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MECHANISM OF CYTOTOXICITY OF THE AIDS VIRUS, HTLV-III/LAV

ANNUAL REPORT

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Understanding the mechanism of human immunodeficiency virus (HIV) type 1 replication and cytopathicity are critical to determining the pathogenesis and treatment of the acquired immunodeficiency syndrome (AIDS) and associated diseases. Sudies of related viruses, (SIV) and HIV-2, complement these studies and allow additional animal model systems for testing hypotheses. We have studied three aspects of HIV pathogenesis. First, a mutagenic analysis of HIV-1, SIV, and HIV-2 genes has been performed to decifer their role in replication and cytopathic activity. Second, immunopathogenetic consequences have been studied with respect to the characterization of lymphotoxin-like molecule which is secreted by HIV-1 infected cells. Third, the structure and function of HIV-1 env variation has been studied in a clustered outbreak of HIV-1 infection to elucidate the role of envelope alterations in immune evasion and tissue tropism.

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Foreword

1) Citations of commerical organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

2) For the protection of human subjects the investigators have adhered to policies of applicable Federal Law 45CFR46.

3) The investigators have abided by the National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules (April 1982) and the Administrative Practices Supplements.

Background and Significance

Human immunodeficiency virus (HIV) type 1 is a complex virus with at least three structural and five regulatory genes (1,2). The structural genes include gag, pol, and env. The 53 kilodalton (kd) gag precursor protein is encoded by the 9.0 kb full-length viral mRNA. It is cleaved by the viral protease to a 17 kd myristylated protein, a 24 kd phosphorylated major capsid protein, a 9 kd nucleic acid binding protein, and a 7 kd proline-rich protein. A 180 kd gag-pol precursor is synthesized from the same mRNA by ribosome frame-shifting occuring in the region of overlap between the gag and pol genes. The pol proteins processed from this polyprotein include a 10 kd aspartyl protease, a 55 kd reverse transcriptase, a 61 kd reverse transcriptase-RNase H, and a 32 kd endonuclease or integrase. The 160 kd envelope protein is encoded from a 4.5 kilobase (kb) spliced mRNA. The primary translation product is 863 amino acids long, including the first 30 amino acid signal peptide which is cleaved off. It is therefore estimated that this glycoprotein is 40% carbohydrate. The envelope precursor is processed by a cellular protease to a 120 kd extra-cellular envelope protein with 481 amino acids, and a 41 kd transmembrane protein with 345 amino acids.

At least five genes encode regulatory proteins. The transactivator protein, tat, gene is encoded by a double or triple spliced 2.0 kb mRNA. It is a 14 kd protein which is both highly basic and includes an array of cysteine and histidine residues characteristic of "zinc fingers." It interacts with the tat-responsive region, tar, localized between nucleotide 1 and 34 within the R region of the long terminal repeat sequences (LTR) and/or the mRNA (3). Tat increases gene expression about 1000-fold. However, its mechanism of action is not clearly defined, and may include effects on the initiation or elongation of transcription, RNA stability or processing effects, and/or effects on translation (4,5).

The anti-repressor of transactivation, art, or trans-repressor of splicing, trs, is an 18 kd protein encoded from the same 2.0 kb mRNA which encodes tat, though it utilizes the second AUG codon for translational initiation. It acts as a strong positive-feedback regulator of virus expression increasing protein synthesis about 100-fold. Its mechanism of action is not understood.

The short open reading frame of sor gene, also designated orf A, Q, or P', is likely encoded by a 5.0 kb mRNA. It is translated into a 23 kd protein. This protein acts at a post-translational step to markedly increase the infectivity of the virus particle (6).

The 3' open reading frame or 3'orf, also designated orf B, F, or E' is encoded by a double or triple spliced 2.0 kb mRNA. It encodes the synthesis of a myristylated and phosphorylated 27 kd protein (7). This protein acts as a negative regulator of virus replication (8).

The mechanism of expression of the R gene product is not well understood (9). The function of this protein is not yet defined.

Lastly additional potential genes exist, including one designated U which may be encoded from the minus strand of the proviral DNA, and another which may be encoded from the plus strand of the proviral DNA (10).

The mechanism of cell killing by HIV-1 is likely a critical event in the development of immunosuppression in vivo. Indirect experimental data suggests an important role for both the HIV-1 envelope and the cellular T4 antigen. The extracellular envelope domain is critical for interactions with T4 and the formation of syncytia (11). The transmembrane domain serves to anchor the extracellular envelope on the infected cell or virion, as well to have a role in cell fusion, and a separate role in cell killing. The latter activity determined by the carboxyl terminal domain of the transmembrane envelope protein has been explored in these studies (12). The possible role of interactions of T4 and envelope independent of syncytia formation have also been studied here with respect to their role in cell killing. The development of new assays for cell killing independent of virus replication has been critical to these studies.

