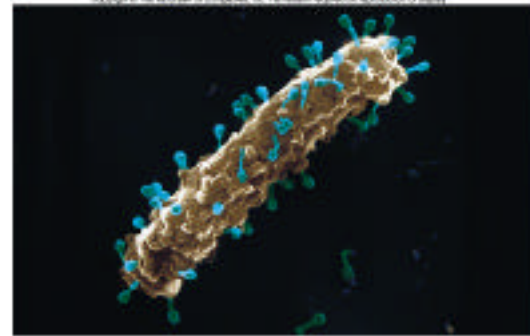
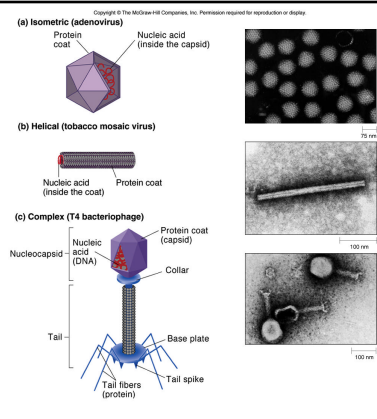


Viruses

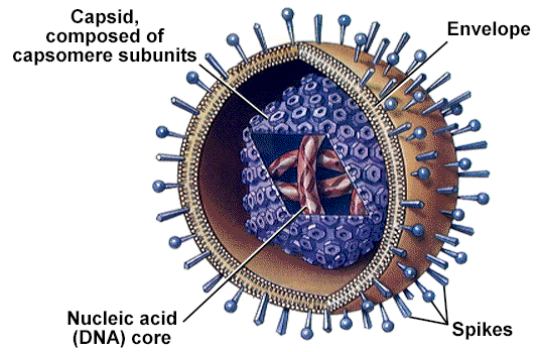
Bacteriophages (ready to eat)



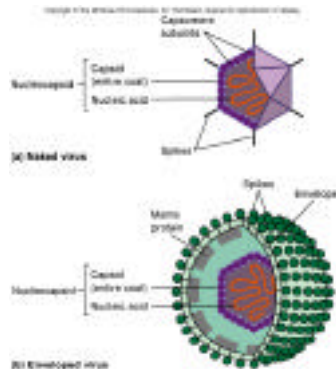
Common shapes of viruses





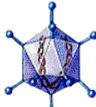

Viral components (virion)



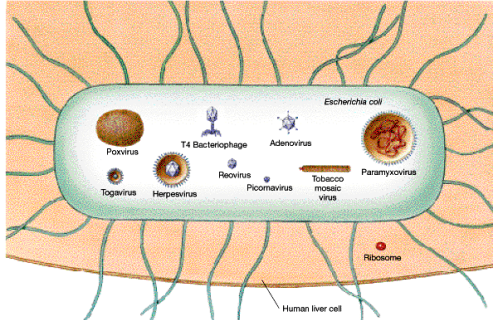
Types of viruses



Viruses can have DNA or RNA as the for their genome

	DNA viruses	RNA viruses
Enveloped	 Herpesvirus	 Retrovirus
Naked	 Adenovirus	 Picornavirus

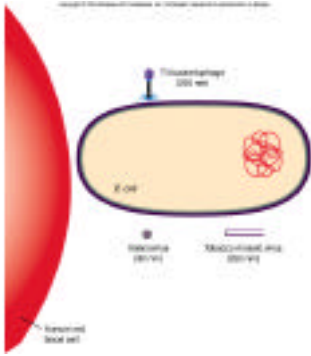
Relative sizes and shapes of viruses



Many shapes - Spherical to icosahedral

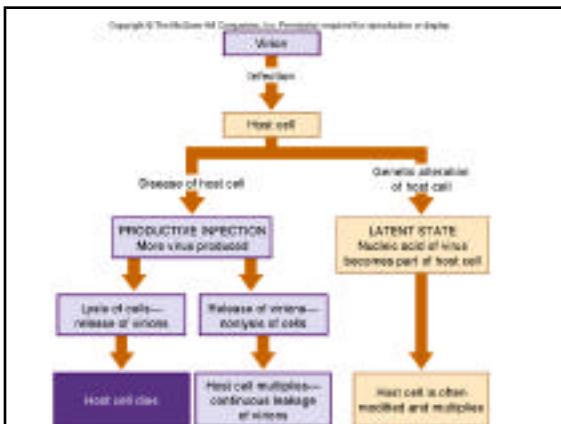
RELATIVE SIZES AND SHAPES OF DIFFERENT VIRUSES	
DNA VIRUSES	Poxvirus, Herpesvirus, T2 Bacteriophage, Adenovirus, Papovavirus, Parvovirus
RNA VIRUSES	Paramyxovirus, Rhabdovirus, Tobacco-mosaic virus, Myxovirus, Coronavirus, Togavirus, Picornavirus, Reovirus

Virion sizes

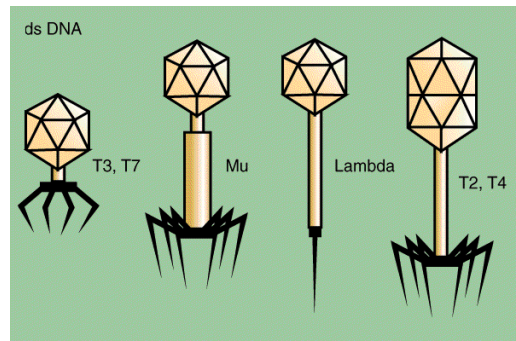


Copyright © The McGraw-Hill Companies, Inc. Properties required for reproduction in a host.

