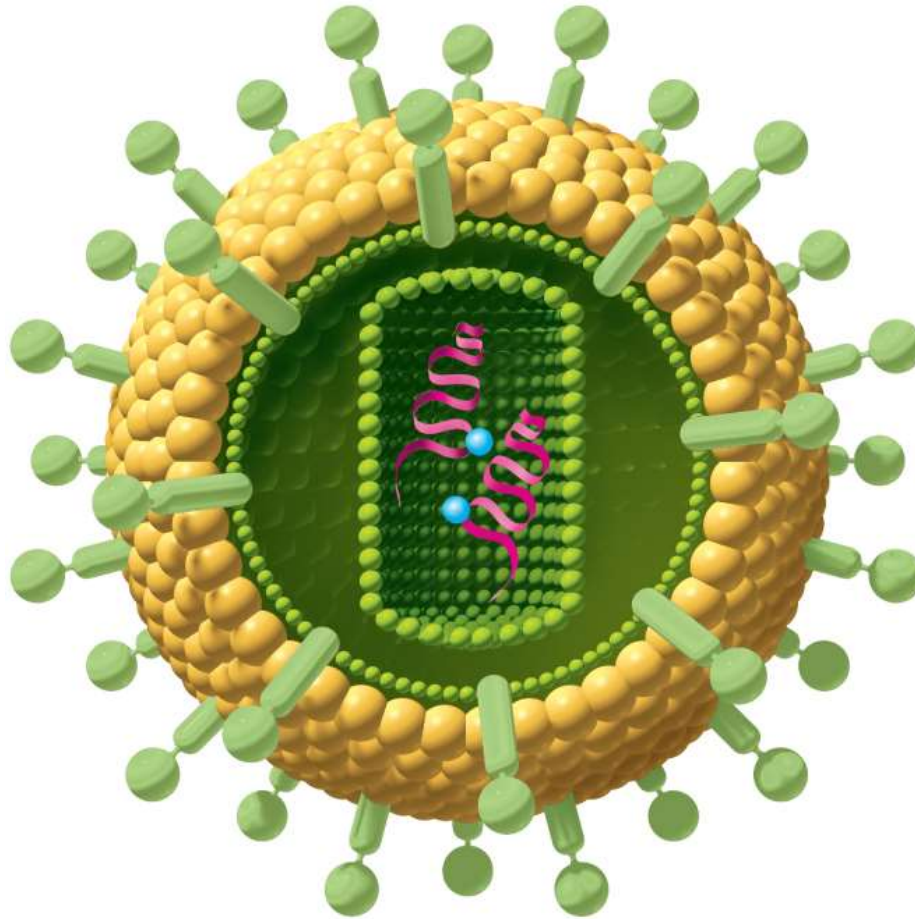


# Autoimmune and Immunodeficiency Diseases



# Autoimmune Diseases

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- Characterized by
  - Failures of self-tolerance
  - Immune system unable to recognize self-antigens
  - Immune system produces **auto-antibodies** that attack the body's own tissues

# Autoimmune Diseases

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- Reasons for lack of self-tolerance:
  - cross-reactivity /// some antibodies against foreign antigens react to similar self-antigens /// rheumatic fever = streptococcus antibodies react with tissue of the heart valves
  - abnormal exposure of self-antigens in the blood /// some of our native antigens are not exposed to blood // blood-testes barrier isolates sperm from blood
  - changes in structure of self-antigens /// viruses and drugs may change the structure of self-antigens or cause the immune system to perceive them as foreign
- Self-reactive T cells /// not all are eliminated in thymus during development /// these “bad” T cells are normally kept in check by the regulatory T ( $T_R$ ) cells

# Immunodeficiency Diseases

- Immune system fails to react vigorously enough
- **Extreme Case: Severe Combined Immunodeficiency Disease (SCID)**
  - genetic disease which fails to make both T cells and B cells
  - vulnerability to opportunistic infection and must live in protective enclosures



