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Methods and compositions for the use of HIV env polypeptides and antibodies thereto.

(5) The Human Immunodeficiency Virus envelope protein or its fragments that are capable of binding to the T4 helper lymphocyte receptor are used in therapeutically effective doses for the treatment of immunoinflammatory disorders or diseases. Amino acid residues that constitue an essential portion of the T4 receptor binding domain of HIV env fall within a 64 residue sequence extending about from residues 411 to 454 of the 3B isolate. This domain is useful as a vaccine component, or for cytotoxic T cell targeting when conjugated with a target cell binding substance. HIV env which is devoid of a functional T4 receptor binding domain is useful as a vaccine for immunization against HIV infection. Antibodies capable of binding this domain also are provided for therapeutic and diagnostic use. An immunotoxin comprising a monoclonal antibody to a virally encoded cell surface antigen, linked to a toxin such as ricin A chain, is disclosed. Also, a method of killing virally infected cells such as HIV infected cells, comprising administering to the infected cells a therapeutically effective amount of the immunotoxin is disclosed.

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Description

METHODS AND COMPOSITIONS FOR THE USE OF HIV ENV POLYPEPTIDES AND ANTIBODIES THERETO

This invention relates to methods for the use of Human Immunodeficiency Virus, or HIV, (HTLV-III) envelope (env) polypeptides, especially their use in suppressing undesirable immune responses and their inflammatory sequelae. The invention also is concerned with the use of HIV env variants and antibodies to HIV env in the vaccination and treatment of HIV-infected patients, in the diagnostic assay of test samples and for other therapeutic indications. In particular, this invention is concerned with the treatment of autoimmune diseases and the suppression of transplantation immunity. The invention also relates to immunotoxins and other immunoconjugates and their use in killing cells infected with HIV or other viruses which encode a cell surface antigen.

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Inflammatory responses associated with various immune disorders are typically divided into four classes. However, numerous autoimmune diseases whose treatment is included within the scope herein are of uncertain origin and therefore resistant to classification, e.g. myasthenia gravis, Graves disease, autoimmune sequelae to Chagas disease, and juvenile-onset diabetes. Class I responses are reaginic or allergic reactions

- characterizing atopy or anaphylaxis. Class II responses are dependent upon cytotoxic antibody and are 15 associated, for example, with autoimmune hemolytic anemia and thrombocytopenia attendant to systemic lupus erythematosus (SLE). Class III responses are characterized by chronic generation of immune complexes containing IgG and/or IgM. Class IV responses, associated with delayed hypersensitivity, are mediated by cytokines and T-lymphocytes and are typically found in tuberculosis, sarcoidosis, polymyositis, granulomatosis and vasculitis. 20
 - Rheumatoid arthritis (RA) is a serious class III disorder. Synovitis is the characteristic tissue reaction in RA, wherein the normally thin connective tissue is replaced by hyperproliferating synovial fibroblasts, and the synovium is invaded by an infiltrate of lymphocytes, macrophages and other immune cells. The turnover of complement components is increased in rheumatic synovial fluid, and complement cleavage products,
- especially C5a, are present in rheumatoid synovial fluid. This is significant because C5a and other derivatives of 25 complement contribute to the activation of immune cells and the production of inflammatory cytokines. The fluid also contains hydrolytic enzymes (including collagenase) derived from inflammatory cells, together with kinins and LTB4.
- Various mechanisms have been proposed to account for the degree of tissue destruction characteristic of rheumatoid arthritis. These mechanisms involve a complex interplay of activation and suppression 30 mechanisms which modulate the type and magnitude of the inflammatory response to RA. These mechanisms involve arachidonic acid metabolites, especially prostaglandin E2 produced by leukocytes and rheumatoid synovia, biologically active amines such as histamine and serotonin, complement cleavage products, eosinophil chemotactic factors, kinins, interleukins and proteolytic enzymes, especially collagenase or 35 procollagenase activating enzymes.

One commonly accepted postulate for induction of RA holds that an undefined antigen is chronically deposited in the synovium where it is phagocytized by the Type A synovial cells. Presentation of the antigen to B cells induces their differentiation to plasma cells, which then produce antibodies, rheumatoid factors and cytokines. Antigen activation of T lymphocytes triggers lymphokine synthesis, blastogenesis and the

- subsequent generation of antigen-specific helper and cytotoxic T-cells. The combination of antibody with 40 antigen, as well as combination of antigen-antibody complexes with rheumatoid factors, or self-association of rheumatoid factors, activates complement as well as the kinin-forming system by means of activating Hageman factor. This results in the production of proinflammatory products such as C5a, arachidonic acid metabolites, kinins, and fibrinopeptides, which diffuse into the synovial fluid and to synovial blood vessels.
- These agents enhance vascular permeability and attract polymorphonuclear leukocytes and macrophages. 45 Polymorphonuclear leukocytes ingest the abundant immune complexes in the fluid, release lysosomal and other destructive enzymes, and generate superoxide anions. This causes destruction of hyaluronate polymers in the joint fluid, as well as injury to cartilage. Cytokine production in the synovium leads to the further accumulation of macrophages, other immune cells and rheumatoid synovial fibroblasts. These cell types can
- all contribute further to the cycle of immune cell recruitment, activation and production of immune mediators 50 (e.g., cytokines) which is characteristic of RA and leads to the perpetuation of the inflammatory state and the resulting tissue destruction.

The unique structure of the joint space is important, as enzymes present in synovial fluid or released and synthesized locally by the cells constituting the proliferative synovial lesion contribute to the pathology evident

- in articular structures. The cartilege-degrading lysosomal enzymes collagenase and elastase are primarily 55 derived from inflammatory cells (immune cells and rheumatoid synovial fibroblasts). Proteinase released by dying cells may aid in superficial cartilage destruction by virtue of their role in uncrosslinking collagen fibrils, thus increasing their susceptibility to enzymatic degradation. Macrophages in the synovium produce prostaglandins, hydrolytic enzymes, collagenase, plasminogen activator, and IL-1. Collagenase synthesis by
- macrophages or rheumatoid synovial fibroblasts is greatly enhanced in the presence of IL-1 and other 60 inflammatory proteins. In addition to collagenases, lysosomal proteinases can degrade aggregates of proteoglycans, and, once released from cartilage, these solubilized components are then sensitive to further enzymatic attack.

Persistent antigen activation or disordered regulation of T and B cell activation leads to a chronic inflammatory response in the synovium. Continued cellular proliferation and influx lead to synovial proliferation and its invasion into surrounding structures. Diffusion of collagenase, PGEs, hydrolytic enzymes, and cvtokines into cartilage and bone results in erosion of these tissues. Rheumatoid arthritis thus illustrates the devastating local tissue destruction that results from chronic inflammatory reactions produced by delayed hypersensitivity types of immune responses.

Current therapy for RA includes bed rest, application of heat, and drugs. Salicylate is the currently preferred drug, particularly as other alternatives such as currently available immunosuppressive agents and adrenocorticosteroids can cause greater morbidity than the underlying disease itself. Nonsteroidal anti-inflammatory drugs are available, and many of them have effective analgesic, antipyretic and anti-inflammatory activity in RA patients. These include indomethacin, phenylbutazone, phenylacetic acid derivatives such as ibuprofen and fenoprofen, naphthalene acetic acids (naproxen), pyrrolealkanoic acid (tometin), indoleacetic acids (sulindac), halgenated anthranilic acid (meclofenamate sodium), piroxicam, zomepirac and diflunisal. These are not generally considered any more effective than aspirin, but may be better tolerated by some patient classes.

Other drugs for use in RA include antimalarials such as chloroquine, gold salts and penicillamine. These alternatives frequenty produce severe side effects, including retinal lesions and kidney and bone marrow toxicity. Methotrexate, an immunosuppressive agent, has been used only in the treatment of severe and unremitting RA because of its toxicity. Corticosteroids also are responsible for undesirable side effects and are not well tolerated in many RA patients.

Methods and compositions are needed for the effective therapy of chronic inflammatory diseases or disorders associated with class I-IV response, in particular for the suppression of responses associated with ulcerative colitis (inflammatory bowel disease), RA or SLE (systemic lupus erythematosus) myasthenia gravis. Graves disease, Chagas disease and juvenile-onset diabetes.

This invention also is concerned with suppressing the immune rejection of, or by, transplanted cells, organs 25 or tissues. Transplant rejection has been suppressed by the use of immunosuppressive drugs such as cyclosporin antibiotics and steroids. Such drugs exert extensive and undesirable side effects. In another approach, monoclonal antibodies have been used to target and neutralize lymphocyte subsets believed to be involved in transplant rejection. These antibodies are murine in origin. As is the case with murine monocional antibodies in general, these antibodies exhibit low affinity for their target T cell subsets. They also pose a risk of inducing murine hypersensitivity in treated patients and, because murine constant regions are capable of activating human complement, the anti-T subset antibodies pose the risk of T cell lysis and depletion. Compositions and methods are needed for the treatment of graft rejections which do not employ murine immunoglobulins.

Acquired immunodeficiency syndrome (AIDS) is caused by a retrovirus identified as human immuno-defi-35 ciency virus (HIV)(1-6). A number of immunologic abnormalities have been described in AIDS including abnormalities in B-cell function, abnormal antibody response, defective monocyte cell function, impaired cvtokine production (7-10), depressed natural killer and cytotoxic cell function (11), and defective ability of lymphocytes to recognize and respond to soluble antigens (12). Other immunologic abnormalities associated with AIDS have been reported (13,14). Among the more important immunologic defects in patients with AIDS 40 is the depletion of the T4 helper/inducer lymphocyte population (1,2,9,10).

In spite of the profound immunodeficiency observed in AIDS, the mechanism(s) responsible for immunodeficiency are not clearly understood. Several postulates exist. One accepted view is that defects in immune responsiveness are due to selective infection of helper T cells by HIV resulting in impairment of helper T cell function and eventual depletion of cells necessary for a normal immune response (1-6,15). Recently in 45 vitro and in vivo studies showed that HIV can also infect monocytes which are known to play an essential role as accessory cells in the immune response (16,17). HIV may also result in immunodeficiency by interfering with normal cytokine production in an infected cell resulting in secondary immunodeficiency as for example, IL-1 and IL-2 deficiency (18). An additional means of HIV-induced immunodeficiency consists of the production of factors which are capable of suppressing the immune response (19). None of these models resolves the 50 question of whether a component of HIV per se, rather than infection by replicative virus, is responsible for the immunologic abnormalities associated with AIDS.

The HIV env protein has been extensively described, and the amino acid and RNA sequences encoding HIV env from a number of HIV strains are known (34). The HIV virion is covered by a membrane or envelope derived from the outer membrane of host cells. The membrane contains a population of envelope glycoproteins (gp160) anchored in the membrane bilayer at their carboxyl terminal region. Each glycoprotein contains two segments. The N-terminal segment, called gp120 by virtue of its relative molecular weight of about 120 kD, protrudes into the aqueous environment surrounding the virion. The C-terminal segment, called gp41, spans the membrane. gp120 and gp41 are covalently linked by a peptide bond that is particularly susceptible to proteolytic cleavage. For the purpose herein, HIV env includes all forms of gp120, e.g. fusions such as gp160 or 60 gp120 fused to N-terminal fragments of gp41, variantly glycosylated or unglycosylated HIV env and T cell-binding fragments of HIV env. HIV env and its variants are conventionally prepared in recombinant cell culture. For example, see EP Publication No. 187041. Henceforth, gp41 prepared in recombinant cell culture is referred to as rgp120. Recombinant synthesis is preferred for reasons of safety and economy, but it is known to purify HIV env from viral cultures and such env preparations are included within the definition of HIV env.