The role of the cellular gene products in cell killing also remains to be determined. Though viral product might cause direct lysis of infected cells through membrane effects, other mechanisms are more consistent with experimental data. Induction of cytopathic cellular proteins may explain the cytopathic effects of the virus and are likely to be more consistent with data obtained from both in vitro and in vivo studies (13). Several of these possible mechanisms have been explored in the studies outlined below.

Lastly the interaction of the virus and the immune system is critical to the pathogenesis of HIV-1 infections in vivo, and to the development of vaccines for this disease. It is clear that HIV-1's are a heterogeneous collection of related viruses, which differ more in the extracellular envelope product than other viral proteins (14). However, the functional signficance of envelope sequence variation with respect to rate of virus replication, infectivity, tissue tropism, responsiveness to neutralizing antibodies and other immune responses reamins to be determined.

Experimental Methods and Results

Analysis of HIV-1 Replication and Cytopathicity by Mutagenesis

Gag

We have been interested in the role of gag p17 myristylation. In the cases of Moloney murine leukemia virus and Mason Pfizer monkey virus, alteration of the myristylation acceptor site in gag leads to a marked decrease in virus replication, and loss of assembly and release of mature virus particles (15,16). It is likely that myristylation of gag p17 is critical to HIV-1 replication and that methods of inhibiting myristylation in vivo may provide anti-viral therapies. Thus, to test the role of gag myristylation in HIV-1 replication, we have constructed an M13 clone with this portion of the HIV-1 genome. It has been mutagenized by the method of Kunkel (17), to substitute the glycine codon at the second codon position of gag to an alanine. The resultant mutant has been confirmed by nucleotide sequencing.

Env

We have begun three types of analyses of specific domains of the envelope gene. The first set of studies examine the role of the carboxyl terminal domain of gp41 in virus replication and cytopathicity. Two previously constructed mutants demonstrated virus replication in the absence of detectable cytopathic effects (12). The low percentage (1-2%) of syncytia formed in cultures infected by these viruses was similar to that found in cultures infected by the parental viruses. These clones were designated X10-1 which had a deletion of 5 amino acids of envelope replaced by 15 amino acids, and X9-3 which had a deletion of 5 amino acids of envelope replaced by 153 amino acids. A clone with a large deletion of env (about 50 amino acids), designated delta-E demonstrated greatly attenuated virus replication. The reason for the diminished cytopathicity of these viruses was not related to an alteration of interaction with T4 as demonstrated by the formation of syncytia using number of different lymphoid cell types. A defect in envelope protein synthesis or processing was also not detected as demonstrated by immunoprecipitation analysis of 35S-methionine labeled cultures infected with these virus strains. Thus, we felt that it is likely that the carboxyl terminus of gp41 has a separate enzymatic function separate from the ability of envelope to interact with T4 or form syncytia, and that this activity was critical for cytopathicity. Though T4-envelope interactions were shown not to be sufficient for this cytopathic activity, it could not be ruled out that such interactions are necessary for the activity. We next asked

whether envelope-T4 interactions may occur on the same cell, since these interactions may be critical to cytopathic effects. Thus, we asked whether capping either envelope or T4 using monoclonal antibodies and cross-linking them with a second antibody, led to internalization of the other protein. For this purpose, we have determined the concentration dependence of antibody binding to these proteins to obtain saturating levels. These concentrations of antibodies are in use in the co-modulation experiments at this time.

We also asked what portions of the carboxyl terminus of gp41 were important for virus replication and cytopathic effects. Thus, additional mutants have been constructed by Bal 31 nuclease treatment as previously described with or without the addition of a termination codon Xba I linker, their structure determined by nucleotide sequencing, and summarized in Table 1. Preliminary data with regards to the functional activity of these mutants performed in collaboration with Drs. Sue Jan Lee, Amanda Fisher, David Looney, and Flossie Wong-Staal (NCI) are summarized on the same table. Several interesting phenotypes are readily apparent. First, large deletions or additions (>10 amino acids) to gp41 lead to greatly attenuated virus replication in both Molt 3 and H9 cells. Several viruses, however, replicate well in H9 cells but not Molt 3 cells. Thus, differing modes of transmission, i.e. cell-to-cell versus free virus transmission, may be dependent on the conformation of gp41. Cytopathic activities of each cell-free virus and cell-bound virus are being studied in collaboration with Dr. Mitsuya (NCI).