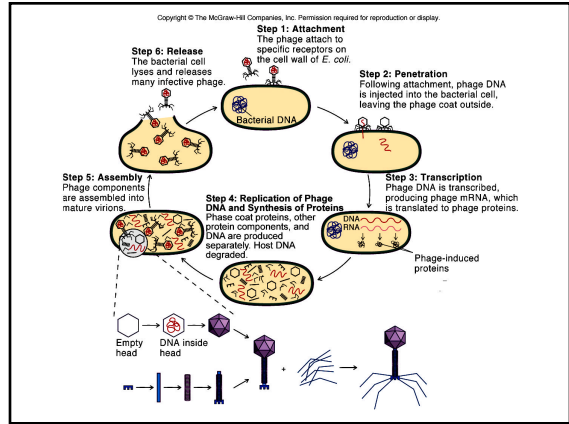
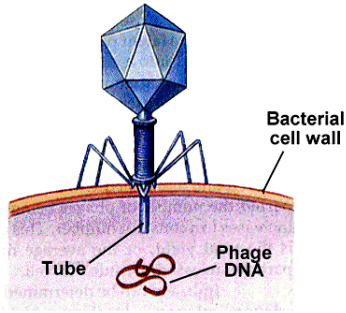
	Viruses	Cells
Size	20-400 nm	Bacteria: 1-10 microns; animal: 10-100 microns; plant: 10-100 microns
Reproduction	Require entry into cells, which the cell has an ability to defend against and respond to the invasion	Most are free-living and capable of independent reproduction
Genetic Material	Carbon: either RNA or DNA, but never both	Always contain both DNA and RNA
Energy Capture	Carbon: either RNA or DNA	Carbon: many viruses
Metabolic Capabilities	Lack enzymes and require for providing energy	Carbon: Bacteria and require for providing energy



Bacteriophages

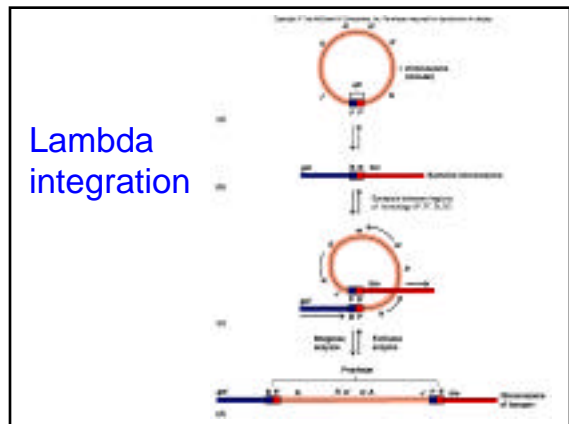
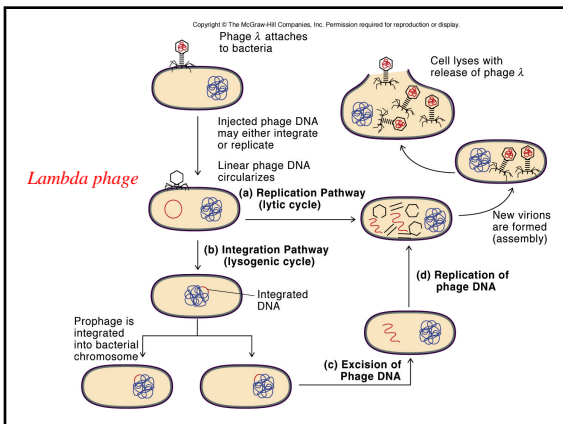
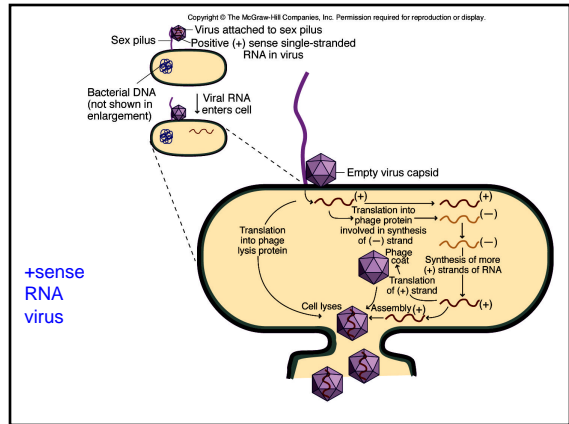


Bacteriophage injecting genome



18.2 Representative Impactful Bacteriophages

Bacteriophage	Head	Shape	Genome Structure	Reproduction in Host Cell
T4	Icosahedral	Capsid	ds DNA	Lytic
λ	Icosahedral	Hexameric	ds DNA	Lytic
φ	Icosahedral	Spherical	ss DNA	Lytic
φX174	Icosahedral	Capsid	ss DNA	Lytic
φ229	Icosahedral	Spherical	ss DNA	Lytic
φ801	Capsid/Hexameric/Hexameric	Spherical	ds DNA	Lytic/latent for prophage form



fd phage

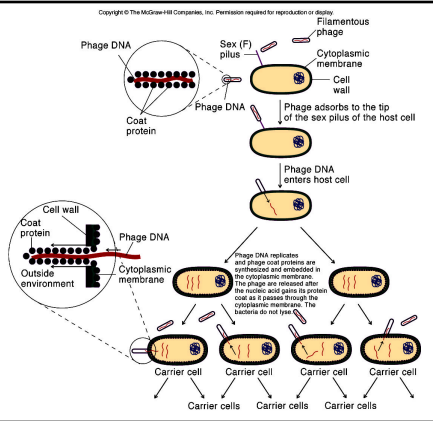


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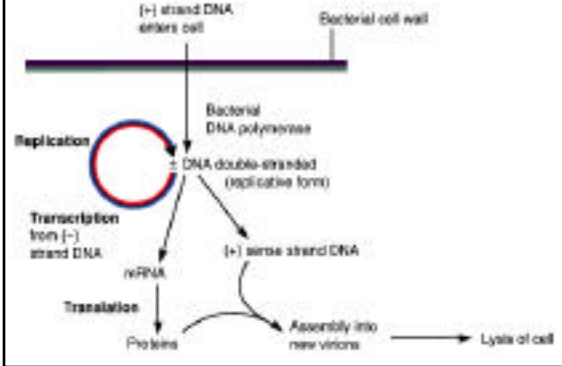
Table 13.3 Some Properties Conferred by Prophage

Mutagenesis	Medical importance	Property Conferred by Phage
Conjugation efficiency	Gene transfer	Spreads to nonhost cells
Excretion resistance	Gene deletion	Spreads to nonhost cells
Stability of genome	Gene transfer from other phage species	Cytophages that replicate in cytoplasm
Sexuality	Gene modification	Mutational effects on host cell
Other factors	Gene transfer	Spreads to other cells