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Current AIDS therapy which is directed towards protecting uninfected cells, consists of oral dosing about every four hours with nucleoside analogues (such as AZT and DDC) which inhibit viral RNA replication. Although these drugs inhibit viral replication at concentrations of 50-500 μ m, at higher concentrations (⁻¹ mM) they also inhibit the DNA polymerase of healthy cells which is required for cell division (Mitsuya and

- 5 Broder, 1985). The current therapy requires very large doses of drugs (up to a gram/day). Because the drugs are taken orally and in a form that is absorbed by all cells, the entire body is exposed to them. Toxicity is a serious limitation to their use; anemia being one of the most severe side effects. Because nucleoside derivatives must be phosphorylated before they can be incorporated into DNA (and express their chain disrupting activity) they require kinases which are not present in equal amounts in all cells susceptible to viral infection. Thus the oral nucleoside analogue therapy, which is ineffective against already infected cells is only.
- 0 infection. Thus the oral nucleoside analogue therapy, which is ineffective against already infected cells, is only able to protect those susceptible cells which can convert high concentrations of nucleosides into nucleotides (i.e., dividing cells). For these reasons this therapy is limited and the progression of the disease is only slowed. At least two kinds of immune system cells are infected by HIV (human immunodeficiency virus), monocytes, and T-lymphocytes (Streicher, 1986). Only those monocytes and T-cells which have the CD4 receptor are

15 thought to be infected by HIV (McDougal et al., 1986). A conserved region of the HIV viral coat protein (gp160) binds to the CD4 receptor which undergoes internalization and carries the RNA virus into the cell. Once inside the cell the virus makes a DNA copy of its RNA with its enzyme reverse transcriptase. Nucleoside analogues protect cells by serving as chain breakers in the transcription of viral RNA. They are incorporated into the growing polymer but lack the functional group necessary to bind the next nucleoside into the chain, thus the chain is interrupted and therefore non-functional.

- Before a nucleoside analogue can be incorporated into a strand of nucleic acid it must be phosphorylated by a kinase (converted to a nucleotide) (Furman et al., 1986). T-cells which are capable of rapid division possess high levels of kinases to phosphorylate antiviral drugs like AZT and DDC. Monocytes which divide only under special circumstances, possess relatively low levels of the requisite kinases and the nucleoside derivatives do
- 25 not protect them against infection. The simple solution would be to administer the phosphorylated form of the nucleotide analogues. These, however, are not transported across cell membranes. Thus the current nucleoside analogue therapy is ineffective in protecting monocytes from HIV infection. Lyerley et al., PNAS 84, 4601 (1987) have shown that uninfected CD4⁺ lymphocytes that have bound gp120
- become targets for antibody-dependent cellular cytotoxicity by a goat serum raised against native gp120.
 However, human sera that binds to gp120-adsorbed cells failed to direct their destruction in the presence of complement. In contrast, these sera were potent mediators of antibody dependent cellular cytotoxicity.
 - Monoclonal and polyclonal antibodies have been developed which are specific for HIV-encoded proteins see for example WO-A-8604613.

Immunotoxins (ITs) composed of cell-reactive antibodies coupled to the A chain of the ricin toxin (IT-As), have been used to specifically kill a variety of target tumor cells. Kronke et

Immunotoxins (ITs) composed of cell-reactive antibodies coupled to the A chain of the ricin toxin (IT-As), have been used to specifically kill a variety of target tumor cells. Kronke et al., in Cancer Res, 46(7) 3295 (1986) disclose killing of HTLV-I infected leukemic T cells by monoclonal anti-interleukin 2 receptor antibody-ricin A chain conjugates. See also Kronke in Blood 65(6), 1416 (1985).

- 40 Shouval et al., U.S. Patent No. 4,714,613, discloses a method of suppressing the growth of hepatitis B virus infected hepatocytes or hepatoma cells which express hepatitis B surface antigen on the surface, wherein the surface antigen is coded for by the DNA of the HBV. The Shouval et al. method comprises administering to the infected cells, complement fixing monoclonal antibody against hepatitis B surface antigen. Desiderata which may be achievable by the present invention include:
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i) to provide an improved method of treating immunoinflammatory disorders.

ii) to provide an improved method of treating AIDS with reduced side effects.

iii) to provide a method of killing non-tumorigenic cells which express virally encoded antigens on their cell surface.

HIV env is useful in the therapy of immunoinflammatory responses and disorders. The desiderata of the invention may be accomplished by administering an HIV env preparation to a patient having an immunoinflammatory response in an amount sufficient to suppress the immunoinflammatory response.

In an embodiment of this invention the HIV env polypeptide employed is the portion of HIV env that is responsible for binding of the polypeptide to the T4 cell surface marker of T helper cells. This portion of the HIV env sequence, which is referred to as the TCB domain, has been located in an unexpected region of the

molecule including residues 400 to 465. The TCB domain, including variant analogues thereof, in HIV env also is useful for the treatment of immunoinflammation. The TCB domain is useful as well in diagnostic assays for TCB domain-neutralizing antibody in patient samples.

HIV env which is devoid of a functional TCB domain is useful in vaccines for immunization against HIV infection.

- A monoclonal antibody is provided that is specific for a region of the TCB domain. This antibody appears to be directed to an epitope that is located adjacent to the sequence in the TCB domain that binds to the T4 cell surface marker. This is demonstrated by the ability of the antibody to at least partially block the binding of recombinant gp120 to the T4 cell surface marker, probably by sterically hindering access of the TCB domain to its binding site on the T4 surface antigen. This antibody also is useful in passively immunizing patients infected
- 65 with HIV with the additional advantage of binding any free HIV env that is exerting an immunosuppressive effect

on such patients.

Immunotoxins comprising a monoclonal antibody specifically binding gp160 or other virally encoded proteins, and a toxin such as ricin A chain linked to said monoclonal antibody are provided to target virally encoded proteins. Then, to the extent that the proteins which have bound the toxic conjugate are taken up by infected cells such as helper T cells, the cells are killed. The invention also relates to a method of killing virally infected cells comprising administering to a patient a therapeutically effective amount of an immunotoxin comprising a monoclonal antibody linked to a toxin which specifically binds virally encoded proteins such as gp160 on the cell surface thereby killing the infected cells.

HIV env or its immunosuppressive fragments, including the TCB domain, are conjugated to haptens or polypeptides capable of binding a cell population against which a cytotoxic T cell cytolytic response is desired. These conjugates have particular utility as antitumor agents or in the treatment of allergic responses.

HiV env is defined as envelope protein of Human Immunodeficiency Virus as described above, together with its immunosuppressive amino acid sequence variants and derivatives produced by covalent modification of HIV env or its variants in vitro. Variants include HIV env in which one or more residues have been substituted in the env amino acid sequence, deletions of one or more residues in the env sequence and insertions of one or more residues therein.

The principal deletion variants of interest are those in which immune epitopes other than the TCB domain have been deleted, or the converse in which the TCB domain has been deleted but the remaining epitopes of HIV env remain. Each of these deletion variants, as well as further substitutional variants are described in more detail below. Another class of variants are those in which a polypeptide heterologous to HIV env is fused to the amino or carboxyl terminus of the HiV env sequence or an immunosuppressively active fragment thereof, e.g. the TCB domain. Alternatively, HIV env or its TCB fragment is covalently bonded to the heterologous polypeptide or to a hapten. Another class of TCB domain variants is produced by fusing the TCB domain to HIV immune epitopes other than those which may normally flank the TCB domain in native HIV env, in particular other than the TCB domain C-terminal flanking sequence FRPGGGDMRDNWRSELYKYKV.

The fusions of the HIV env TCB domain with an immunogenic hapten or polypeptide are useful as vaccine components for the immunization of patients against HIV infection. Fusions of the hapten or heterologous polypeptide with HiV env or its active fragments are useful in directing cytotoxic T cells against target cells where the hapten or heterologous polypeptide is capable of binding to a target cell surface receptor or other binding partner. For example, membrane-bound transforming growth factor- α (TGF- α) is present on the surface of many solid (non-hematopoietic) neoplastic tumors. Antibodies capable of binding TGF- α are known. Such antibodies are linked to HIV env or its TCB domain-containing fragments, e.g. by covalent crosslinking (33), or by expression in recombinant cell culture as an N- or C-terminal fusion with HIV env or its TCB domain-containing fragment. The latter alternative is accomplished by obtaining DNA encoding the TGF- α antibody in the fashion generally described in EP 125,023A. This DNA is ligated by the use of appropriate adaptors to the DNA encoding the amino or carboxyl terminus of gp120 or its TCB domain-containing fragments, inserted into a mammalian cell expression vector such as is described in EP 187,041A and the vector used to transform a suitable host cell such as CHO cells or others described in EP 187,041A. Optionaliy, DNA encoding the variable region of the TGF- α antibody is ligated to DNA encoding the TCB domain in place of the human constant regions described in EP 184,187; EP 194,276A; EP 171,496A; or Bouliamne et al. (32). The resulting fusions are recovered, e.g. by adsorption to immobilized TGF-α or immobilized antibody directed against the constant region of the TGF-a antibody when the constant region is retained, formulated into a therapeutically acceptable vehicle, e.g. physiological saline, and administered to patients bearing TGF-a expression neoplasms. The fusions will direct cytotoxic T cells to tumors having TGF-a cell surface antigens, resulting in lysis of the tumor cells. Similarly, the TCB domain is fused to an antigen against which a patient is raising an undesirable immune response, e.g. as in an allergic or transplantation rejection episode, and administered to a patient in doses sufficient to target an autoimmune cytotoxic T cell response to the clonal cells responsible for the undesirable response.

The TCB domain of HIV env is believed to include the region extending from about nucleotide 7006 to about nucleotide 7203 of the HIV strain described in EP 187,041A, or the equivalent region of other HIV strains (the 50 same nucleotide and amino acid residue numbers may not be applicable in other strains where upstream deletions or insertions change the length of the viral genome and HIV env, but the region encoding this portion of the TCB domain in each strain is readily identified by amino acid sequence homology. The TCB domain includes the sequence:

TEGSNN	TEGSDTITLE	PCRIKQFINM	JQEVGKAMYAI	PISCQIKCS	SNITGLLLTRI	OGGNNNNE	SEI
				440			
400	410	420	430		450	460	465

particularly the sequence falling within residues 411-454, 416-443 and 420-442. In Table 1 below, the amino acid sequences of the TCB domains from a plurality of HIV stains are shown in the right column under "origin" while predetermined variant TCB domains are shown in the left column. The variant identified as SL22,1D3" (variant 1) led to the identification of this portion of the TCB domain for HIV. Deletion of the $\Delta 3$ residues from rgp120 by site-directed M13 mutagenesis and expression of the variant in recombinant CHO cell culture otherwise as

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shown in EP 187,041 resulted in the abolition of the T4 binding capacity of rgp120, notwithstanding that the rgp120 was indistinguishable from rgp120 based on assays such as binding by selected AIDS patient sera. Surprisingly, the $\Delta 3$ region is not highly conserved among a number of HIV strains, as can be appreciated by comparison with the homologous sequences from other HIV strains than BH10 shown in Table 1, and the TCB domain as a whole contains regions of HIV <u>env</u> characterized as highly variable (34). It would have been expected that only highly conserved regions would have the constancy suitable to ensure that the virus could always recognize the T4 receptor and thereby infect permissive host cells, but this hypothesis has not

withstood investigation. For example, deletion of the first 29 amino terminal residues of HIV env had no effect on T4 binding of rgp120, despite the fact that resides 5-31 are highly conserved among various HIV strains.