We have also constructed mutants in the N-terminal domain of envelope. These utilized Bal 31 deletions from a unique Nde I site in a sor-minus clone, HXB2gpt-deltaS (6). The structure of each mutant was determined by nucleotide sequencing, and the data is summarized on Table 2. Notably, 3 clones have in-frame deletions in envelope. Clone MP79 has a deletion of amino acides 10-102, and thus a loss of most of the signal peptide. Clones MP22 and MP76 have slightly different deletions of the first conserved domain without affecting the signal peptide, including amino acids 36-105 and 35-107, respectively. Clone MP76 has been transfected into COS-1 cells and then cocultivated with Molt 3 cells. Virus replication was demonstrated by syncytia production and reverse transcriptase assays, though it was attenuated.

In additional studies of HIV-1 cytopathic effects, we have established a new assay system for measuring cytopathic effects in the absence of virus replication. For this purpose we have constructed a T4 expressing HOS cell line, and have been provided the T4 expressing HeLa cell line constructed by Maddon and colleagues. Transfection of HIV-1 DNA clones which also contain the xanthine-guanine phosphoribosyltransferase gene into T4 negative HOS or HeLa cell lines led to the production of only 3-fold fewer gpt+ clones in the presence of mycophenolic acid than did the vector lacking

HIV-1 sequences. We are currently assaying the number of gpt+ clones obtained after transfection of T4 positive cell lines as a measure of cytotoxicity from either full proviral clones or partial proviral clones. The transfection efficiency in this assay is standardized by measuring both the level of transfected DNA by slot blot hybridization and the level of expression of HIV-1 envelope by FACS.

Sor

As proposed in the original contract application, we have constructed a deletion mutant and three site-directed mutants in the sor gene (6). These clones gave rise to virus which had markedly decreased infectivity. These viruses, however, could be transmitted efficiently by cell-to-cell transmission. This work was completed prior to the award of the contract.

R

We have constructed 4 mutants of the R gene. These are summarized in Fig. 1. Virus has been obtained from each DNA clone. The R40 virus has been extensively studied, and found to replicate and kill lymphocyte similar to the parental virus. Cell lines used for these analyses included normal peripheral blood mononuclear cells and monocytes, as well as several lymphoid cell lines (Sup T1, CEM, Molt 3, HUT 102) and a monocytoid cell line (U937). Preliminary data with R31, R21, and R2 demonstrate that these clones also give rise to functional virus. These data would suggest that R is not critical to HIV-1 replication and cytopathicity in vitro. Its in vivo role remains to be determined.

F

Our previous studies with mutants in the 3'orf/F gene demonstrated that F was not required for virus replication or cytopathic effects (12). We have now analyzed more critically a clone with an intact F gene, pHIV-F+, and one with a frame shift a codon 34, pHIV-F-. Transfection of these clones into several lymphoid cell lines, including Jurkat, H9, CEM, and Molt 3 demonstrated that virus derived from pHIV-F- replicated 10-30-fold faster than virus derived from the pHIV-F+ DNA clone over 20 days. Down-regulation of T4 was more notable in the pHIV-F- infected cells compared to pHIV-F+ infected cells, contrary to the predictions of Guy and colleagues who showed that overexpression of F led to depression of T4 (7). Mixing cells infected with the F- and F+ virus gave a phenotype consistent with F- infected cultures, demonstrating that a factor down-regulating HIV-1 replication was not secreted from F+ infected cells. Transfection of the clones into COS-1 cells, similarly

demonstrated a 3-5-fold difference in virus production as measured by reverse transcriptase or p24 antigen assays in a single cycle of virus replication. Similar results were obtained with HeLa and SW480 colon carcinoma cells. F- and F+ virus derived from COS-1 cells showed similar infectivity on H9 cells as measured by the production of viral DNA within 12 hrs after infection. We have demonstrated that F is a trans-activating factor. Cell co-transfected with an F- HIV-1 DNA clone and an F expression plasmid have the same phentoype as F+ transfected cells. Thus, these data demonstrate that the effects of F in down-regulating virus production occur exclusively in the latter half of the virus replication cycle. Studies of gag p24 antigen production by immunoprecipitation studies of F- and F+ infected COS-1 cells again revealed a 3-5-fold difference, suggesting that F operated at a translational or pre-translational step. Studies of HIV-LTR-CAT assays in the presence of tat with or without F failed to show a difference suggesting that effects were not occurring at the level of transcription. Studies in the absence of tat, however, have not yet been performed. Thus, these data have localized the negative regulatory effect of F at the level of RNA or protein synthesis, processing, or stability.