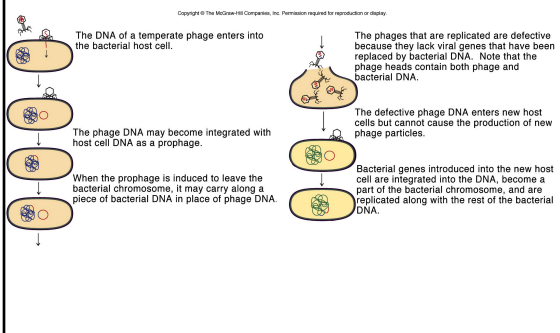
Filamentous phage



Lytic phages



Transduction



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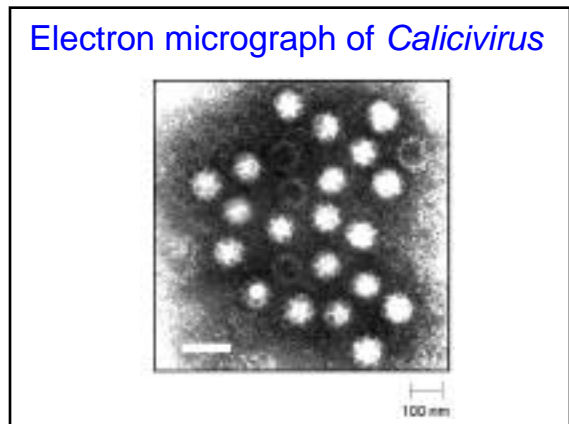
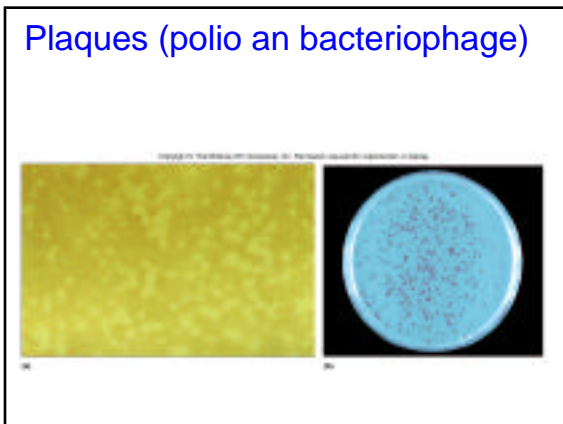
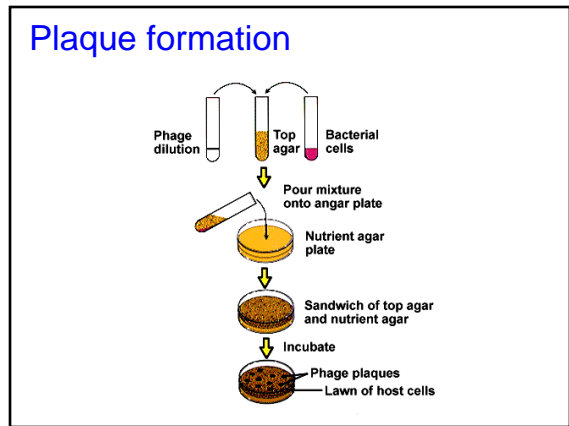
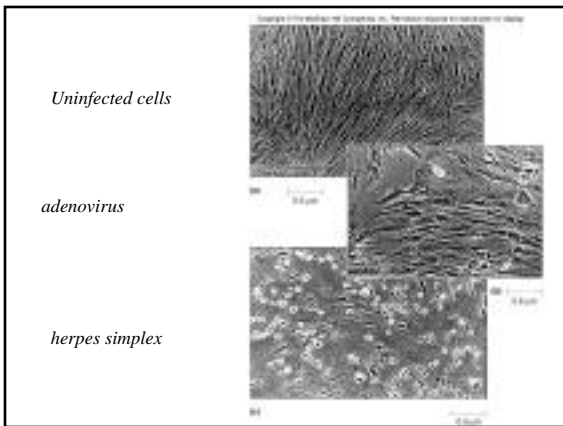
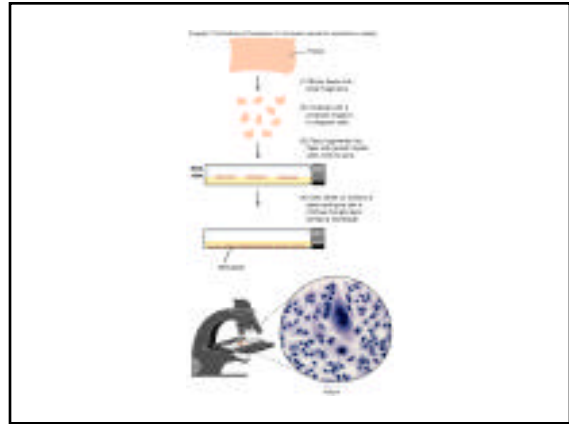
Table 13.4 Features of Interoactions of Phage with Host Cells

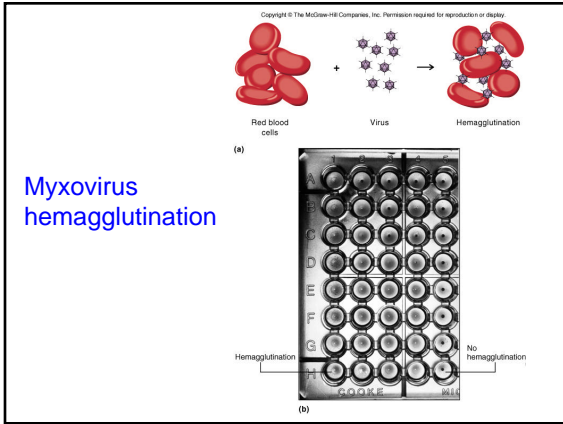
Phage	Type of Interoaction	Type of Nucleic Acid	Result of Interoaction
T4	Reproductive	dsDNA	Lytic cycle
λ	Reproductive	dsDNA	Lytic cycle
λ _{int}	Lysogenic	dsDNA	Phage integrated into host cell's chromosome
φX174	Reproductive	ssDNA	Phage integrated into host cell's chromosome
φ229	Reproductive	ssDNA	Lytic cycle

Note: dsDNA = double-stranded DNA; ssDNA = single-stranded DNA.