The variants designated in Table 1 by numbers 2-15 are expected to modify or eliminate the T4 binding characteristics of rgp120. For example, substitution for alanine by aspartic acid at position 431 reduced the 65

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binding of the variant to about 10-15% of that exhibited by rpg120 bearing the native sequence. However, substitution of lys₄₃₀ with glutaminyl, tyr₄₃₃ with phenylalanyl, and pro₄₃₅pro₄₃₆ with valylvalyl did not result in any change in rgp120 binding detectable by our assays. Accordingly, each variant will be screened by routine assays in order to determine its activity. In the light of the role of the Ala₄₃₁ residue, substitutions, deletions or

- 5 insertions at this site are particularly preferred, including substitutions by histidine, tryptophan, proline, phenylalanine, glycine, leucine, isoleucine, methionine, valine, serine, threonine, tryosine, glutamine, asparagine, lysine, glutamic acid, cysteine and arginine, or insertions by such residues or aspartic acid adjacent to Ala₄₃₁. Such variants, as well as the Δ 3 variant, are useful in preparing HIV env antigens for use in diagnostic assays or vaccines. HIV env which is free of the TCB domain is particularly useful in vaccines
- 10 because it is not immunosuppressive but nonetheless retains as many of the remaining gp120 eptitopes as are desired, thereby leading to higher titers of anti-HIV and prolongation of the titers. Other variants will be apparent to the ordinary artisan. For example, substitutions are made within residues 416-442 in order to identify variants that act as HIV env agonists. Deletions or insertions also can be introduced into the TCB domain and evaluated for agonist activity. "Agonist" in this context means that the HIV env activity of the
- 15 variant is enhanced in comparison to the native molecule (for example the variant exerts higher affinity for T4 than does native HIV env). It will be understood, however, that this activity is antagonistic to infectivity by HIV. HIV env agonist analogues are useful as agents for the treatment of undesirable immunoinflammatory events in the same fashion as described herein for intact or native HIV env. Agonist analogues are administered to AIDS or ARC patients in the treatment of HIV infection, optionally together with tumor necrosis factor α, tumor
- 20 necrosis factor β, an interferon, and/or other therapeutic agents for the treatment of HIV infections, e.g., AZT. HIV env agonist activity is measured in the fluorescence activated cell sorter system described in the example below by measuring the ability of the agonist to compete with labelled rgp120 or native gp120, or with fluorescein isothiocyanate-conjugated anti-T4A antibody, for binding to the T4 receptor. This ability of the candidate variant to compete with the labelled conjugates for T cell binding in PBMC is one measure of its activity: The greater the competition with labelled conjugates by the varianet for the T4 binding site, the greater

is the variant's agonist activity.

The HIV env TCB domain or its variants are produced by methods known per se. One method is to synthesize the TCB domains by in vitro procedures such as Merrifield synthesis. Another method is to prepare the domains in recombinant cell culture. It is practical to prepare DNA encoding the domain by conventional in

- 30 vitro methods, providing suitable 5' and 3' adaptors or linkers to facilitate ligation into conventional vectors for bacterial expression. In one preferred embodiment the DNA encoding the domain is ligated at its 5' end to DNA encoding a signal sequence recognized by the host cell. Examples of such signals are well known and include the STII, alkaline phosphatase, <u>Ipp</u>, and penicillinase signals. Certain heterologous signals are also recognized by bacteria, e.g. mammalian or yeast signals. Since the DNA encoding such signals is only about
- 45 to 75 nucleotides in length, one would prepare and ligate signal DNA to the 5' end of the DNA encoding the TCB domain, ligate the fusion gene into a conventional vector, e.g. pBR322, transfect host <u>E. coli</u>, culture the cells and determine the amount of TCB domain secreted into the periplasm of the host cell. Alternatively, the TCB domain is synthesized in recombinant cell culture as a secreted or non-secreted fusion which is recovered.
- An antibody capable of blocking or binding the TCB domain is obtained by immunizing mice such as Balb/c or, preferably C57 black/6, against gp120 and screening for a clonal antibody that, when preincubated with gp120, prevents its binding to the T4 T cell marker. The 5C2E5 antibody is an example of such an antibody, but is not unique since other antibodies having the same qualitative activity can be obtained by the method described herein. "Qualitative" activity means that the antibody binds to the T4 binding site of HIV env or a
- 45 flanking region, in the latter situation binding in such a way as to sterically hinder the binding of rgp120 or HIV env to the T4 site. A tryptic digest of the 44 residue TCB domain showed that the 5C2E5 antibody bound the peptide spanning residues 420-430. This domain is thus included in the TCB domain or is immediately adjacent thereto. The 5C2E5 antibody was found in about 1 out of 500 myeloma fusions with murine B cells recovered from mice immunized against gp120. An additional blocking antibody is 7F11, which binds to the peptide spanning residues 430-459.
- Spanning residues 430-459. The TCB domain binding characteristics of antibody 5C2E5 are defined as the ability to inhibit the binding of rgp120 to the T4 receptor of helper lymphocytes. Monoclonal antibodies other than 5C2E5 which are capable of doing so are included within the scope of this definition, despite any differences in affinity, immunoglobulin class, species of origin, or exact TCB sequence, as are antibodies which are expressed in recombinant cell
- culture or that are predetermined amino acid sequence variants of the 5C2E5 antibody, e.g. chimeras of the variable region of the 5C2E5 antibody and the human constant region.
 The antibody described herein is recovered from hybridoma cell cultures by conventional methods for purification of IgG or IgM as the case may be that heretofore have been used to purify these immunoglobulins from pooled plasma, e.g. ethanol or polyethylene glycol precipitation procedures. The purified antibody is sterile filtered and optionally conjugated to a cytotoxin such as ricin for use in AIDS therapy or conjugated to a

detectable marker such as an enzyme or spin label for use in diagnostic assays of HIV in test samples. A new application of immunotoxins has been discovered. Surprisingly, it has been found that an

immunotoxin specifically binding virally induced surface antigen of non-tumorigenic virus infected cells, kills the infected cells. Specifically immunotoxins binding gp160, kill HIV infected cells.

65 Described below is a treatment designed to kill cells that are already infected and are actively producing new

virus. Killing is accomplished by an immunotoxin that binds to viral coat protein which is expressed on infected cells. The immunotoxin is then internalized and kills the cell. Infected cells that have incorporated viral genome into their DNA but are not synthesizing viral protein (i.e., cells in which the virus is latent) may not be susceptible to killing by immunotoxin until they begin to synthesize virus.

It has been discovered that cells infected with HIV that are actively producing virus, express viral coat protein (gp160) on their plasma membrane. This molecule represents an infected-cell-specific antigen that can be used to target and kill infected cells. Monoclonal antibodies specific for a conserved region (strain independent) on the gp160 can be used as targeting molecules to deliver toxins to infected cells. Additionally or alternatively, a "cocktail" of immunotoxins against nonconserved regions is used. In addition the toxin-antibody conjugate can bind to circulating viruses or viral coat protein which will then effect killing of cells that internalize virus or coat protein.

The subject invention provides a highly selective method of destroying HIV infected cells. Because the antibodies specifically bind antigen not present in the cells when not infected, the method permits the antibody to pinpoint with great accuracy cells to be destroyed. Unlike tumor treatment with immunoconjugates where loss of antigen occurs and resistance develops, with active virus infection antigen expression always occurs.

While not wishing to be constrained to any particular theory of operation of the invention, it is believed that the expression of the target antigen on the infected cell surface is transient. The antibodies must be capable of reaching the site on the cell surface where the antigen resides and interacting with it. After the antibody complexes with the antigen, endocytosis takes place carrying the toxin into the cell.

The immunotoxins are particularly helpful in killing monocytes/macrophages infected with the HIV virus. In contrast to the transient production of virus from T cells, macrophages produce high levels of virus for long periods of time. Current therapy is ineffective in inhibiting the production of new viruses in these cells.

Not all monoclonal antibodies specific for gp160 make highly cytotoxic immunotoxins when coupled to ricin A chain (IT-As). An assay was developed which is used to predict the ability of an antibody to function as part of an IT-A. Using this assay, a variety of anti-HIV antibodies were screened for their ability to make effective IT-As against HIV-infected cells. Results demonstrate that only some HIV-specific antibodies make effective IT-As. These antibodies are purified, coupled to ricin A chain and used to specifically kill HIV-infected cells. Advantageously the antibodies cross react with several (or all) strains of HIV.

Immunotoxins can be made in a variety of ways (see detailed discussion below). Several crosslinking reagents can be used to make the conjugate to yield stable conjugates.

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In a preferred embodiment, ricin A chain is deglycosylated or produced without oligosaccharides, to decrease its clearance by irrelevant clearance mechanisms (i.e., the liver). In another embodiment, whole ricin (A chain plus B chain) is conjugated to antibody if the galactose binding property of B-chain can be blocked ("blocked ricin").

In a further embodiment toxin-conjugates are made with Fab or (F(Ab')₂ fragments. Because of their 35 relatively small size these fragments can better penetrate tissue to reach infected cells.

Antibodies

In accordance with this invention, monoclonal antibodies specifically binding an epitope of gp160 or antigenically active, cell surface-exposed fragments thereof (for example epitopes chosen frm gp120, gp41, the TCB and the like) were isolated from continuous hybrid cell lines formed by the fusion of antigen-primed immune lymphocytes with myeloma cells. Advantageously, the monoclonal antibodies of the subject invention which bind gp160, bind the domain of this protein which is exposed on the cell surface. In another embodiment of the invention, polyclonal antibodies specifically binding gp160 are used.

The antibodies of the subject invention are obtained through screening. An assay is used for screening monoclonal antibodies for their cytotoxic potential as ricin A chain containing immunotoxins. The assay involves treating cells with dilutions of the test antibody followed by a Fab fragment of a secondary antibody coupled to ricin A chain ("indirect assay"). The cytotoxicity of the indirect assay is compared to that of the direct assay where the monoclonal antibody is coupled to ricin A chain. The indirect assay accurately predicts the potency of a given monoclonal antibody as an immunotoxin and is thus useful in screening monoclonal antibodies for use as immunotoxins - see also Vitetta et al., Science 238: 1098-1104 (1987), and Weltman et al., Cancer Res, 47, 5552 (1987), hereby incorporated by reference.