© Science VU/Visuals Unlimited

# Immunodeficiency Diseases

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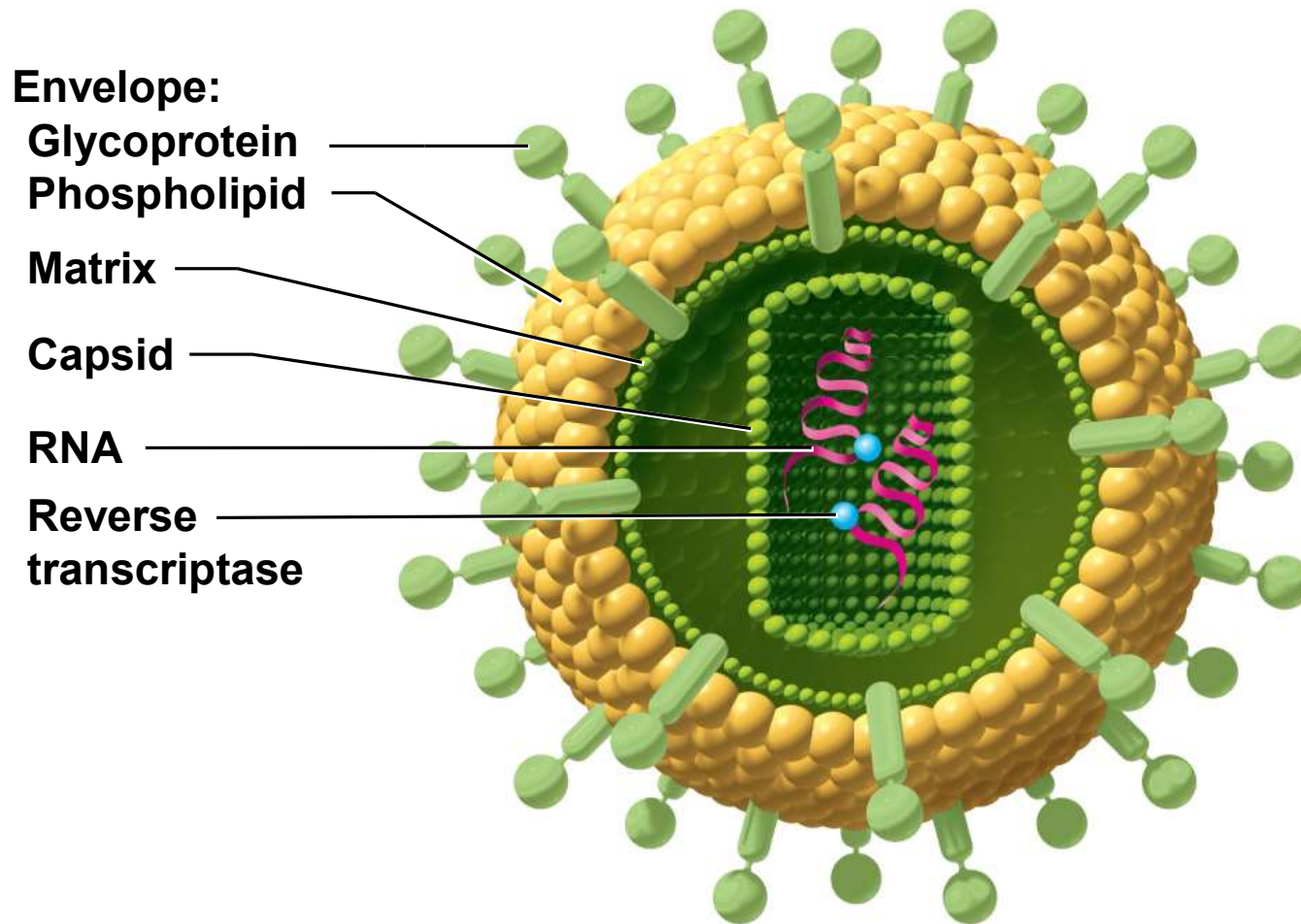
- **Example: Acquired Immunodeficiency Syndrome (AIDS)**
  - Nonhereditary diseases contracted after birth
  - Severely depress both cellular and humoral immunity
  - Also diminish some aspects of the second line of defense
  - Caused by the **human immunodeficiency virus (HIV)**
  - Aids Associated Diseases (syndrome) // group of conditions that develop because of the original viral infection