A myristylation minus mutant of F has also been obtained by site directed mutagenesis for analysis of the role of this post-translational modification in F activity.

X

HIV-2 and SIV differ from HIV-1 in that they contain an open reading frame encoding a 14 kd protein designated X (18). We have constructed functional clones of both HIV-2 and SIV, as demonstrated by the production of syncytia and reverse transcriptase in transfected H9 cells and in the case of HIV-2 in transfected CEM cells as well. An X mutant of HIV-2 has been constructed in which the initiator methionine codon has been converted to a serine codon. A second HIV-2 X mutant is being constructed as well as two SIV X gene mutants.

Immunopathogenesis of HIV-1

We have performed two studies of HIV-1 lymphokine production. We have identified a lymphotoxin-like molecule secreted by HIV-1 infected peripheral blood mononuclear cells (13). Though some lymphoid cell lines constitutively excrete such a substance, no increase was detected after HIV-1 infection, despite the presence of cytopathic effects. Cell fractionation studies by panning of peripheral blood mononuclear cells failed to demonstrate in a convincing fashion which cell type was responsible for secretion of this agent.

It is known that lymphotoxin, tumor necrosis factor, and dexamethasone activate cell death via activation of a cellular nuclease and DNA degradation (19). We have examined whether HIV-1 produces a similar DNA degradation pattern. Though we succeeded in confirming the results of dexamethasone in induction of DNA degradation in human lymphoid cells, we failed to identify DNA degradation in HIV-1 infected cultures undergoing cytopathic effects. These data would suggest that the programmed mechanism of cell death involving cellular nuclease activation is not involved in HIV-1 induced cytopathic effects.

Interaction of HIV-1 and the Immune System

We have undertaken two types of studies of the interaction of HIV-1 and the immune system. First, we are establishing a murine model for study of cytotoxic responses to HIV-1. For this purpose we have established an AKR-2B murine cell line expressing the HIV-1 envelope. This was performed by transfecting an env expression clone with a selectable marker into these cells, and selecting a clone with expressed the HIV-1 envelope as detected by immunofluorescence studies with a specific antibody. These cells are being used as a target to study the cytotoxic responses of vaccinia-env vaccinated mice in collaboration with Dr. R. Markham (Washington University).

Second, we have studied a clustered outbreak of HIV-1 infection in 3 children who received HIV-1 contaminated blood via transfusion from an asymptomatic HIV-1 infected donor (Table 3). We have cultured virus from the blood donor (patient 1) and three of the recipients (patients 5, 6, and 7). All three patients have now developed AIDS and patients 5 and 6 have died of their disease. The virus isolates from each of these individuals is indicated in Table 4. Interestingly, the virus isolates from the lung and brain of patient 5 obtained in 9/86 grew well in monocytes, whereas those from the blood obtained in 2/86 and 8/86 from the same patient failed to grow at high levels in normal monocytes. DNA has been prepared from cultures infected with isolates from each of the patients, and libraries have been screened for HIV-1 env clones from blood isolates from 2/86 and 8/86 of patient 5, lung isolate from patient 5, and blood isolate from 8/86 from patient 1. Three-ten clones have been obtained from each library and have been purified. Each clone has been excised in plasmid form for use in dideoxy sequencing. These studies will allow a comparison of the structure of the envelope from closely related isolates of blood from 4 different patients and from different tissues obtained at the same time from the same patient.

Conclusions

Work performed during the last year under this contract has better defined viral determinants, cellular determinants, and interactions of viral and cellular determinants in HIV-1 induced cytopathicity.

In studies of viral determinants of HIV-1 replication and cytopathicity, we have produced a number of mutants to better characterize the function of particular gene products. A myristylation acceptor mutant of gag has been produced and should be useful in defining the role of myristylation in gag protein intracellular transport and virus assembly.