Monoclonal antibodies are highly specific, being directed against a single antigenic site. Furthermore, in contrast to conventional antibody (polyclonal) preparations which typically include different antibodies directed against different determinants (epitopes), each monoclonal antibody is directed against a single determinant on the antigen. Monoclonal antibodies are useful to improve the selectivity and specificity of diagnostic and analytical assay methods using antigen-antibody binding. A second advantage of monoclonal antibodies is that they are synthesized by the hybridoma culture, uncontaminated by other immunoglobulins. Monoclonal antibodies may be prepared from supernatants of cultured hybridoma cells or from ascites induced by intra-peritoneal inoculation of hybridoma cells into mice.

The hybridoma technique described originally by Kohler and Milstein, Eur. J. Immunol. 6, 511 (1976) has been widely applied to produce hybrid cell lines that secrete high levels of monoclonal antibodies against many specific antigens.

The route and schedule of immunization of the host animal or cultured antibody-producing cells therefrom are generally in keeping with established and conventional techniques for antibody stimulation and production.

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Applicants have employed mice as the test model although it is contemplated that any mammalian subject including human subjects or antibody producing cells therefrom can be manipulated according to the processes of this invention to serve as the basis for production of mammalian, including human, hybrid cell lines.

- After immunization, immune lymphoid cells are fused with myeloma cells to generate a hybrid cell line which can be cultivated and subcultivated indefinitely, to produce large quantities of monoclonal antibodies. For purposes of this invention, the immune lymphoid cells selected for fusion are lymphocytes and their normal differentiated progeny, taken either from lymph node tissue or spleen tissue from immunized animals. Applicants prefer to employ immune spleen cells, since they offer a more concentrated and convenient source of antibody producing cells with respect to the mouse system. The myeloma cells provide the basis for
 - continuous propagation of the fused hybrid. Myeloma cells are tumor cells derived from plasma cells. It is possible to fuse cells of one species with another. However, it is preferred that the source of immunized antibody producing cells and myeloma be from the same species.
- The hybrid cell lines can be maintained in culture in vitro in cell culture media. The cell lines of this invention can be selected and/or maintained in a composition comprising the continuous cell line in the known hypoxanthine-aminopterin-thymidine (HAT) medium. In fact, once the hybridoma cell line is established, it can be maintained on a variety of nutritionally adequate media. Moreover, the hybrid cell lines can be stored and preserved in any number of conventional ways, including freezing and storage under liquid nitrogen. Frozen cell lines can be revived and cultured indefinitely with resumed synthesis and secretion of monoclonal antibody. The secreted antibody is recovered from tissue culture supernatant by conventional methods such
- as precipitation, ion exchange chromotography, affinity chromatography, or the like. While the invention is demonstrated using mouse monoclonal antibodies, the invention is not so limited; in fact, human antibodies may be used and may prove to be preferable. Such antibodies can be obtained by using human hybridomas (Cote <u>et al., Monoclonal Antibodies and Cancer</u> Therapy, Alan R. Liss, p. 77 (1985)). In fact,
- according to the invention, techniques developed for the production of "chimeric antibodies" (Morrison et al., Proc. Natl. Acad. Sci. 81, 6851 (1984); Neuberger et al., Nature 312, 604 (1984); Takeda et al, Nature 314, 452 (1985)) by splicing the genes from a mouse antibody molecule of appropriate antigen specificity together with genes from a human antibody molecule of appropriate biological activity (such as ability to activate human complement and mediate ADCC) can be used; such antibodies are within the scope of this invention.
- 30 As another alternative to the cell fusion technique, EBV immortalized B cells are used to produce the monoclonal antibodies of the subject invention. Other methods for producing monoclonal antibodies such as recombinant DNA, are also contemplated.
 - The immunochemical derivatives of the antibodies of this invention that are of prime importance are immunotoxins (conjugates of the antibody and a cytotoxic moiety). The antibodies are also used to induce lysis through the natural complement process, and to interact with antibody dependent cytotoxic cells normally present.

Immunotoxins

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- The cytotoxic moiety of the immunotoxin may be a cytotoxic drug or an enzymatically active toxin of bacterial, fungal, plant or animal origin, or an enzymatically active fragment ("A chain") of such a toxin. Enzymatically active toxins and fragments thereof used are diphtheria A chain, nonbinding active fragments of diphtheria toxin, exotoxin A chain (from Pseudomonas aeruginosa), ricin A chain, abrin A chain, modeccin A chain, alpha-sarcin, <u>Aleurites fordii</u> proteins, dianthin proteins, <u>Phytolacca americana</u> proteins (PAPI, PAPII, and PAP-S), momordica charantia inhibitor, curcin, crotin, sapaonaria officinalis inhibitor, gelonin, mitogellin,
- 45 restrictocin, phenomycin, enomycin and the tricothecenes. In another embodiment, the antibodies are conjugated to small molecule anticancer drugs. Conjugates of the monoclonal antibody and such cytotoxic moieties are made using a variety of bifunctional protein coupling agents. Examples of such reagents are SPDP, IT, bifunctional derivatives of imidoesters such a dimethyl adipimidate HCl, active esters such as disuccinimidyl suberate, aldehydes such as glutaraldehyde, bis-azido compounds such as bis (p-azidoben-
- 50 zoyl) hexanediamine, bis-diazonium derivatives such as bis-(p-diazoniumbenzoyl)-ethylenediamine, diisocyanates such as tolylene 2,6-diisocyanate and bis-active fluorine compounds such as 1,5-difluoro-2,4-dinitrobenzene. The lysing portion of a toxin may be joined to the Fab fragment of the antibodies. Advantageously, monoclonal antibodies specifically binding the domain of the protein which is exposed on
- the infected cell surface, are conjugated to ricin A chain. Most advantageously the ricin A chain is deglycosylated and produced through recombinant means. An advantageous method of making the ricin immunotoxin is described in Vitetta et al., Science 238, 1098 (1987) hereby incorporated by reference. When used to kill infected human cells in vitro for diagnostic purposes, the conjugates will typically be added to the cell culture medium at a concentration of at least about 10 nM. The formulation and mode of administration for invitro use are not critical. Aqueous formulations that are compatible with the culture or
- 60 perfusion medium will normally be used. Cytotoxicity may be read by conventional techniques. Cytotoxic radiopharmaceuticals for treating infected cells may be made by conjugating radioactive isotopes (e.g. I, Y, Pr) to the antibodies. Advantageously alpha particle emitting isotopes are used. The term "cytotoxic moiety" as used herein is intended to include such isotopes.

In another embodiment, fusogenic liposomes are filled with a cytotoxic drug and the liposomes are coated with antibodies specifically binding gp160.

Antibody Dependent Cellular Cytotoxicity

The present invention also involves a method based on the use of antibodies which are (a) directed against gp160, and (b) belong to a subclass or isotype that is capable of mediating the lysis of HIV virus infected cells to which the antibody molecule binds. More specifically, these antibodies should belong to a subclass or isotype that, upon complexing with cell surface proteins, activates serum complement and/or mediates antibody dependent cellular cytotoxicity (ADCC) by activating effector cells such as natural killer cells or macrophages.

The present invention is also directed to the use of these antibodies, in their native form, for AIDS therapy. For example, IgG2a and IgG3 mouse antibodies which bind HIV-associated cell surface antigens can be used in vivo for AIDS therapy. In fact, since gp160 is present on infected monocytes and T-lymphocytes, the subject antibodies and their therapeutic use have general applicability.

Biological activity of antibodies is known to be determined, to a large extent, by the Fc region of the antibody molecule (Uananue and Benacerraf, <u>Textbook of Immunology</u>, 2nd Edition, Williams & Wilkins, p. 218 (1984)). This includes their ability to activate complement and to mediate antibody-dependent cellular cytotoxicity (ADCC) as effected by leukocytes. Antibodies of different classes and subclasses differ in this respect, and, according to the present invention, antibodies of those classes having the desired biological activity are selected. For example, mouse immunoglobulin of the IgG3 and IG2a class are capable of activating serum complement upon binding to the target cells which express the cognate antigen.

In general, antibodies of the IgG2a and IgG3 subclass and occasionally IgG1 can mediate ADCC, and antibodies of the IgG3, and IgG2a and IgM subclasses bind and activate serum complement. Complement activation generally requires the binding of at least two IgG molecules in close proximity on the target cell. However, the binding of only one IgM molecule activates serum complement.

The ability of any particular antibody to mediate lysis of the target cell by complement activation and/or ADCC can be assayed. The cells of interest are grown and labeled in vivo; the antibody is added to the cell culture in combination with either serum complement or immune cells which may be activated by the antigen antibody complexes. Cytolysis of the target cells is detected by the release of label from the lysed cells. In fact, antibodies can be screened using the patient's own serum as a source of complement and/or immune cells. The antibody that is capable of activating complement of mediating ADCC in the in vitro test can then be used therapeutically in that particular patient.

Antibodies of virtually any origin can be used according to this embodiment of the present invention provided they bind a gp160 epitope and can activate complement or mediate ADCC. Monoclonal antibodies offer the advantage of a continuous, ample supply. In fact, by immunizing mice with gp160 establishing hybridomas making antibodies to gp160 and selecting hybridomas making antibodies which can lyse infected cells in the presence of human complement, it is possible to rapidly establish a panel of antibodies capable of reacting with and lysing infected cells.

Therapeutic Uses of the Antibodies

When used in vivo for therapy, the antibodies of the subject invention are administered to the patient in
therapeutically effective amounts (i.e. amounts that restore T cell counts). They will normally be administered
parenterally. The dose and dosage regimen will depend upon the degree of the infection, the characteristics of
the particular immunotoxin (when used), e.g., its therapeutic index, the patient, and the patient's history.
Advantageously the immunotoxin is administered continuously over a period of 1-2 weeks, intravenously to
treat cells in the vasculature and subcutaneously and intraperitoneally to treat regional lymph nodes.
Optionally, the administration is made during the course of adjunct therapy such as combined cycles of tumor45

For parenteral administration the antibodies will be formulated in a unit dosage injectable form (solution, suspension, emulsion) in association with a pharmaceutically acceptable parenteral vehicle. Such vehicles are inherently nontoxic, and non-therapeutic. Examples of such vehicles are water, saline, Ringer's solution, dextrose solution, and 5% human serum albumin. Nonaqueous vehicles such as fixed oils and ethyl oleate can also be used. Liposomes may be used as carriers. The vehicle may contain minor amounts of additives such as substances that enhance isotonicity and chemical stability, e.g., buffers and preservatives. The antibodies will typically be formulated in such vehicles at concentrations of about 1 mg/ml to 10 mg/ml.

IgM antibodies are advantageous since the antigen is highly specific for the target cells and rarely occurs on normal cells. IgG molecules by being smaller may be more able than IgM molecules to localize to infected cells.