TABLE 24.4 Grouping of Human Viruses Based on Route of Transmission

Virus Group	Mode(s) of Transmission	Common Viruses Transmitted
Arboviruses	Insect and tick bites	Dengue fever virus, yellow fever virus, West Nile virus, Japanese encephalitis virus, Chikungunya virus, Zika virus
Respiratory	Respiration or saliva contact	Influenza virus, measles virus, mumps virus, adenovirus, rhinovirus, coronavirus
Sexual	Sexual fluids or contact	Herpes simplex virus, human immunodeficiency virus (HIV), hepatitis B virus, hepatitis C virus
Foodborne	Ingestion of contaminated food	Hepatitis A virus, poliovirus, norovirus, rotavirus
Waterborne	Ingestion of contaminated water	Poliovirus, hepatitis A virus, norovirus, rotavirus
Transfusion	Transfusion of contaminated blood	Hepatitis B virus, hepatitis C virus, HIV, cytomegalovirus, Epstein-Barr virus
Vertical	From mother to fetus or newborn	Cytomegalovirus, rubella virus, HIV, hepatitis B virus, hepatitis C virus, toxoplasma gondii

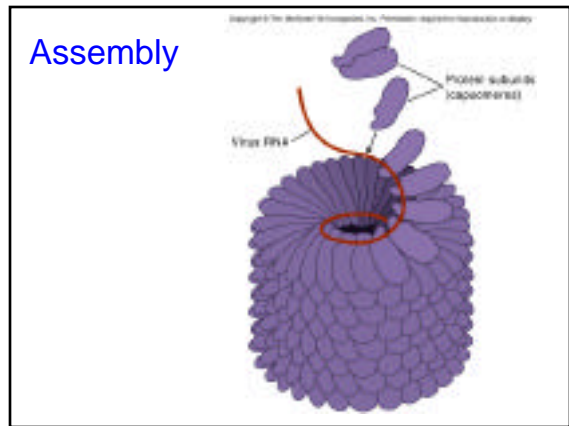




Myxovirus hemagglutination



Cell entry of enveloped viruses

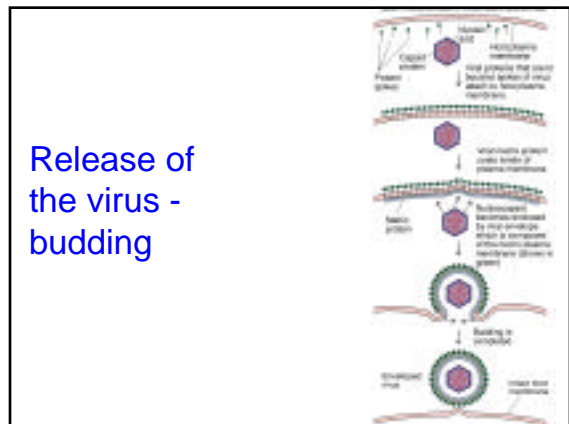


Assembly

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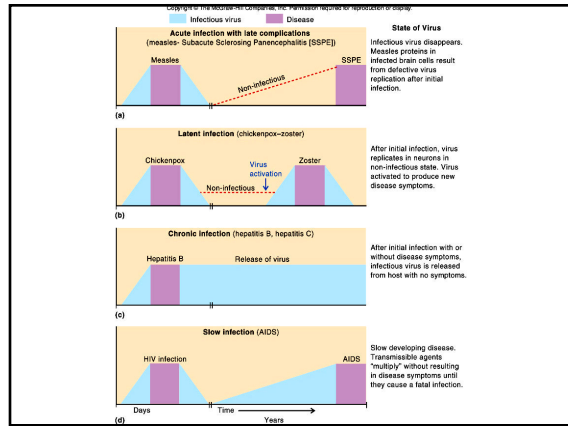
TABLE 14.5 Relationship of Virus Size to Dependency on Host Cell Enzymes for DNA Replication

Virus	Increasing Size of Virus	Dependency on Host Cell DNA Synthesis Enzymes
Parvovirus	↓	Highly dependent on host cell enzymes
Adenovirus	↓	Highly dependent on host cell enzymes
Herpesvirus	↓	Highly dependent on host cell enzymes
Poxvirus	↓	Highly dependent on host cell enzymes
Rotavirus	↓	Highly dependent on host cell enzymes
Poliovirus	↓	Highly dependent on host cell enzymes
Adenovirus	↓	Highly dependent on host cell enzymes
Herpesvirus	↓	Highly dependent on host cell enzymes
Poxvirus	↓	Highly dependent on host cell enzymes
Rotavirus	↓	Highly dependent on host cell enzymes
Poliovirus	↓	Highly dependent on host cell enzymes

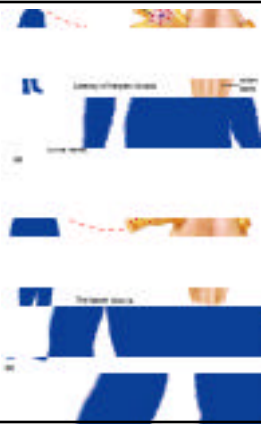


Release of the virus - budding

Budding



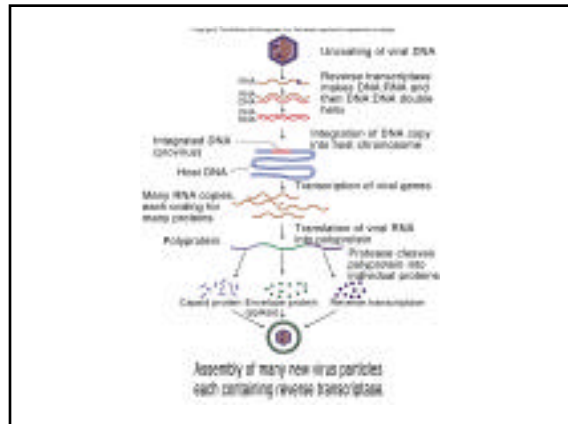
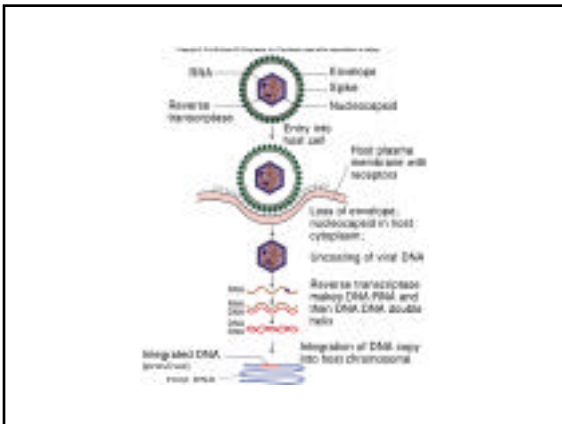
Herpes simplex 1