We have constructed a number of mutants with an altered carboxyl terminus of gp41. These have demonstrated that additions or deletions of more than 10 amino acids attenuates infectivity and/or replication. Replication of certain mutants occurred in H9 cells but not Molt 3 cells suggesting that a region within the carboxyl terminus of gp41 may be critical to cell-to-cell transmission of virus but not transmission via free virus particles. Several of these mutants should be useful for characterizing regions in the carboxyl terminus of gp41 which affect cytopathicity without affecting virus replication. A number of mutations in the first conserved domain of gp120 have also been produced. One of these with an in-frame deletion, gives rise to virus which replicates to attenuated levels. These mutants will better define the role of this portion of gp120 in infectivity, virus replication, and responsiveness to neutralizing antibodies. Interactions of envelope with T4 may be critical for cytopathicity. We have determined experimental conditions which are appropriate to study whether co-modulation of T4 and env occur with cross-linking antibodies which would suggest an interaction on the same cell. We have also established an assay for cytopathicity independent of virus replication using sub-genomic proviral clones transfected into HeLa or HOS cells expressing T4. This assay should be useful in defining viral determinants of cell killing and their mechanism of action.

Studies of sor have demonstrated that it acts at a post-translational level to increase the infectivity of the virus particle. A number of R mutants have also been constructed. Preliminary data suggests that they all give rise to virus which replicates and kills lymphoid cells similar to the parental virus.

Studies of F have demonstrated that it is negative regulator of virus replication acting at the level of viral RNA or protein synthesis, processing, or stability. Additional studies should better characterize its mechanism of action. A site directed mutant in the myristylation acceptor codon of F has been constructed to assess the role of myristylation in F processing and activity.

HIV-2 and SIV have an additional gene, designated X. We have constructed several HIV-2 and SIV functional clones to test the effect of mutation of the X gene. We have constructed a single HIV-2 X mutant and will construct an additional HIV-2 X mutant and two SIV X mutants for this purpose.

In studies of cellular determinants of HIV-1 cytopathicity, we have identified a lymphotoxin-like factor secreted by HIV-1 infected cells. Its role in cytopathicity is unclear at this point. We have failed to detect DNA fragmentation in HIV-1 infected cultures, similar to that which occurs in glucocorticoid or lymphotoxin treated cultures.

To examine interactions of viral and cellular determinants of cytopathicity, we have focused on the significance of HIV-1 envelope sequence heterogeneity. We have isolated virus from 3 children who were infected from a single blood donor. Virus was isolated at different times and from different tissues. Interestingly, virus isolates from the lung and brain of one child was monocyte-tropic whereas that isolated from the blood grew poorly in monocytes. Env clones have been obtained from lung and two blood isolates from one child and from the blood isolate of the donor. Sequencing will be used to identify structural alterations that occur over time and that occur in different tissues. Functional clones will be generated to localize the monocyte tropic determinants and will also be used to examine neutralizing antibody responses.

Recommendations

We recommend the following studies be carried out over the next year.

1) With respect to the studies of the gag myristylation mutant, we plan to clone the mutagenized M13 fragment into clone pHXB2gpt. This clone will be transfected into COS-1 and lymphoid (Jurkat) cells and compared to the parental clone and the negative control, SP65HPgpt, with respect to virus production by reverse transcriptase and antigen assays. If loss of the myristylation acceptor site causes a decrease in virus production, we will analyze the transfected COS-1 cultures for viral DNA, RNA, and protein expression as well as by electron microscopy for production of virus particles. If the expected result of normal amounts and species of viral DNA, RNA, and proteins are found without assembly of virus particles, we will then perform cell fractionation, immunofluorescent, and immuno-gold electron microscopy experiments to look for a defect in intracellular processing of gag in cells transfected with myristylation acceptor mutant.

2) With respect to the studies of the HIV-1 envelope, we propose to perform several experiments:

a) We will analyze the cytopathic activities of each of the carboxyl terminal gp41 mutants, their susceptibility to neutralizing antibodies, the interaction of their envelope with T4, and their cytopathic activities.

b) We will utilize saturating concentrations of antibodies to envelope or T4 in the co-modulation experiments to look for interactions of envelope and T4 on the same cell type. If this is identified, we will examine co-modulation with each of the carboxyl and amino terminal mutants of envelope that we have constructed.

c) We will replace the deleted sor gene in each of the clones with deletions in the first conserved domain of the N-terminus of envelope and examine the abilities of the clones derived from MP22 and MP76 to give rise to virus, its replication rate, and cytopathic activities. We will also transfect each of the clones already available and listed in Table 2 into COS-1 cells either alone or together with an env expression clone to assess the role of the first conserved domain and all of envelope in virus production.

d) We will assess the cytopathic activities of clones derived from HIV-1 by measuring the number of gpt+ clones obtained after transfection of HeLa/T4 and/or HOS/T4 cell lines. These assays will seek to identify cytopathic genes in HIV-1 independent of virus replication.

e) We will look for interactions of gp41 with other viral and cellular proteins to try to identify mediators of the cytopathic activity. This will be performed by cross-linking experiments using 35S-methionine labeled cells and specific antibodies to gp41 which have been either purchased commercially (DuPont, Epitope) or provided by other investigators (Dr. Kennedy, Southwest Medical Foundation).