There is evidence that complement activation in vivo leads to a variety of biological effects, including the induction of an inflammatory response and the activation of macrophages (Uananue and Benecerraf, <u>Textbook of Immunology</u>, 2nd Edition, Williams & Wilkins, p. 218 (1984)). The increased vasodilation accompanying inflammation may increase the ability of various anti-AIDS agents to localize in infected cells. Therefore, antigen-antibody combinations of the type specified by this invention can be used therapeutically in many ways. Additionally, purified antigens (Hakomori, <u>Ann. Rev. Immunol. 2</u>, 103 (1984)) or anti-idiotypic antibodies (Nepom <u>et al., Proc. Natl. Acad. Sci. 81</u>, 2864 (1985); Koprowski <u>et al., Proc. Natl. Acad. Sci. 81</u>, 216 (1984)) relating to such antigens could be used to induce an active immune response in human patients. Such a response includes the formation of antibodies capable of activating human complement and mediating ADCC and by such mechanisms cause infected cell destruction.

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The antibody of the subject invention also is useful in the diagnosis of HIV in test samples. It is employed as one axis of a sandwich assay for HIV env, together with a polyclonal or monoclonal antibody directed at another sterically-free epitope of HIV env. For use in some embodiments of sandwich assays the 5C2E5 antibody or its equivalent is bound to an insolubilizing support or is labelled with a detectable moiety following

conventional procedures used with other monoclonal antibodies. In another embodiment a labelled antibody, e.g. labelled goat anti-murine IgG, capable of binding the 5C2E5 antibody is employed to detect HIV env binding using procedures previously known per se.

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Finally, in another embodiment the antibody is immobilized on a water insoluble support and used for the immunoaffinity purification of HIV env, rgp120 or the TCB domain as is described below in greater detail. Any known procedure for immobilizing monoclonal antibodies can be used for this purpose.

In general, the inflammatory or immune-potentiated inflammatory events to be treated with HIV env are characterized by humoral and/or cytotoxic cellular responses directed against foreign or self target tissue which are not desirable in the therapeutic context concerned. Typically, immune-potentiating inflammatory events are characterized by the generation of antibodies and/or a cytotoxic T cell response directed against

- (1) a host antigen as in the case of undesirable autoimmune diseases or in graft versus host disease, or (2) antigens present in grafted tissue, e.g. organ transplants. Such events are clinically characterized by infiltration of polymorphonuclear neutrophils and mononuclear leukocytes into the target tissue, pain, localized edema, possible vascular endothelial injufry and excessive production of cytokines by stimulated cells.
- 20 The HIV <u>env</u> compositions to be used in the therapy will be formulated and dosages established in a fashion consistent with good medical practice taking into account the disorder to be treated, the condition of the individual patient, the site of delivery of the <u>env</u> polypeptide, the method of administration and other factors known to practitioners.

HIV env is prepared for administration by mixing HIV env at the desired degree of purity with physiologically acceptable carriers, i.e., carriers which are nontoxic to recipients at the dosages and concentrations employed. Ordinarily, this will entail combining HIV env with buffers, low molecular weight (less than about 10 residues) polypeptides, proteins, amino acids, carbohydrates including glucose or dextrans, chelating agents such as EDTA, and other excipients. HIV env for use in therapeutic administration must be sterile. This is readily accomplished by sterile filtration through (0.2 micron) membranes. HIV env ordinarily will be stored as lyophilized formulations for reconstitution, but is stable for storage as an aqueous formulation.

- Generally, where the disorder permits, one should formulate and dose the HIV env for site-specific delivery. This is convenient in the case of RA and inflammatory bowel disease. In the former case, HIV env is formulated into a sterile sustained release composition suitable for injection into the synovial fluid or implantation into the synovial lining or capsule. In the case of inflammatory bowel disease, the HIV env is formulated into
- 35 suppositories with pharmaceutically acceptable oleaginous substances as are generally known in the art. Sustained release formulations will be selected from the classes of microcapsular particles and implantable articles. Liposomal encapsulation is not preferred for injection directly into the synovial cavity in RA because it entails the introduction of lipid into the joint. However, liposomal encapsulation is suitable for implementation of sustained release HIV env into the synovial capsule. For the treatment of RA using sustained-release HIV
- 40 <u>env</u>, the HIV <u>env</u> is preferably incorporated into a biodegradable matrix or microcapsule. A suitable material for this purpose is a polylactide, although other polymers of poly (α- hydroxycarboxylic acids), such as poly-D-(-)-3-hydroxybutyric acid (EP 133,988A), can be used. Other biodegradable polymers include poly(lactones), poly(acetals), poly(orthoesters) or poly(orthocarbonates). The initial consideration here must be that the carrier itself, or its degradation products, is nontoxic in the target tissue and will not further
- 45 aggravate the disease. This can be determined by routine screening in animal models of the target disorder or, if such models are unavailable, in normal animals. For examples of sustained release compositions, see U.S. patent 3,773,919, EP 58,481A, U.S. patent 3,887,699, EP 158,277A, Canadian patent 1176565, U. Sidman et al., "Biopolymers" 22:547 [1983], and R. Langer et al., "Chem. Tech." 12:98 [1982].
- The dosage of HIV <u>env</u> to be employed is dependent upon numerous factors, including the T4 binding affinity of the HIV <u>env</u> preparation, the half-life of the <u>env</u> preparation, the route of administration, the clinical condition of the patient (including the presence of infections), the presence of anti-HIV <u>env</u> antibodies, and whether or not the HIV <u>env</u> is to be used for the prophylaxis or for the treatment of acute autoimmune or transplant rejection episodes. As a general proposition, the HIV <u>env</u> dose delivered at the target site should be about from 0.5 x 10⁻⁸M to 5 x 10⁻⁹M. Typically, the HIV <u>env</u> concentrations in the therapeutic dosage forms should

55 be delivered by continuous infusion, sustained release of injection at empirically determined frequencies. Since RA synovial fluid can be present in amounts up to 50 ml, for example in a knee joint, the actual amount of HIV env will depend upon its dilution into the synovial fluid as well as the empirically determined losses of HIV env to endogenous proteases, leakage into the general circulation and sequestration by any anti-HIV env that is present. Thus it is best to evaluate the efficacy of the initial dosage protocol by withdrawing synovial fluid

60 samples for HIV env T4 binding assay during early stages of treatment in order to determine the proper dosage regimen.

The HIV <u>env</u> therapy may be delivered in concert with other anti-inflammatory substances such as salicylate, nonsteroidal anti-inflammatory drugs, penicillamine, gold salts, TGF- β , TNF- α or TNF- β antagonists (described in copending U.S.S.N. 898,272), γ -interferon antagonists and/or IL-1 antagonists. It is not necessary that such substances in block of the link environment of the link environment of the second second

65 substances be included in the HIV env compositions per se, but the anti-inflammatory substances can be

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formulated together with HIV env.

HIV env concentrations localized at the sites of inflammation may exceed the whole body maximum therapeutic dose. Assay of the HIV env concentration in inflammatory infiltrates will provide guidance as to the amount of HIV env to be intravenously injected, particularly if localized administration is impractical. The key factor in selecting an appropriate dose is the result obtained. If the patient's inflammatory response does not at least partially resolve within about 48 hours after administration, the dose should be gradually elevated until the desired effect is achieved. Correspondingly higher doses of HIV env preparations having lower T4 binding capacity and/or lower affinity for T4 will be required, and vice versa for preparations with greater capacity and affinity. Also, relatively higher doses initially will be needed for the treatment for acute rejection or inflammatory episodes, i.e., for patients in acute organ transplant rejection or undergoing arthritic flares.

In view of the therapeutic urgency attendant acute rejection episodes, HIV env should be intravenously infused or introduced at the inflammatory lesion immediately upon the development of symptons or serological evidence of rejection. On the other hand, prophylaxis is suitable accomplished by intramuscular or subcutaneous administration.

The invention will be more fully understood by reference to the following examples. They should not, *15* however, be construed as limiting the scope of the invention. All literature citations are incorporated by reference.

EXAMPLE 1

It has been shown that the initial event in T-helper infection with HIV involves the selective interaction between HIV envelope glycoproteins and the T4 surface structure (1-6,15,23-26). More specifically, McDougal et al, showed that HIV can selectively bind to the T4A epitope of the T4 antigen complex (25). Further, much of the impaired immunologic functions in patients infected with AIDS virus have been linked to the selective ability of HIV to infect and eventually destroy the helper cell population (1,2,9,10). It has also been suggested that PBMC from AIDS patients are hyporesponsive to mitogenic and antigenic, particularly tetanus toxoid, stimulation (12) possibly due to HIV associated depletion of helper cell function. This Example was directed principally at determining the activity of rgp120 on the tetanus toxoid response in normal PBMC.

Materials and Methods

Recombinant HIV envelope glycoprotein (rgp120):

Chinese hamster ovary cells transfected with an HIV envelope gene expression plasmid (20) were used for the production of the rgp120 used in these samples. The rgp120 was purified from the conditioned cell culture medium by immunoaffinity chromatography and was > 98% pure as determined by SDS-polyacrylamide electrophoresis.

Isolation of peripheral blood mononuclear cells (PBMC):

Heparinized syringes were used for the collection of blood from healthy donors. Each blood sample was diluted with an equal volume of saline, layered on a Ficoll-Hypaque gradient (sp.gr.1.08) and centrigued at 400xg for 40 min. at room temperature. PBMC at the plasma-Ficoll interface were removed, washed three times in Hank's balanced salt solution (HBSS) (Gibco; Grand Island Biological Co, Grand Island, NY), resuspended in complete medium and counted. Cell viability as determined by trypan blue exclusion was consistently greater than 95%.

Culture medium:

RPMI 1640 medium purchased from Gibco was used. It was supplemented with 10% heat inactivated fetal bovine serum (Hyclone, Logan, Utah), 2mM L-glutamine, 10 mM HEPES, penicillin/streptomycin (Gibco), and 5 x 10^{-5} . M2-mercapteothanol (Sigma, St. Lous, MO). The same medium, without 2-mercaptoethanol was used for polyclonal activation. RPMI 1640 with 2% heat Inactivated fetal bovine serum was used for staining of cells with monoclonal antibodies.

Tetanus toxoid (TT) induced proliferative activities:

The RPMI 1640 medium used for this assay was supplemented with 10% autologous plasma, 2 mM L-glutamine and antibiotics. PBMC were cultured in quadruplicate as 10⁵ cells in 200 µl medium per well in a microtiter plate in the presence or absence of TT (obtained from Dr. A Muchmore, National Cancer Institute, Bethesda, MD) at a final dilution of 1L300 as established by preliminary experiments for attainment of optimal response. Replicate cultures containing various concentrations of rgp120 were established in parallel. After six days of incubation when peak responses occurred, cultures were pulsed with [³H]-thymidine, processed and counted as described above.

