> murine spleen cells are cultured in 1.0 milliliter of 5% FCS-containing medium for 4 or 5 days in the presence of immunogen. Cells are incubated in culture trays (Costar, Cambridge, MA) at 37°C in a humidified atmosphere of 10% CO<sub>2</sub> in air 35 using tissue culture boxes (CBS Scientific, Del Mar,

CA) that are rocked at a frequency of 7 cycles per minute. Pooled SRBC are available from the Colorado Serum Co., Denver CO.

Human peripheral blood lymphocytes (PBL) are prepared from normal heparinized venous blood by Ficoll-diatrizoate density gradient centrifugation. PBL are depleted of suppressor T cells bearing the histamine type 2 receptor by adhering them to the surfaces of histamine-rabbit serum albumin-coated plastic petri dishes (Cell-ect No. 2 kit; Seragen, Boston, MA) and by recovering the nonadherent cells by panning as described by Wysocki and Sato, Proc. Natl. Acad. Sci. USA, 75:2844 (1978) and modified by Cavagnaro and Osband, Biotechniques, January/February:30 (1983).

The tissue culture medium employed in these studies is prepared as follows: One hundred milliliters (ml) contained 87.9 ml RPMI 1640 (Flow Laboratories, Rockville, MD), 0.1 ml 100 x glutamine, 1.0 ml of 1.0 M HEPES buffer (Microbiological Associates, Bethesda, MD), 1.0 ml of water containing  $10^4$  U of penicillin G and  $10^4$  micrograms of streptomycin, and 10 ml of fresh autologous heat-inactivated plasma. For evaluation of the primary humoral immune response to SRBC, lymphoid cells are cultured at a density of  $2 \times 10^6$ /ml in a volume of 1.0 ml containing  $5 \times 10^6$  SRBC as antigen (Colorado Serum Co., Denver, CO) together with IL-2 (a partially purified preparation of human IL-2 that is free of interferon-gamma activity is obtained from Electro-Nucleonics, Inc., Silver Spring, MD) and the guanosine analog derivative.

Assay of plaque forming cells (PFC). PFC secreting antibodies against SRBC are evaluated after

4 or 5 days of culture using a modification of the hemolytic plaque assay of Jerne and Nordin, Science, 140:405 (1963). The cells are brought up in complete medium before plaquing; they are plaqued in standard  
5 low  $M_r$  agarose (Bio-Rad Laboratories, Richmond CA), and are incubated in SRBC-absorbed guinea pig complement for one hour after a 1.5 hour incubation without complement.

T Cell Replacing Activity.  $5 \times 10^6$  Viable  
10 CBA/CaJ mouse B cells are cultured. These cells are generated by sequentially treating spleen cells first with complement-fixing monoclonal antibodies directed against with thy 1.2 antigens of T cells and second with complement to lyse any T cells present (New  
15 England Nuclear, Boston, MA). The cells so treated are thereafter grown with or without 0.1 ml of 0.1 percent (v/v) SRBC as immunogen in serum-containing media further containing incremental amounts of a guanosine analog derivative ranging in amount from  
20 zero through  $10^{-4}$  molar. Direct PFC to SRBC are determined 4 days thereafter.

Mice. CBA/CaJ mice, 8-16 weeks of age, are purchased from the Jackson Laboratory, Bar Harbor, ME. A breeding nucleus of CBA/N mice is provided by  
25 the Animal Production Section, National Institutes of Health, Bethesda, MD. All mice are maintained on Wayne Lab Blox F6 pellets (Allied Mills, Inc., Chicago, IL) and chlorinated water acidified with HCl to a pH value of 3.0.

Cell preparations. Spleen and thymus cell  
30 suspensions are prepared as described in Goodman et al., J. Immunol., 121:1905 (1978). B cell-enriched populations are prepared by treating  $10^8$  spleen cells with a 1:1000 dilution of monoclonal  
35 anti-thy 1.2 antibody (New England Nuclear, Boston,

MA) for 30 minutes at 4°C. Treated cells are centrifuged at 280xgravity for 10 minutes, antibodies are removed, and the cells are resuspended in a 1:6 dilution of CBA RBC-absorbed guinea pig complement at 5 37°C for 45 minutes. Cells are then washed and cultured as described before.

Injections. Mice are injected i.p. with a solution containing 50 ug of TNP-BSA. Within about 30 minutes of the immunizing injection, two groups of 10 six mice each also receive 0.2 ml i.p. injections of a guanosine analog derivative of the invention in 100 percent sesame oil, or 2 percent (v/v) sesame oil sonicated in normal saline, with the guanosine analog derivative being present at 5 mg/ml. A third group 15 of six mice receive the immunization but no guanosine analog derivative. Anti-TNP-BSA antibody titers are thereafter determined using standard techniques.

The present invention has been described with respect to preferred embodiments. It will be 20 clear to those skilled in the art that modifications and/or variations of the disclosed subject matter can be made without departing from the scope of the invention set forth herein.