3) In our studies of R, we will complete the analyses of virus replication and cytopathic effects utilizing the other site directed mutants, R31, R23, and R2. If no defects are seen with these mutants, we will make similar truncations of the coding potential of the R gene in SIV and HIV-2 and test the effect of the mutants in vitro and in appropriate animal systems (in collaboration with Dr. R. Desrosiers, New England Primate Research Center).

4) In our studies of F, we will perform three types of studies.

a) We will complete the analysis of COS-1 cells transfected with F- and F+ virus, to determine precisely the step in virus replication affect by F. We will focus on viral RNA and protein expressed in the transfected cells. Appropriate studies of viral RNA or protein synthesis, processing, and stability will be performed based on these results.

b) We will determine the functional sites of F by analysis of a variety of site directed mutants with regards to negative regulation of virus replication or the particular step in virus replication that is involved and GTP binding activity in transfected COS-1 cells.

c) We will also perform in vivo phosphorylation experiments with F- and other mutants to assess the role of F in phosphorylation of viral and cellular proteins. We will particularly focus on phosphorylation of gag p24 and F itself.

d) We will assess the myristylation acceptor minus mutant of HIV-1 in the same way already described for the other F minus mutants. Cell fractionation experiments are likely to be utilized to define whether myristylation regulates via an intracellular sorting mechanism or by other means.

5) In our studies of the SIV and HIV-2 X genes, we will complete the construction of the X gene mutants and reconstitute these subclones into the full functional proviral clones. These will be transfected into COS-1 cells and cocultivated with H9 cells to determine the ability of these clones to give rise to replicating virus and their cytopathic effects.

6) In the studies of a murine model of cell mediated immunity, we will collaborate with Dr. Richard Markham (Washington University) to assess cytotoxic T cell responses to AKR cells expressing the HIV-1 envelope. A similar target system will be developed utilizing murine Lyt3+ cells expressing the HIV-1 envelope.

7) In the studies of envelope variation and its significance in the clustered HIV-1 outbreak, we will carry out several studies.

a) We will sequence the env gene in 2-10 clones obtained from each 2/86 and 8/86 blood and 9/86 lung samples from patient 5 and 8/86 blood sample from patient 1.

b) We will clone the env genes from the other blood and tissues samples from patients 6 and 7, and from the 9/86 brain sample of patient 5.

c) We will clone and sequence the env gene from another set of monocyte tropic and lymphocyte tropic viruses obtained at one time from a blood specimen of an HIV-1 infected individual (in collaboration with Dr. Howard Gendelman, WRAIR).

d) We will reconstitute the env gene from each clone into the functional clone, HXB2gpt to assess the role of the env gene in tissue tropism and susceptibility to neutralizing antibodies.

Manuscripts in preparation from this work

1. Dedera D and Ratner L. The HIV-1 R protein is not critical to virus replication and cytopathic effects.

2. Dedera D and Ratner L. The mechanism of cell killing by HIV-1 does not involve DNA degradation.

3. Ratner L and Neiderman T. The HIV-1 F protein negatively regulates HIV-1 replication in a late step of the virus cycle.

4. Polmar S, Whittier R, and Ratner L. Immunological and virological studies of a cohort of premature infants that received blood from the same HIV infected donor.

5. Lee SJ, Fisher AG, Hu W, Ratner L, Looney D, Gallo RC and Wong-Staal F. The role of the carboxyl terminus of the human immunodefiency virus type 1 envelope in replication and cell killing.

6. Ratner L. A variant of human immunodefiency virus type 1 with attenuated cytopathic effects manifests normal envelope synthesis and function.

Invited reviews supported by this contract

1. Ratner L. Is the HIV envelope guilty of murder? Minireview. AIDS Targetted Information Newsletter, January, 1987.

2. Ratner L. The family of immunosuppressive human retroviruses. AIDS Targetted Information Newsletter, June, 1987.

3. Ratner L. The human immunodeficiency virus protease and its role in virus repliciation. Minireview. AIDS Targetted Information Newsletter, February, 1988.