Staining of cells with monoclonal antibodies;

Fluorescein isothiocyanate (FITC) conjugated monoclonal antibodies (MAb) OKT3 OKT4, OKT4A, and OKT8 were purchased from Ortho Diagnostic Systems, Inc., (Raritan, N.J.). Aliquots of cells (10⁶/50µl) were mixed with FITC-conjugated OKT3, OKT4, OKT4A, OKT8 or the murine IgG2ab control (5µl). After 40 min. of incubation on ice, the cells were washed twice in media, fixed in 2% paraformaldehyde and samples were

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analysed using a fluorescein activated cell sorter (FACS IV, Becton Dickinson, Mt. View CA) equipped with a 4 watt argon laser at a wavelength of 488 nm. Ten thousand cells were aquired by list mode and measurements were performed on a single cell basis and were displayed as frequency distribution histograms (21). Dead cells and debris were gated out of the analysis on the basis of forward light scatter. The data are expressed as percent specifically stained cells (number of fluroescein labeled cells/number of cells analyzed x 100) less non

5 specific staining (IgG2ab-FITC control). The mean channel of intensity of stained cells was also determined but is not presented.

Statistical analysis:

The data were analyzed by the paired design Student's test and by analysis of variance for multiple group 10 comparison.

Results

The influence of rgp120 on PBMC response to a soluble specific antigen was investigated. Six experiments were performed in which TT was used as the stimulus with and without rgp120 added to the cultures. The 15 results are presented in Table 2, demonstrating that rgp120 can cause significant inhibition (p = 0.05) of PBMC proliferative response to a specific antigen in normal PBMC. The extent of inhibition varied in these five experiments ranging from 19 to 51 percent of control values. No inhibition was observed in experiment No. 6 (not shown).

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Table 2

rgp120 inhibition of TT-induced PBMC proliferative response

	[³ H]-Thymidine Incorporated, cpm x 10			
Exp. No.	Control	+rgp120	% inhibitio	
1	199	145	27	
2	144	115	21	
3	60	49	19	
4	90	44	51	
5	52	23	43	

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Interaction of rgp120 with various T-cell subsets:

It has been suggested that infection of T-cells by HIV is initiated by the selective interaction of the virus envelope glycoproteins with the T4 component of the T-helper membrane receptor complex (1-6,15,23-26). Therefore, it was of interest to determine whether rgp120 has the same selective ability of binding to human

lymphoid cells, PBMC were incubated in the absence or presence of rgp120 (5µg/ml) for 24 hr at 4°C and at 40 37°C. The cells were washed and stained directly with FITC-conjucated OKT4 and OKT4A. The results of FACS analysis show that the treatment of cells with rgp120 at 4°C did not interfere with the binding of OKT4. The treatment with rgp120 at 37°, however, caused an alteration in OKT4 binding as reflected by a reduction in fluorescein intensity of T4+ cells. Conversely, the binding of OKT4A was completely absent following incubation of cells with rgp120 at 37°C. These results indicate that similar to HIV (25,26) rgp120 can occupy the 45

T4A epitope or a neighboring epitope of the T4 helper membrane receptor. The selective binding of rgp120 to the T4A epitope was examined further in a series of experiments involving the treatment of cells with a high concentration of 100 µg rgp120 per ml for 24 hr at 37°C. The cells were then washed and stained with FITC-conjugated OKT3, OKT4, OKT4A, and OKT8. The results of FACS analysis

- showed that the pretreatment of PBMC with rgp120 completely blocked the T4A epitope of T-helper 50 membrane surface antigen. The binding of OKT3 and OKT8 ro rgp120 treated cells was similar to that of the untreated cell preparation indicating that even at high concentrations, rgp120 does not bind to the T3 or the T8 membrane surface antigen. It is interesting to note that rgp120 treatment did not completely block the T4 receptor but only diminished the mean channel of the fluorescence of T4 stained cells. This may indicate a partial binding and/or and alteration in membranal structures of the T-helper receptor.
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EXAMPLE 2

Anti-TCB Domain Monoclonal Anitbody

This example describes the procedure by which monocional antibody 5C2E5 was obtained. A female Balb/c 60 mouse was immunized with about 30 micrograms rgp120 per dose over a period extending approximately seven months. An initial 3-site subcutaneous vaccination with rgp120 in complete Freund's adjuvant was followed by 4 3-site subcutaneous injections in incomplete Freund's adjuvant and then by 2 3-site subcutaneous injections in phosphate buffered saline. A final intraperitoneal boost also in phosphate buffered saline.

The hybridoma that secreted monoclonal antibody 5C2E5 was obtained by the general method of Oi et al. (37) using the mouse myeloma cell line NP3x63-Ag8.653 and spleen cells from the rgp120 immunized animal described above. This cell line is widely available to the public. The fused cell culture was plated out into 10 plates, each of which contained 60 wells per plate. Approximately 480 wells (80%) contained viable cells. Each well was screened for antibody against rgp120 by radioimmunoprecipitation or ELISA. The ELISA was a conventional double antibody sandwich assay using (a) rgp120 coated microtiter wells in which nonspecific binding sites had been blocked by incubating the coated wells for 30 min. at room temperature with 1% (wt/vol) and (b) horseradish peroxidase labelled goat anti-mouse IgG. 10 wells out of 480 were positive for antibody to rgp120. These 10 wells were then screened for the ability to block the binding of rgp120 to human T4 helper cells. The blocking assay was conducted as follows:

Ascites fluid, in vitro culture fuid supernatant or purified preparations of ascites or supernatant are screened in the typical assay. The purification method, for example, comprises adsorption to a column of insolubilized staphylococcal protein A followed by elution of the antibody. Serial dilutions of the monoclonal antibody preparation, from undiluted to 1:1000, were prepared in assay buffer. Assay buffer contained the following components:

a) Gibco F-12/DMEM 50:50 mix (media).

b) 10% Extensively dialyzed fetal bovine serum.

c) .2mM Phenylmethylsulfonyl Fluoride.

d) .05% Tween 80 in phosphate buffered saline.

e) .06M NaCl.

f) .25 mg/ml BSA (bovine serum albumin).

g) 12.5 mM Hepes Buffer pH 7.4.

50 µl of each serial dilution was combined in 12 x 75 polystyrene test tubes with 50-100 µl of radioiodinated rgp120 (~100,000 cpm) in assay buffer and 100 µl of assay buffer containing 3-5x10⁵ CHO (chinese hamster ovary) cell line SVE OKT4 (clone 17) and incubated for 1 hour at 4°C. The cells were centrifuged to pelletize the 25 cells, the supernatant aspirated, the pellet resuspended in 1.0 ml of assay buffer, repelletized, aspirated and the pellet counted in a gamma counter.

The CHO cell line was a transformant CHO cell line in which the gene encoding the human T4 receptor was placed in a DHFR-encoding vector under the control of the SV-40 early promoter, transfected into CHO cells and amplified in 500 nM methotrexate in order to amplify the T4 receptor gene and increase its expression on the transformant cell surface. Other T4 transformants that are suitable for use in this assay are known in the art and readily produced from publicly available starting materials (38,39,40). Preferably, such T4 transformants are cotransformed with DHFR and amplified by conventional techniques in order to maximize T4 cell surface expression. Such cells, containing large populations of T4, provide greater sensitivity to the assay.

It is important to use care, in radioiodinating rgp120. Several otherwise conventional methods were found to 35 result in ¹²⁵I-rgp120 havng binding characteristics that rendered the tracer unusable in the assay. The sucessful method employed was as follows: 400µl of rgp120 (1mg/400µl) was mixed with 1 mCi 125I, 20µl of lactoperoxidase (0.35mg/ml) and 20µl of 1mM H2O2, incubated for 10 min. at room temperature, 20µl of beta-mercaptoethanol (1mM) added, the reaction mixture incubated for 2 min. at room temperature, 50µl of 0.5% wt/vol BSA added, the reaction mixture diluted to 2.5 ml in PBS buffer containing 0.5 wt/vol BSA 40 (PBS-BSA) loaded on a G-25 column and eluted with 3.5ml of PBS-BSA. 125I-rgp120 was recovered in the eluate.

The cells in the sole blocking antibody-producing well (5C2) were subcloned. The same inhibitory activity was obtained from well E5. This activity, attributed to IgG, was purified as desired by ammonium sulfate precipitation or the like. The 5C2E5 monoclonal antibody exerted maximal inhibition of ¹²⁵I-rgp120 T4 receptor binding by reducing bound counts to about 10-15% of murine monoclonal antibody controls as measured by the reduction in pellet cpm. The 5G2E5 hybridoma is available to the public (ATCC HB9435)

EXAMPLE 3

Recovery of TCB Domain from rgp120

This example describes the procedure used to prepare the portion of TCB domain spanning residues 411-454.

The rgp120 used in this example was purified from the culture fluid of CHO cells transfected with pAIDSenvTrDHFR and cultured as described in EP 187,041. The rgp120 was purified to near homogeneity by 55 immunoaffinity chromatography. The purified rgp120 was hydrolyzed in 0.25 M glacial acetic acid, under a reduced oxygen atmosphere, at 110°C for 18 hours according to the procedure of Ingram (35). Under these conditions the rgp120 protein backbone is cleaved on both the N and C terminal sides of aspartyl residues. The digested rgp120 was neutralized by the addition of Tris buffer and adjustment of the pH to 7.

The digested rgp120 was then passed over a column of murine monoclonal antibody 5C2E5 covalently 60 coupled to aldehyde-silica by a standard procedure (36). The column was then washed with a saline solution buffered at pH 3. Monoclonal antibody 5C2E5 has been shown to bind to rgp120 in such a manner as to prevent the binding of rgp120 to the T4 surface antigen of T4+ helper T cells (see example 2). The eluent from the 5C2E5 column was analyzed by a standard method of quantitative amino acid analysis and the following amino acid composition was obtained: 65

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amino acid	D/N	Т	S	E/Q	Ρ	G	A	С	V	М	I	L
moles/mole rgp120	3.0	3.9	2.8	4.2	3.4	3.1	1.9	0.8	1.4	1.5	5.2	3.8
amino acid	Y	F	K	R								
moles/mole rgp120	1.0	1.6	2.1	2.6								

The conditions under which the analysis was performed preclude the accurate determination of C and W. The eluent from the 5C2E5 column was also analyzed by N-terminal sequencing and only the following sequence was obtained: __1 __ L P __ R I K Q F.

The amino acid analysis and N-terminal sequencing data confirm that the only peptide in the acetic acid digest of rgp120 that bound to the 5C2E5 column was the 44 amino acid fragment from threonyl residue 411 to arginine residue 454 of the HIV env sequence. The region has the following sequence: TITLPCRIKQFINMWQ-

¹⁵ EVGKAMYAPPISGQIRCSSNITGLLLTR. This peptide contains the sequence deleted in the delta 3 mutant described above and the epitope of the murine monoclonal antibody 5C2E5 which blocks the binding of rgp120 to the T4 surface antigen of T4+ helper T cells, thereby inferring that this peptide is a portion of the TCB domain.

20 EXAMPLE 4

Immunotoxins

Monoclonal antibodies directed against HIV-encoded proteins which (either separately or as a cocktail) are coupled to deglycosylated ricin A chain (dgA) and are used to kill cells infected with HIV from a wide variety of viral subtypes, are generated as follows:

Sera are obtained from mice immunized (multiple i.p. injections) with heated (30'/60°) NP-40 lysates from HIV-infected human Hp (CD4⁺) cells. Sera can also be obtained from mice immunized with gp120 or gp150. The protein gp150 is the extracellular domain of gp160 with the region which clips to form gp120 and gp41, removed. All sera are tested by:

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1. The indirect immunotoxin (IT) assay using either HIV infected H9 cells, uninfected H9 cells, or ap120-coated unifected H9 cells.