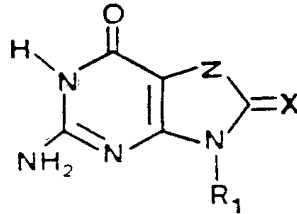
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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:  
~~WHAT IS CLAIMED IS:~~

1. A method of enhancing an immune response comprising contacting leukocytes in an aqueous medium with a composition containing a diluent amount of a physiologically tolerable carrier admixed with an immune response-effective amount of a guanosine analog derivative active ingredient whose structure conforms to that of the formula



wherein

Z is O or S;

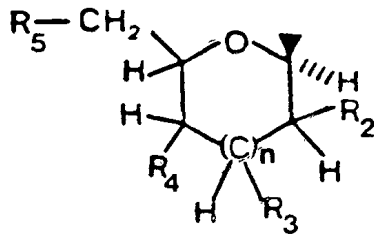
X is O, S, Se or NCN; and

R<sub>1</sub> is a beta-bonded D aldoglycoside radical selected from the group consisting of 1'-aldopentosidyl, 1'-aldohexosidyl, mono-deoxygenated-1'-aldopentosidyl, and mono-deoxygenated-1'-aldohexosidyl and their O-substituted lower alkyl, lower alkylidene, lower alkanoyl, benzyl and benzoyl derivatives, and the pharmaceutically acceptable non-toxic, base addition salts of said guanosine analog derivative; and

maintaining said contact for a time period sufficient for said cells to modulate their response.

2. The method in accordance with claim 1 wherein R<sub>1</sub> is selected from the group consisting of 1'-ribofuranosidyl, 1'-(2'-deoxy)ribofuranosidyl and 1'-glucopyranosidyl radicals.

3. The method in accordance with claim 1 wherein the structure of said aldoglycosidyl radical conforms to the formula



wherein n is zero or one;

$R_2$ ,  $R_3$ ,  $R_4$  and  $R_5$  are selected from the group consisting of hydrogen, hydroxy, lower alkoxy, benzyloxy, lower alkylidendioxy, lower alkanoyloxy, and benzoxy.

4. The method in accordance with claim 1 wherein said leukocytes are lymphocytes.

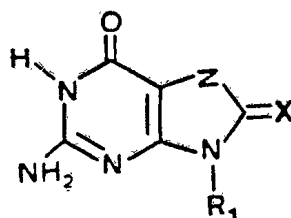
5. The method according to claim 1 wherein said guanine analog derivative is a 7-deaza-7-thia-8-oxo-9,1'-beta-D-aldoglycosidylguanine.

6. The method according to claim 1 wherein said guanine analog derivative is a 7-deaza-7-oxa-8-thio-9,1'-beta-D-aldoglycosidylguanine.

7. The method according to claim 1 wherein said guanine analog derivative is a 7-deaza-7-thia-8-thio-9,1'-beta-D-aldoglycosidylguanine.

8. The method according to claim 1 wherein said guanine analog derivative is a 7-deaza-7-oxa-8-oxo-9,1'-beta-D-aldoglycosidylguanine.

9. A guanosine analog derivative whose structure conforms to that of the formula



wherein

Z is O or S;

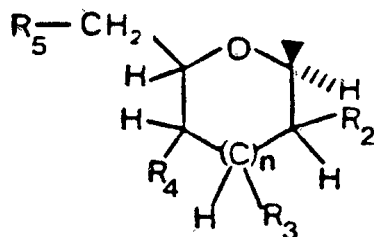
X is O, S, Se or NCN;

$R_1$  is a beta-borided D aldoglycoside radical  
 5 selected from the group consisting of 1'-aldopentosidyl,  
 1'-aldohexosidyl, mono-deoxygenated-1'-aldopentosidyl,  
 and mono-deoxygenated-1'-aldohexosidyl and their  
 O-substituted lower alkyl, lower alkanoyl, lower  
 10 alkylidene, benzyl and benzoyl derivates, and the  
 pharmaceutically acceptable non-toxic, base addition  
 salts of said guanine analog derivative.

10. The guanosine analog derivative according  
 to claim 9 wherein  $R_1$  is selected from the group  
 consisting of 1'-ribofuranosidyl, 1'-(2'-  
 15 deoxy)ribofuranosidyl and 1'-glucopyranosidyl radicals.

11. The guanosine analog derivative according  
 to claim 9 wherein the structure of said aldoglycosidyl  
 radical conforms to the formula

20



25

wherein n is zero or one;

$R_2$ ,  $R_3$ ,  $R_4$  and  $R_5$  are selected from the group  
 30 consisting of hydrogen, hydroxy, lower alkoxy,  
 benzyloxy, lower alkylidendioxy, lower alkanoyloxy, and  
 benzyloxy.

12. The guanosine analog derivative according  
 to claim 9 wherein said guanosine analog derivative is  
 35 selected from the group consisting of 7-deaza-7-oxa-8-

5 oxo-9-(1'-beta-D-ribofuranosidyl)guanine, 7-deaza-7-oxa-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine, 7-deaza-7-oxa-8-oxo-9-(1'beta-D-glucopyranosidyl)guanine, 7-deaza-7-thia-8-oxo-9-(1'-beta-D-ribofuranosidyl)guanine, 7-thia-8-oxo-9-(1'-beta-D-2'-deoxyribofuranosidyl)guanine, and 7-thia-8-oxo-9-(1'-beta-D-glucopyranosidyl)guanine.

13. A method of enhancing an immune response substantially as described herein.

14. A guanosine analog derivative substantially as described herein with reference to the examples.

DATED this 15th day of MAY, 1989  
SCRIPPS CLINIC AND RESEARCH FOUNDATION  
By their Patent Attorneys  
GRIFFITH HACK & CO.