# Acquired Immunodeficiency Syndrome (AIDS)

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- HIV invades helper T cells // use macrophages and dendritic cells to internalize viruses using receptor mediated endocytosis
- *Reverse transcriptase (retrovirus)* uses viral RNA as template to synthesize DNA
  - new DNA inserted into host cell DNA (may be dormant for months to years)
  - when activated, it induces the host cell to produce new viral RNA, capsid proteins, and matrix proteins
  - as virus are shed from host the virus are coated with bits of the host cell's plasma membrane
  - adhere to new host cells and repeat the process

# HIV Structure



# AIDS

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- By destroying  $T_H$  cells, HIV strikes at the central coordinating agent of the specific defense system, humoral immunity, and cellular immunity // the virus (HIV) attacks the helper T cells
- incubation period ranges from several months to 12 years
- signs and symptoms
  - early symptoms: flu like symptoms of chills and fever
  - progresses to night sweats, fatigue, headache, extreme weight loss, lymphadenitis
  - normal  $T_H$  count is 600 to 1,200 cells/ $\mu$ L of blood, but in AIDS it is less than 200 cells/ $\mu$ L
  - person susceptible to **opportunistic infections** (*Toxoplasma*, *Pneumocystis*, herpes simplex virus, cytomegalovirus, or tuberculosis)
  - Candida (thrush): white patches on mucous membranes
  - Kaposi sarcoma: cancer originates in endothelial cells of blood vessels causes purple lesions in skin



# Kaposi Sarcoma



© Roger Ressmeyer/Corbis

# HIV Transmission

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- through blood, semen, vaginal secretions, breast milk, or across the placenta
- most common means of transmission
  - sexual intercourse (vaginal, anal, oral)
  - contaminated blood products
  - contaminated needles
- not transmitted by casual contact
- undamaged latex condom is an effective barrier to HIV, especially with spermicide nonoxynol-9