Table 1

SUMMARY OF STRUCTURE AND FUNCTION OF 3'ENVELOPE DELETION CLONES

Amino Acid Sequence of 3'terminus of Envelope:

No. From C-Terminus: 230 220 210 200 190 180 170 160 150 140 130 120 110
AA Residue: 630 640 650 660 670 680 690 700 710 720 730 740 750
TMEVDRELHKVTSLIHSLIEESQNQQEKNEQELLELDKWASLWNWFNITNWLWYIKLFIMIVGGLVGLRIVFAVLSIVNRVRQGYSPLSFQTHLPTPRGPDRPEGIEEEGGERDRDRSIRLVNGSLAL

No. From C-Terminus: 100 90 80 70 60 50 40 30 20 10
AA Residue: 760 770 780 790 800 810 820 830 840 850
INDLRRLCLFSYHKLRDLLLIVTRIVELLGRRGWEALKYWWNLLQYWSQELKNSAVSLLNATAIAVAEGTDRVIEVVQGACRAIRHIPRRIRQGLERILL

Clone	Intact 3'Orf	Env Ant/Trs	Polypurine	3'LTR	No. Nucleotides Added	Nucleotides Deleted	No. Env Amino Acids Deleted	No. Env Amino Acids Added	Amino Acids Added	CC/B-1/R1	Rat13/gag	MJ/gag
E389		•	•	•	-	8370-8601	0	67	RPHTYKAAVDLSHFLKEKGGLEGL	+++++	++++	+
E206		•	•	•	-	8357-8544	4	55	EVGFPVTPQVPLRPMTYKAAVDLSHFLKE	+++++	+	+
E10-1		•	•	•	-	8456-8633	3	15	RGGLEGLIHSURRGSILDLMIYHTGGYFFD			
E9-2		•	•	•	-	8456-8518	5	75	ERRRRAVFGGHLRYL	+++++	++++	+
E368		•	•	•	-	8352-8537	6	2	MTHAAGALEADEEEEVGFPVTPQ	+++++	+	+
E493		•	•	•	-	8328-8627	14	2	LV	nt	nt	+
E378		•	•	•	-	8326-8624	15	2	AS	+++++	++	+
E489		•	•	•	8+	8326-8624	15	4	PGLS	+++	+	+
E269		•	•	•	28	8326-8601	15	4	PGLS	nt	+	+
E306		•	•	•	-	8320-8628	17	2	AS	++++	+/-	+
E319	OMIT FROM FURTHER ANALYSIS DUE TO CLONING ARTIFACT				-	8303-8603	22	2	MS	nt	-	-
E468		•	•	•	28	8270-8636	33	0		+++	+/-	+
E368		•	•	•	-	8259-8577	37	14	SHTDGTFKTHDLQGDCRS	+++	-	+
RC318		•	•	•	14	8328-8768	14	3	OUI			
RC474		•	•	•	14	8244-8736	42	2	PD			
RC404		•	•	•	14	8351-8660	6	12	LEQLIHSQRAQD			
RC2048		•	•	•	14	8351-8618	6	0				
RC318		•	•	•	14	8352-8710	6	24	QSTTIHATSLISRTTHQGQCSQLV			
RC194			•	•	14	8142-8711	76	9	SLPHTRLLPD			
E358		•			-	8351-8728	6	3	LLP	++	+	-
E318		•			-	8352-8710	6	24	QSTTHATSLISRTTHQQQQSSIN	+++++	+	-
E204		•			-	8351-8660	6	27	LEQLIHSQRAQSIL	+++++	+/-	-
E312		•			-	8328-8768	14	74	SLWIYW/QQYFPD VRYPLTFQUCYRLVPVEPDKIEEA AKQENTSLLHPVSLHQMDDPEREV LEVWFDSALAFHAVARELHPEYFLNC	+++++	-	-
E192		•			-	8318-8660	14	3	QQI	+++++	-	-
E189		•			-	8247-8671	41	0		+++++	-	-
E274		•			-	8244-8736	42	2	PD	+++++	-	-
E194					-	8142-8711	76	9	SLPHTRLLPD	+++++	-	-
E360			•	•	-	7809-8537	187	38	CLAMSTRQQQQQFSSH TSGTFKTHDLQGDCRS	-	-	-
E387			•	•	-	7639-8573	177	89	FSSHTSGTFKTHDLQGDCRS	-	-	-
E330	•	•	•	•	-	8401-8569	-	-	-	++++	++++	+
E236	OMIT FROM FURTHER ANALYSIS DUE TO CLONING ARTIFACT											
E364	OMIT FROM FURTHER ANALYSIS DUE TO CLONING ARTIFACT											
H380	•	•	•	•	•	-	-	-	-			+

KEY for Rat13/gag: + transient expression, lost by week 4
++ 1-15 expression by week 4
+++/++++ 30-90% expression by week 4

RC clones constructed by putting the 3' linker on Eco RV site at nucleotide of corresponding E clone, digesting with Sal I, and ligating with fragment betw een the Sal I and the 3 sites of clone E-378, thus, regenerating a new polypurine tract and 3'LTR.