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TABLE 16.3 Examples of Latent Infections

Virus	Primary Disease	Recurrent Disease	Cells Involved in Latent State
Herpes Simplex Virus	Oral and genital	Recurrent oral and genital	Neurons and epithelial cells
VZV	Chickenpox	Zoster	Neurons and epithelial cells
Epstein-Barr Virus (EBV)	Mononucleosis	Recurrent infectious mononucleosis	Lymphocytes of many glands
Cytomegalovirus (CMV)	Mononucleosis	Recurrent infectious mononucleosis	Lymphocytes of many glands
Human Herpesvirus 8 (HHV-8)	Kaposi's sarcoma	Recurrent Kaposi's sarcoma	Endothelial cells and T cells



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TABLE 14.8 Examples of Chronic Infections

Virus	Site of Infection	Location of Infectious Virions in Carrier State	Disease
Hepatitis B	Liver	Plasma, saliva, genital secretions	Hepatitis, cirrhosis, carcinoma
Hepatitis C	Liver	Plasma, saliva, genital secretions	Hepatitis, cirrhosis, carcinoma
Rubella virus	Many organs	Urine, saliva	Congenital rubella syndrome

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TABLE 14.10 Some Oncogenes Associated with Tumors

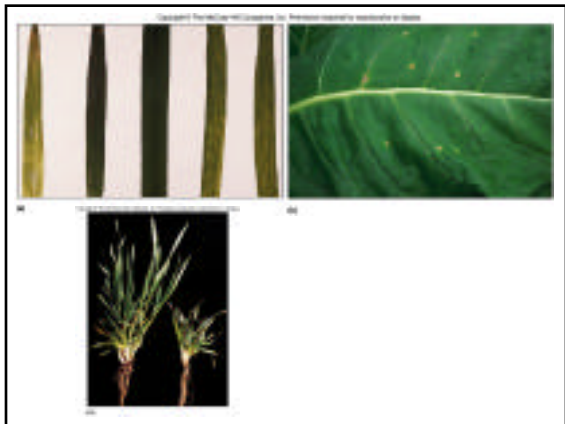
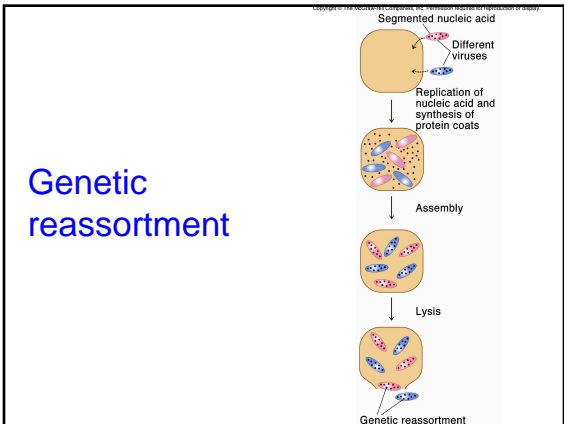
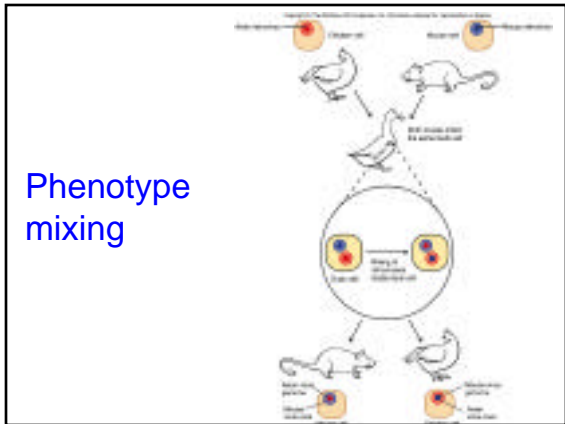
Oncogene	Virus	Function of Oncogene
<i>src</i>	Rous sarcoma	Tyrosine protein kinase*
<i>src</i>	Fajana's sarcoma virus (chickens)	Tyrosine protein kinase
<i>src</i>	Musci sarcoma virus	Mutant guanosine triphosphate-binding protein
<i>src</i>	Musci sarcoma virus	Serine protein kinase
<i>src</i>	Avian sarcoma virus	Mutant sequence-specific gene activator
<i>src</i>	Slack-Kelting virus	Mutant sequence-specific DNA-binding protein

Oncogenes identified in different systems. Each of these oncogenes corresponds to a proto-oncogene in the host.
*An enzyme that adds a phosphate molecule to tyrosine in a regulatory protein modifying the activity of the protein.

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TABLE 14.11 Viruses Associated with Cancers in Humans

Virus	Type of Nucleic Acid	Kind of Tumor
Human papillomavirus (HPV)	DNA	Differentiated cell lines, including squamous cell and genital carcinomas caused by HPV types 16, 18, and 31
Hepatitis B virus	DNA	Hepatocellular carcinoma
Epidemic typhus virus	DNA	Stomach lymphomas, nasopharyngeal carcinoma, B-cell lymphomas
Hepatitis C virus	DNA	Hepatocellular carcinoma
Human herpes virus 8	DNA	Kaposi's sarcoma
EBV-1	DNA	Nasopharyngeal carcinoma, Hodgkin's lymphoma, Burkitt's lymphoma, nasopharyngeal carcinoma, B-cell lymphomas





Viral epidemics

- ✓ 1918 & 1919 - Spanish flu (swine flu)
(read page 619)
- ✓ 1940s & 50s - polio
- ✓ 1970s & 1990s - Ebola
- ✓ 1980s & 1990s - HIV
- ✓ 1996 & 1997 - hepatitis, dengue fever, yellow fever, Ebola, Lassa fever, and polio
- ✓ Others - hantavirus,