2. Radioimmunoassay (RIA) - Positive sera are tested by RIA against purified gp120 and gp150 to determine if the mice have made antibodies against these proteins.

Sera from mice which are positive in one or both of the RIAs and the indirect IT assay are collected, pooled and affinity-purified on Sepharose-gp120 or Sepharose-gp150. The purified antibody is again tested in the three assays. If positive, the mice are boosted with lysates of HIV-H9, ±gp150 ±gp120. Several mice are sacrificed and their spleens fused with Sp2/0 or NP3X63-. Ag8.653 myeloma cells. Supernatants (SN) from wells containing growing hybridomas are tested in the indirect IT assay against (a) H9 vs. (b) HIV-H9. Those hybridomas that are positive in (b) and negative in (a) are further subcloned and tested by RIA, indirect IT,

⁴⁰ immunoprecipitation, et. Antibodies from positive clones are isotyped and the production of antibody scaled up. The antibodies are coupled directly to dgA. These IT-dgAs are tested on HIV-infected cells and cells from AIDS patients. ITs for clinical use are then prepared.

45 Ricin A-chain Antibody Conjugate

Preparation of F(ab')2 and FAB' Fragments of Antibody

The antibody preparations are treated with pepsin (4500 U/ml) (Sigma, St. Lous, MO) for 6 hours at 37°C under the following conditions: pH = 3.7 (0.1 M citrate buffer); protein concentration, 2-3 mg/ml; enzym/protein ratio, 2/100 by weight. The digestion is terminated by raising the pH to 8.0 with 1 N NaOH. F(ab')₂ fragments are isolated by gel filtration on Sephacryl S-200HR (Pharmacia, Piscataway, NJ) equilibrated in phosphate-buffered 0.3 M NaCl or by adsorbing the non-neutralized digest to a column (10 x 2 cm) of SP-Sephadex equilibrated in 0.1 M citrate buffer, pH 3.7, and eluting the F(ab')₂ fragment with phosphate-buffered saline (PBS), pH 7.2. The yields of F(ab')₂ fragments generally range from 35-50%.

The Fab' fragment is obtained by reducing the F(ab')₂ fragment (5-10 mg/ml) with dithiothreitol (DTT) at a final concentration of 5 mM in 0.1 M phosphate-buffer, pH 7.5 containing 0.003 M ethylenediaminetetraacetic acid (disodium salt) (EDTA) (PBE) for 1 hour at room temperature. The excess DTT is removed by gel filtration on Sephadex G-25 and the thiol groups of the Fab' fragment (5 mg/ml) are derivatized with Ellman's reagent (5,5'-dithio-bis(2-nitrobenzoic acid) (DTNB) at a final concentration of 2 mM, as described in Fulton et al., J. Immunol., 136: 3103-3109 (1986) hereby incorporated by reference. The nonreacted DNTB is removed by gel

⁶⁰ filtration on a column (30 x 2 cm) of Sephadex G-25 equilibrated in PBE. The purity of the F(ab')₂ and Fab' fragments is determined by SDS-PAGE and by double diffusion and immunoelectrophoresis using anti-mouse IgG sera which reacts with both Fab' and Fc fragments. The preparations are free of both Fc fragments and intact IgG.

Ricin A. Chain

Deglycosylated A chain (dgA) is prepared as described by Thorpe et al., Eur. J. Biochem., <u>147</u>: 197-206 (1985) hereby incorporated by reference. The LD50s of native and dgA chain in 25 g mice are about 0.7 mg and 0.3 mg, respectively. The IC_{50} in a cell-free rabbit reticulocyte assay is about 10^{-11} - 10^{-12} M for both dgA and native A chain.

For conjugation with the antibody, the A chain is reduced with 5 mM DDT as described in Fulton et al. supra.

Preparation of IT-As with SPDP

IT-As are prepared using IgG or $F(ab')_2$ fragments of antibodies as described in Fulton et al. supra. Briefly, SPDP dissolved in dimethylformamide is added to a solution of IgG or $F(ab')_2$ (10 mg/ml) in PBE, pH 7.5, to give a final concentration of 1 mM. After 30 minutes at room temperature, the solution is filtered on a column of Sephadex G-25 (30 x 2 cm) equilibrated with PBE. The degree of substitution of derivatized IgG and $F(ab')_2$ fragment is about 3-4 molecules PDP/molecule of protein. The derivatized protein is then mixed with reduced A chain (dissolved in PBE) using 1.3 mg/ml and maintained for 2 hours at 25°C and overnight at 4°C. The mixture is then purified.

Preparation of Fab'As with DTNB

The preparation of mouse Fac'-A with DTNB-derivatized Fab' is performed as described for rabbit Fab'-A in Fulton <u>etal</u>. <u>supra</u>. Briefly, the Ellman's-derivatized Fab' fragment containing 1-2 TNB- substituted thiol groups (see preparation of Fab') dissolved in PBE (5 mg/ml) is mixed at room temperature with reduced A chain using 1.3 mg A chain/mg Fab' at a final concentration of 2 mg protein/ml. The reaction between TNB-Fab' and A chain is followed by the increase of absorbance at 412 Nm and is complete after about 2 hours at 25°C. The mixture is then immediately purified.

Purification of the IT-As

The IT-As prepared with intact antibodies or their fragments are purified by affinity chromatography on Blue Sepharose using a modified version of the method described by Knowles and Thorpe Anal. Biochem. <u>160</u>: 440-443 (1987) hereby incorporated by reference. Chromatography is carried out in 0.05 M phosphate buffer, pH 7.0 and A chain and IT-As are eluted with 1 M Na Cl prepared in the same buffer. The eluate is concentrated by ultrafiltration to 5mg/ml and applied to Sephacryl S-200HR equilibrated with phosphate-buffered 0.3 M NaCl, pH 7.2. The peak(s) containing the purified IT-A is collected, concentrated by ultrafiltration to at least 0.5mg/ml, and stored in aliquots at -70°C.

Preparation of Fab'-GAMIg-A and the Indirect Immunotoxin Assay

Fab fragments of affinity-purified goat anti-mouse immunoglobulin (GAMIg) are prepared by papain35digestion using 2% papain in 0.1 M NaPO4, pH 7.0 containing 0.1 M EDTA and cysteine for 5 hours at 37°C.35Fab fragments are separated from Fc fragments by affinity chromatography on SEAE-Sephacel equilibrated36with 0.01 M NaPO4, pH 7.6. Fab fragments are desalted on Sephadex G-25. Reduced Fab fragments are then36reacted with a 100- fold molar excess of 5,5'dithio-bis(2-nitrobenzoic acid) (DTNB, Ellman's reagent).36Fab-GaMIg substituted with Ellman's reagent (E) and are separated from free Fab-GAMIg and free Ellman's4040

Ricin A chain prepared and tested according to Fulton et al. (J. Biol. Chem. 261, 5314 (1986) is reduced with 5 mM DTT. Reduced A chain is desalted on Sephadex-G25 and A chain coupled to the Fab-GAMIg-E. Fab-GAMIg-A is then purified by affinity chromatography on both S200 and Blue Sepharose.

Indirect Immunotoxin Assay

Cells are used in logarithmic growth phase when cell viabilities are greater than 95%. Serial dilutions of primary unconjugated antibody ranging in concentration from 2×10^{-8} to 2×10^{-13} M are prepared in the appropriate media and 100 µl aliquots are plated in triplicate in 96 well plates. 10^{5} H9 to HIV-H9 cells in a volume of 100 µl of the same medium are added to each well and plates are incubated for 1 hour at 4°C. Fab-GAMIg-A (final concentration 1µg/ml) is then added to the appropriate wells. Controls included: 1) untreated cells; 2) cells treated with Fab-GAMIg-A only; 3) cells treated with antibody only; 4) cells treated with antibody followed by Fab-FAMIg (no A chain). The plates are then incubated for 36 hours at 37°C in 5% CO₂. Cells are pulsed for 4-8 hours at 37°C with 5 µCi of ³H-thymidine and then harvested on glass fiber filters using a Titertek automatic harvester. Incorporation of ³H-thymidine is determined by liquid scintillation counting in a LKB Beta Counter. *55* Results are expressed as a percentage of the ³H-thymidine incorporated by the untreated cells. Cells in all the control cultures incorporate 80-100% of the ³H-thymidine taken up by untreated cells.

Data Analysis

The predicted potency of a monoclonal antibody in the indirect IT assay is based on the concentration of antibody (used with an optimal concentration of Fab-GMIg-A) that will kill 50% of target cells (this is the IC_{50}). For IT-As to be useful in vivo, the IC_{50} should be $10^{-12} - 10^{-10}$ M.

 IC_{50} 's are ranked as follows: $10^{-11} M = 4 +$

 $10^{-10} M = 3 +$

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10^{-9} M = 2+

 $10^{-8} M = 1 +$

4⁺ and 3⁺ antibodies are considered to be good condidates for IT-As and are further tested by RIA against gp150 and gp120.

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 $\frac{\text{RIA}}{\text{Wells of 96 well microtiter plates are coated with 5 µl/ml gp120 or gp150 in 100µl PBS for 16 hours/4°C.} Wells are decanted, washed 5 times in dH₂O and blocked with 200 µl PBS-10% FCS for 24 hours/4°C. Wells are decanted and washed 5 times in dH₂O. Dilutions of sera or supernatant (SN) are added for 4 hours at 25°C. Material is removed and wells are washed 5 times in dH₂O. 10⁵ cpm GAMlg is added for 4-6 hours/25°C. Samples are removed, plates are washed 5 times in dH₂O, dried, cut and counted.$

Antibodies and Sera Tested

A) Rabit anti-gp41.

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- B) MoAbs Nos. 1,2,3,4,5,6,7,8,10,12 (coded).
- C) MoAbs 7F11, 1F9, 5B9, 1D10, 5G9, 5C2, 6D8E9, 9F6 (coded).
- D) Polycolnal mouse serum generated by immunizing BALB/c mice with lysates from HIV-H9 cells.

Results

Monoclonal Antibodies

1. Rαgp41 : IC₅₀ 1 x 10⁻⁸ M (non-affinity purified):-

2. Monoclonal Antibodies.

7F11:+1

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- 1F9:-5B9:-1D10:-
- 5G9:-
- 5G9:-5C2:-
- 30
- 6D8E9 : -9F6 : -

Only one monoclonal antibody was modestly effective in the indirect assay.

Initially, 50 BALB/c mice were immunized with a lysate prepared from a x 10^8 H9 cells which were infected with HIV-I. The sera from these mice were screened in the indirect assay. Fifteen of the surviving 38 mice were 3^+-4^+ in the indirect IT assay. RIAs were done and after two immunizations, 3 mice had developed significant

levels of antibody to gp120 (see Table 3).