Table 2

N-TERMINAL ENVELOPE DELETION CLONES

Clone	Frame-shift	Nucleotides Deleted	No. Nucleotides Deleted	Amino Acids Deleted	No. Amino Acids Deleted	Signal Peptide Intact	Mature Envelope Product
MP22	-	5907-6116	210	36-105	70	+	TEKLW/EDIISL...
MP76	-	5904-6122	219	35-107	73	+	TEKL/IISLW...
MP79	-	5829-6107	279	10-102	93	-	
MP7	+	5853-6133	281				
MP10	+	5867-6134	268				
MP19	+	5885-6125	241				
MP70	+	5912-6086	175				
MP82	+	5910-6136	227				
MP87	+	5833-6116	274				
MP92	+	5910-6125	216				
MP100	+	5832-6114	283				
MP122	+	5811-6118	308				
MP18	?	? -6131					
MP51	foreign sequence						

Clones to sequence MP74
Repeat sequence on MP18

Table 3

SEQUENCE HETEROGENEITY OF ISOLATES FROM A CLUSTERED HIV-1 OUTBREAK

Transfusion event:

One unit of blood from patient 1 infused in patients 2-7 in 2/85

Patient descriptions:

Patient 1 - Asymptomatic 21 year old white male homosexual
8/86 - T4 500 cells/cu mm

Patient 2 - Died in neonatal period of complications of prematurity,
HIV-1 assays not performed

Patient 3 - Died in neonatal period of complications of prematurity
HIV-1 assays not performed

Patient 4 - Died at age 5 months of respiratory syncytial virus infection,
HIV-1 assays not performed

Patient 5 - 30 wk gestation, intracranial hemorrhage, hydrocephalus
Age 8 mos - recurrent diarrhea, failure to thrive, generalized lymphadenopathy, hepatosplenomegaly, diffuse pulmonary infiltrate
Age 12 mos - panhypergammaglobulinemia, HIV encephalopathy with CT scan showing cerebral atrophy and basal ganglia calcifications
Age 18 mos - recurrent fevers, aspergillus otitis externa
Died in 9/86 at age 20 months

Patient 6 - 29 wk gestation, respiratory distress syndrome, brochopulmonary dysplasia
Age 5 mos - recurrent diarrhea, posterior cervical lymphadenopathy
Age 7 mos - failure to thrive, diffuse pulmonary infiltrates, generalized lymphadenopathy
Age 9 mos - pneumococcal meningitis
Age 16 mos - recurrent scabies
Died at age 30 mos

Patient 7 - 26 wk gestation, respiratory distress syndrome, bronchopulmonary dysplasia, patent ductus arteriosus
Age 5 mos - failure to thrive, generalized adenopathy
Age 11 mos - respiratory syncytial virus infection

Table 4

ISOLATES FROM A CLUSTERED HIV-1 OUTBREAK

Patient	Date	Tissue Source	Result of Culture
1	4/86	Blood	-
	7/86	Blood	-
	8/86	Blood	+
	9/86	Blood	-
	11/86	Blood	-
	1/87	Blood	-
	3/87	Blood	-
	6/87	Blood	-
5	2/86	Blood	+
	8/86	Blood	+
		CSF	nt
	9/86	Lung	+
		Brain	+
		Lymph node	-
		Spleen	-
6	2/86	Blood	+
	9/86	CSF	nt
	11/86	Blood	+
	2/87	CSF	-
	4/87	Blood	+
	6/87	Blood	+
		CSF	-
7	2/86	Blood	nt
	7/86	Blood	-
	11/86	Blood	+
	4/87	Blood	-
	11/87	Blood	-
	2/88	Blood	-
	3/88	Blood	-

Abbreviations: nt, not tested; CSF, cerebrospinal fluid

Cultures were performed by mixing an equal number of patient peripheral blood mononuclear cells weekly with normal phytohemagglutin-stimulating normal peripheral blood mononuclear cells. Positive cultures are considered positive if two or more indepent culture supernatants are found to give reverse transcriptase values double the background. Positive cultures are confirmed by demonstration of a 3.5 kb Sac I DNA fragment in cellular DNA which hybridizes with

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