Host Range and specificity

- ✓ Most viruses are specific to the host they attack.
 - Bacteria, fungi, algae, protozoa, plants and vertebrates.
 - Polio - only humans
 - Rabies - many warmblooded animals
- ✓ Many are specific to the cells they attack
 - Human papillomavirus (warts) - skin cells
 - Cytomegalovirus (CMV)- salivary glands, liver, lungs, and other tissues

+ sense RNA viruses

- ✓ Picornaviridae
 - Polio, rhinoviruses (common cold), hepatitis A
- ✓ Togaviridae
 - Rubella virus
- ✓ Flaviviridae
 - Yellow fever, Hepatitis C
- ✓ Retroviridae (reverse transcriptase)
 - Adult leukemia, HIV(AIDS)

- sense RNA viruses

- ✓ Paramyxoviridae
 - Mumps, measles, viral pneumonia
- ✓ Rhabdoviridae
 - Rabies
- ✓ Orthomyxoviridae
 - Influenza
- ✓ Filoviridae
 - Marburg, Ebola
- ✓ Bunyaviridae
 - Hanta, LaCross virus

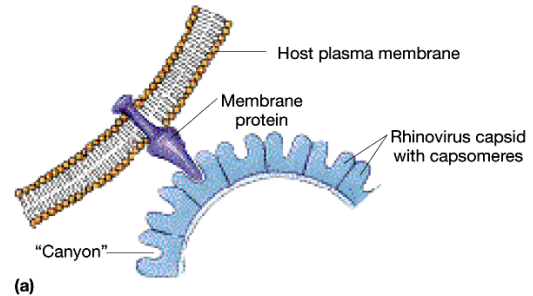
Double-stranded RNA viruses

- ✓ Reoviridae
 - Respiratory and gastrointestinal infections
 - Rotavirus - diarrhea in children
 - Bluetongue virus - sheep

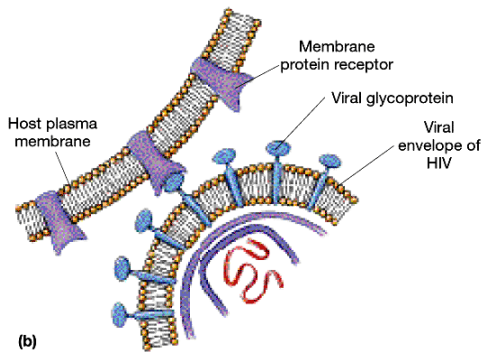
DNA viruses

- ✓ Adenoviridae
 - Respiratory infections
- ✓ Herpesviridae
 - Oral and genital herpes
- ✓ Poxviridae
 - Smallpox
- ✓ Papovaviridae
 - Human papilloma viruses (warts), cervical and penile cancers
- ✓ Hepadnaviridae
 - Hepatitis B

Cold virus attaching

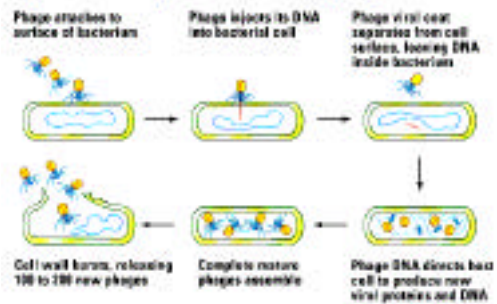


HIV virus binding



Lytic cycle

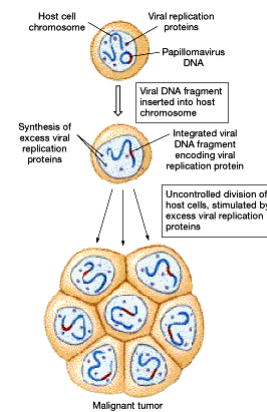
Reproductive cycle of a bacteriophage

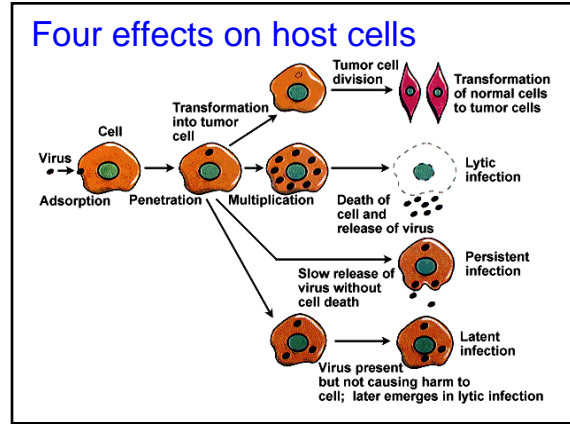
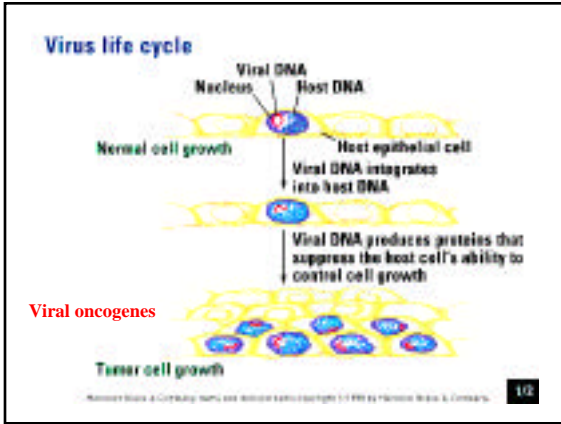


Viroids and Prions

- ✓ Viroids (plants - stunt disease)
 - Low molecular weight circular RNA molecule
 - Exist without capsid or envelope
 - Do not require a helper virus
 - Do not produce proteins
- ✓ Prions (Creutzfeldt-Jakob disease CJD, kuru, scrapie, BSE)
 - Resist heating to 90°C
 - Insensitive to radiation treatment
 - Not destroyed by nucleases
 - Are sensitive to protein-denaturing agents

Tumor formation





- ### Viral epidemics
- ✓ 1918 & 1919 - Spanish flu (swine flu)
 - ✓ 1940s & 50s - polio
 - ✓ 1970s & 1990s - Ebola
 - ✓ 1980s & 1990s - HIV
 - ✓ 1996 & 1997 - hepatitis, dengue fever, yellow fever, Ebola, Lassa fever, and polio
 - ✓ Others - hantavirus, West Nile virus