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TABLE 3

RESULTS OF THE INDIRECT IT ASSAY AND THE RIA				
	Indirect IT	RIA		
<u>Mouse</u>	<u>IC</u> 50 (after 2 boosts)	<u>µG/ML anti-gp120</u> (after 5 boosts)	anti-gp15	10
302	4+	2+		10
304	1+	4+		
306	1+	4+		
310	-	3+		
312	1+	3+		15
314	3+	4+		
316	1+	2+		
318	1+	3+		
320	1+	3+		20
332	-	2+		
334	2+	2+		
336	4+	4+		
338	1+	2+		
340	1+	-		25
344	3+	2+		
348	2+	4+		
350	4+	3+		
352	2+	-		30
354	2+	-	2+	
356	1+	2+	-	
358	3+	3+	-	
362	4+	4+	4+	05
364	4+	3+	3+	35
366	2+	3+	4+	
368	2+	4+	4+	
370	4+	4+	4+	
372	-	1+	-	40
374	-	3+	-	
376	4+	3+	4+	
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Values of 1+ or greater were greater than 1 μ g/ml.

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While the invention has been described in what is considered to be its preferred embodiments, it is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and 50 equivalents included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalents.

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treatment of inflammatory episodes. 17. Use of a composition of any one of claims 9-15 in the manufacture of a medicament for the treatment of AIDS.

18. Use according to claim 17 wherein the medicament is a vaccine and includes an adjuvant.

19. Use according to claim 17 or claim 18 wherein the composition includes a tumor necrosis factor or an interferon.

20. Use according to claim 19 wherein the tumor necrosis factor is tumor necrosis factor- $\alpha$  and the interferon is interferon- $\gamma$ .

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21. An HIV vaccine comprising an HIV env variant which is not capable of binding to the T4 receptor of T4 helper iymphocytes.

22. The vaccine of claim 21 wherein an amino acid residue within the TCB domain of HIV env is substituted or deleted, or another residue is inserted adjacent to such an HIV env residue, whereby the HIV env variant is not capable of binding to the T4 receptor of T4 helper lymphocytes.

23. The vaccine of claim 22 wherein the HIV env is obtained from strain 3B and residues 424 to 435 are deleted.

24. An antibody which has the TCB domain binding characteristics of monoclonal antibody 5C2E5 (ATCC HB9435).

25. The antibody of claim 24 which is conjugated to a cytotoxin.

26. The antibody of claim 25 wherein the cytotoxin is ncin.

27. The antibody of claim 24 which is covalently bound to a detectable marker or a water insoluble matrix.

28. The antibody of any one of claims 24-27 in a sterile pharmaceutically acceptable vehicle.

29. An antibody according to any one of claims 24-28 for the treatment of HIV Infection.

30. Use of the antibody of claim 24 in the manufacture of a medicament for the treatment of HIV infection. 31. A conjugate of (a) a substance capable of binding to the cell surface marker and (b) HIV <u>env</u> or a fragment thereof which is capable of binding to the T4 receptor of helper lymphocytes.

32. The conjugate of claim 31 wherein the celi surface marker is a protein.

33. The	conjugate of claim 31 o	r claim 32 wherein the conjugate comprises an HIV env fragment having	28
the	sequence	TEGSNNTEGSDTITLPCRIKQFINMWQEVGKAMYAPPISGQIRCSS-	
NITGLLL	TRDGGNNNNESEI.		

34. The conjugate of any one of claims 31-33 wherein the substance capable of binding the cell surface marker comprises the variable region of an antibody.

35. The conjugate of claim 34 wherein the antibody is capable of binding TGF- $\alpha$ .

36. The conjugate of claim 31 wherein the marker binding substance is a hapten.

37. The conjugate of any one of claims 31-36 wherein the substance capable of binding to the cell surface marker and the HIV env or its fragment are cross-linked by a covalent bond.

38. The conjugate of claim 37 wherein the covalent bond is a peptide bond.

39. The conjugate of claim 38 wherein the conjugate is a fusion protein having at its N-terminal end the variable region of an antibody capable of binding to the cell surface marker and at its C-terminal end the HIV env TCB domain.

40. A method for targeting cytotoxic lymphocytes to a selected cell surface marker which comprises preparing a conjugate of any one of claims 31-39.

41. An immunotoxin comprising:

a monoclonal antibody specifically binding an HIV encoded cell surface antigen, and a toxin linked to said monoclonal antibody.

42. An immunotoxin according to claim 41 wherein said toxin is ricin A chain.

43. An immunotoxin according to claim 42 wherein said ricin A chain is deglycosylated.

44. An immunotoxin according to claim 42 or 43 wherein said ricin A chain is produced by recombinant 45 DNA.

45. An immunotoxin according to any one of claims 41-44 wherein said monoclonal antibody is a murine monoclonal antibody.

46. An immunotoxin according to any one of claims 41-44 wherein said monoclonal antibody is a human monoclonal antibody.

47. An immunotoxin according to any one of claims 41-44 wherein said monoclonal antibody is a murine-human hybrid antibody.

48. An immunotoxin as in any one of claims 41-47 wherein said cell surface antigen is gp160.

49. An immunotoxin according to any one of claims 41-47 for killing HIV infected cells.

50. Use of an immunotoxin according to any one of claims 40-48 in the manufacture of a medicament for *b* killing HIV infected ceils.

51. Use of an immunotoxin comprising a monoclonal antibody specifically binding said cell surface antigen, linked to a toxin, in the manufacture of a medicament for killing non-tumorigenic virus infected cells.

52. Use according to claim 51 wherein said toxin is ricin A chain.

Claims for the following contracting States: GR, ES

1. Use of HIV env in the manufacture of a medicament for the treatment of immunoinflammatory episodes.

2. Use according to claim 1 wherein the episode is associated with inflammatory bowel disease, 65

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	rheumatoid arthritis, systemic lupus erythymatosis, juvenile-onset diabetes, Graves disease, myasthenia gravis, graft-versus-host rejection, and host-versus-graft rejection.
	3. Use according to claim 1 or claim 2 wherein HIV env is rgp120. 4. Use according to any one of the preceding claims wherein HIV env comprises the TCB domain of HIV
5	env.
	5. Use according to any one of the preceding claims wherein the medicament is for administration in a therapeutic dose of about from 0.5 x 10 ⁻⁸ to 5 x 10 ⁻⁹ molar.
	<ol><li>Use according to any one of the preceding claims wherein the medicament is a sustained release composition.</li></ol>
10	7. Use according to claim 6 wherein the sustained release composition is a polylactide.
	8. Use according to any one of claims 1-5 wherein the dose is delivered by intravenous injection. 9. A method comprising production of a composition comprising the TCB domain of HIV enveloped is
	free of HIV immune epitopes ordinarily flanking the C-terminal or N-terminal ends of the TCB domain.
15	free of HIV env sequence flanking the C-terminus or N-terminus of the TCB domain.
	11. The method of claim 10 wherein the TCB domain is resides 411 to 454 of HIV isolate 3B env or a
	12. The method of claim 11 wherein the TCB domain has the amino acid sequence TEGSNNTEGSD-
	TITLPCRIKQFINMWQEVGKAMYAPPISGQIRCSSNITGLLLTRDGGNNNNESEI.
20	13. The method of claim 11 wherein the TCB domain has the sequence CRIKQFINMWQEVGKAMYAP- PISGQIRC.
	14. The method of any one of claims 9-13 wherein the composition is sterile and which further contains a pharmacologically acceptable vehicle.
05	15. Use of the composition of any one of claims 9-14 in the manufacture of a medicament for the
20	16. Use of the composition of any one of claims 9-14 in the manufacture of a medicament for the
-	treatment of AIDS.
	18. Use according to claim 16 or 17 wherein the composition includes a tumor pecrosis factor or an
30	interferon.
	19. Use according to claim 18 wherein the tumor necrosis factor is tumor necrosis factor- $lpha$ and the
	interferon is interferon- $\gamma$ .
	capable of binding to the T4 receptor of T4 helper lymphocytes.
35	21. A method according to claim 20 wherein an amino acid residue within the TCB domain of HIV env is substituted or deleted, or another residue is inserted adjacent to such an HIV env residue, whereby the
	HIV env variant is not capable of binding to the T4 receptor of T4 helper lymphocytes.
	22. The method of claim 21 wherein the HIV env is obtained from strain 3B and residues 424 to 435 are
40	23. A method comprising produciton of an antibody which has the TCB domain binding characteristics of
	monoclonal antibody 5C2E5 (ATCC HB9435).
	24. The method of claim 23 wherein the antibody is conjugated to a cytotoxin. 25. The method of claim 24 wherein the cycotoxin is ricin
	26. The method of claim 23 wherein the antibody is covalently bound to a detectable marker or a water
45	insoluble matrix.
	27. The method of any one of claims 23-26 further comprising the addition of a sterile pharmaceutically
	28. Use of an antibody of claim 24 in the manufacture of a medicament for the treatment of HIV infection
	29. A method for targeting cytotoxin lymphocytes to a selected cell surface marker which comprises
50	preparing a conjugate of (a) a substance capable of binding to the cell surface marker and (b) HIV env or a
	fragment thereof which is capable of binding to the T4 receptor of helper lymphocytes. 30. The method of claim 29 wherein the cell surface marker is a protein.
	31. The method of claim 29 or claim 30 wherein the conjugate comprises an HIV env fragment having the
	sequence TEGSNNTEGSDTITLPCRIKQFINMWQEVGKAMYAPPISGQIRCSSNITGLLLTRDGGNNNNESEI.
<i>55</i>	marker comprises the variable region of an antibody.
	33. The method of claim 32 wherein the antibody is capable of binding TGF- $\alpha$ .
	34. The method of claim 29 wherein the marker binding substance is a hapten.
60	so. The method of any one of claims 29-34 wherein the substance capable of binding to the cell surface marker and the HIV env or its fragment are cross-linked by a covolect band
	36. The method of claim 35 wherein the covalent bond is a peptide bond.
	37. The method of claim 36 wherein the conjugate is a fusion protein having at its N-terminal end the
	variable region of an antibody capable of binding to the cell surface marker and at its C-terminal end the
	HIV env U 'B domain

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HIV <u>env</u> TCB domain. 38. A method comprising production of the conjugate of any one of claims 29-37.

39. A method comprising production of an immunotoxin comprising:

a monoclonal antibody specifically binding an HIV encoded cell surface antigen, and a toxin linked to said monoclonal antibody.

40. A method according to claim 39 wherein said toxin is ricin A chain.

41. A method according to claim 40 wherein said ricin A chain is deglycosylated.

42. A method according to claim 40 or 41 wherein said ricin A chain is produced by recombinant DNA.

43. A method according to any one of claims 39-42 wherein said monoclonal antibody is a murine monoclonal antibody.

44. A method according to any one of claims 39-42 wherein said monoclonal antibody is a human monoclonal antibody.

45. A method according to any one of claims 39-42 wherein said monoclonal antibody is a murine-human hybrid antibody.

46. A method an in any one of claims 39-45 wherein said cell surface antigen is gp160.

47. Use of an immunotoxin according to any one of claims 39-46 in the manufacture of a medicament for killing HIV infected cells.

48. Use of an immunotoxin comprising a monoclonal antibody specifically binding said cell surface antigen, linked to a toxin, in the manufacture of a medicament for killing non-tumorigenic virus infected cells.

49. Use according to claim 48 wherein said toxin is ricin A chain.

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