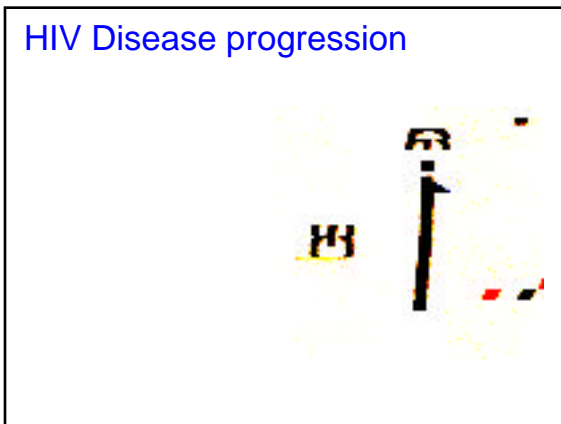
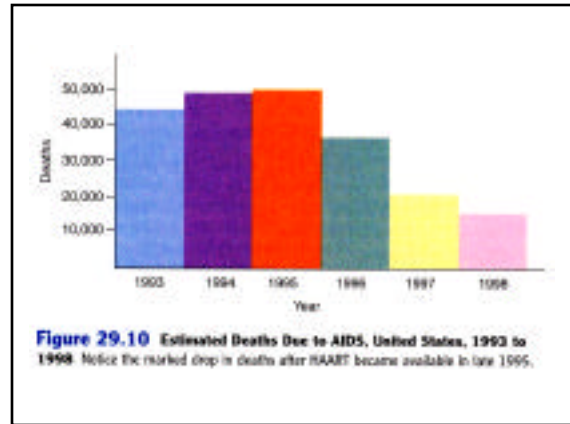
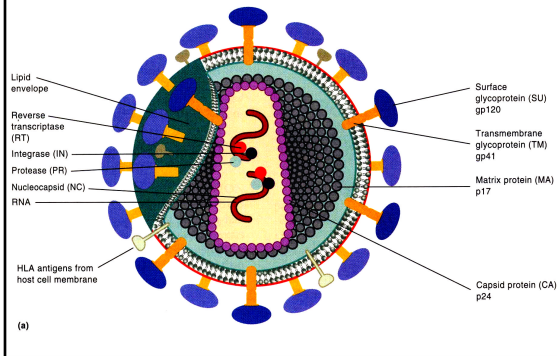
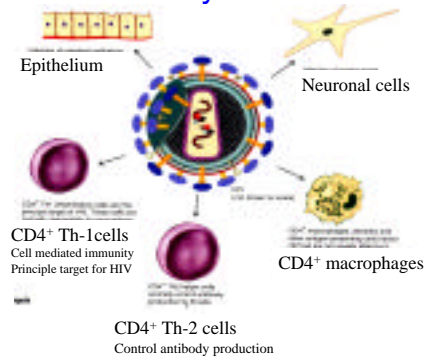


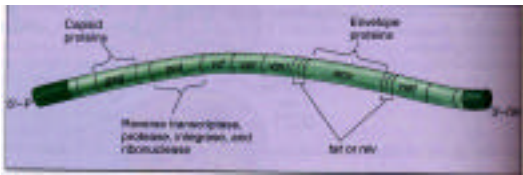
Diagram of HIV



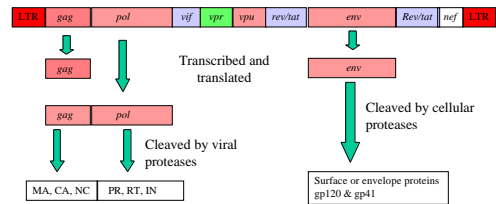
Cells infected by HIV



HIV Genome

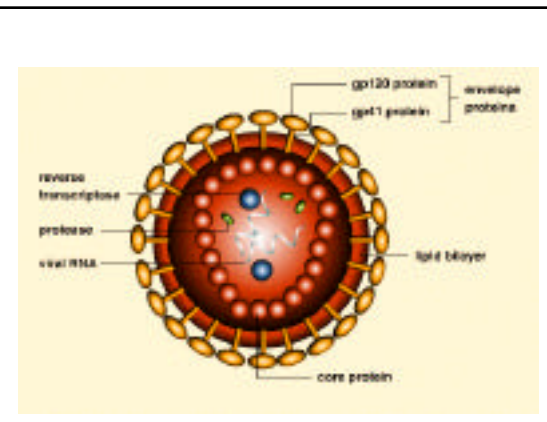


HIV-1 genome

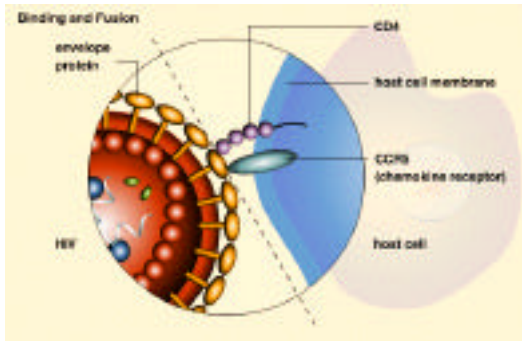


Accessory gene products

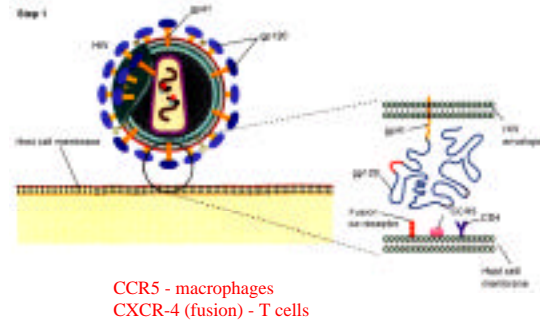
- ✓ Tat - regulates transcription
- ✓ Rev - nuclear export of unspliced RNA
- ✓ Nef - removes CD4 antigens from the surface of the host
- ✓ Vif - regulates virion assembly
- ✓ Vpr - Nuclear transport of uncoated viral DNA and cell arrest in G2
- ✓ Vpu - Blocks transport of CD4 to the cell surface



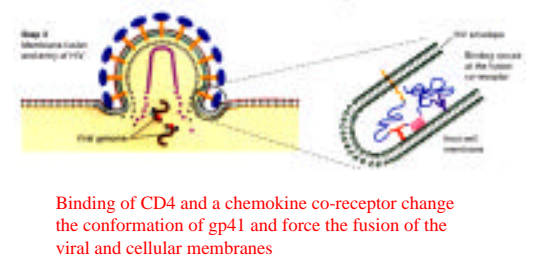
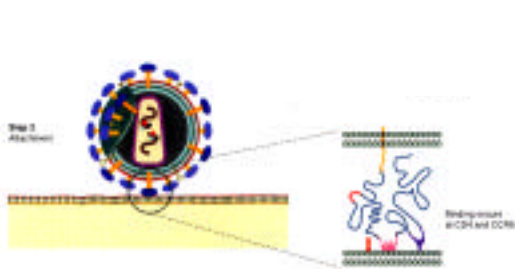
Binding of HIV in macrophages



HIV receptors

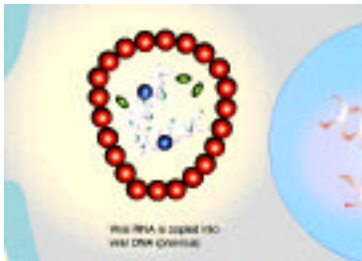


HIV attachment

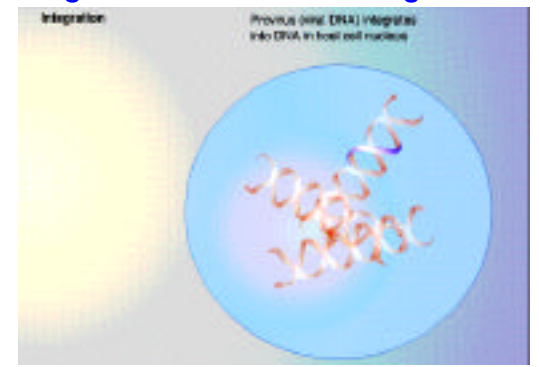


Binding of CD4 and a chemokine co-receptor change the conformation of gp41 and force the fusion of the viral and cellular membranes

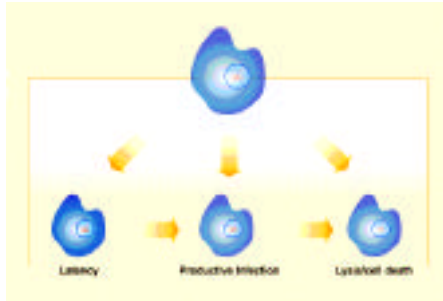
Reverse transcriptase copies viral RNA into DNA



Integration into the host's genome

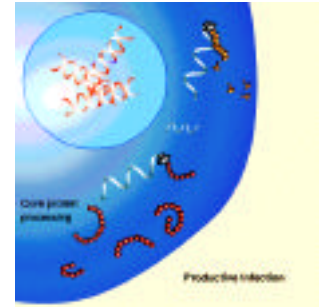


Infection pathways

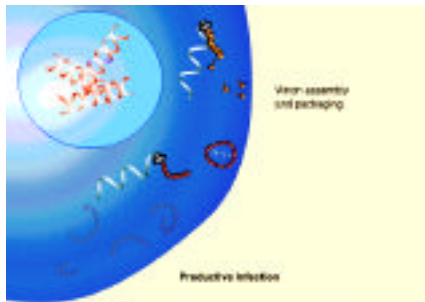


Viron production

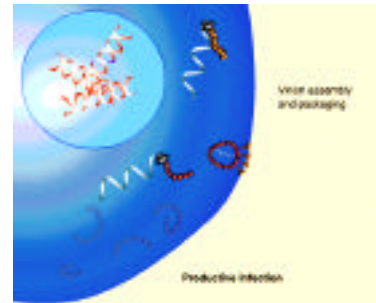
Proteins are translated and cleaved



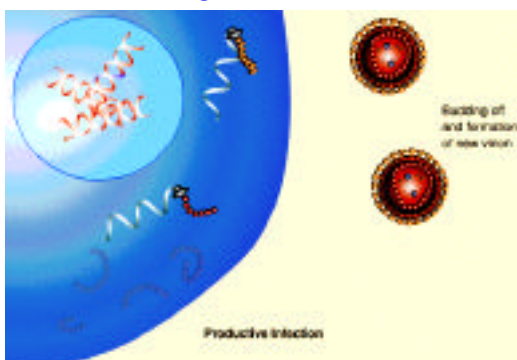
Protein production and cleavage



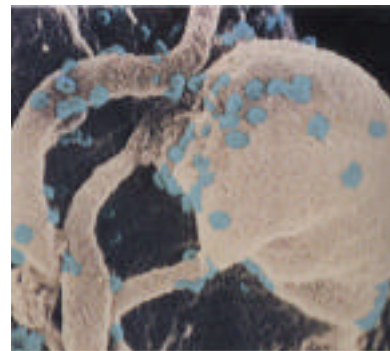
Envelope protein assemble on the cell surface



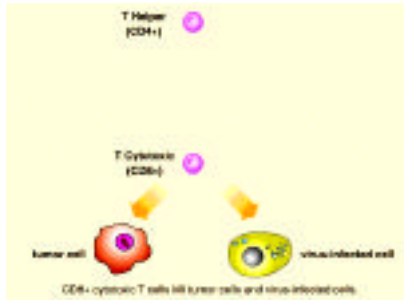
Virus budding



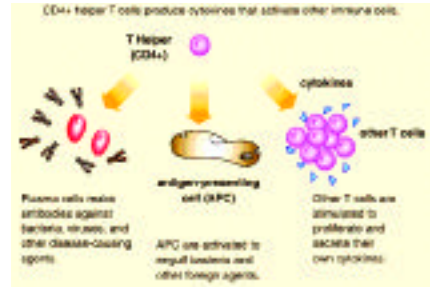
HIV budding from a T-cell



CD8 T-cells are cytotoxic



CD4 T-cells regulate the immune response



HIV infection destroys CD4 T-cells