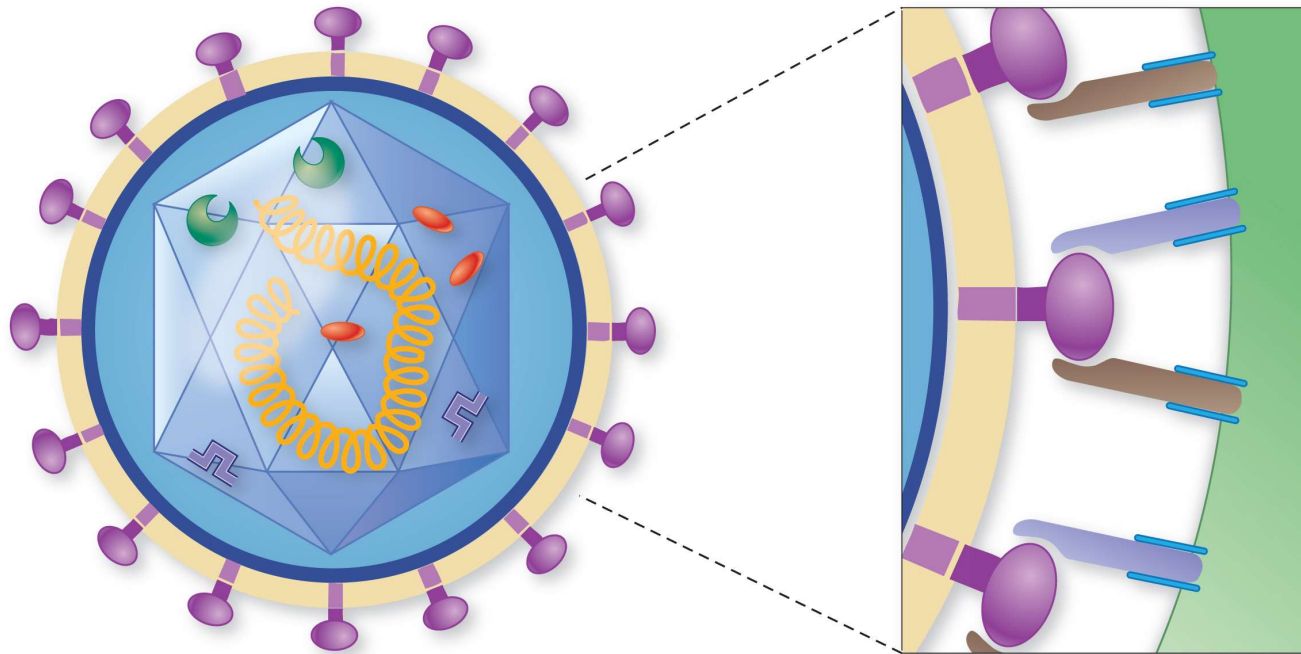
# Treatment Strategies

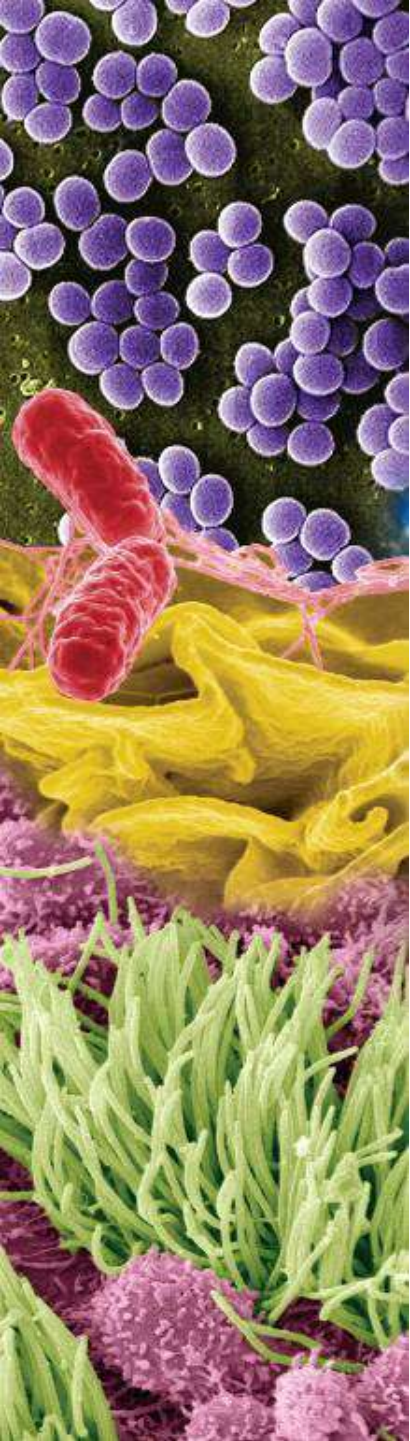
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- prevent binding to CD4 proteins of T<sub>H</sub> cells
- disrupt reverse transcriptase to inhibit assembly of new viruses or their release from host cells
- Medications /// none can eliminate HIV, all have serious side-effects
  - HIV develops drug resistance /// medicines used in combination
  - AZT (azidothymidine) /// first anti-HIV drug - inhibits reverse transcriptase
  - protease inhibitors /// inhibit enzymes HIV needs to replicate
  - now more than 24 anti-HIV drugs on the market

# Review of HIV & AIDs

(This is Not on Exam)





# Human Immunodeficiency Virus Infection (HIV) and AIDS // Signs and Symptoms

A spectrum of clinical signs and symptoms is associated with human immunodeficiency virus

Symptoms of HIV are directly tied to two things

the levels of virus in the blood

the levels of T cells in the blood

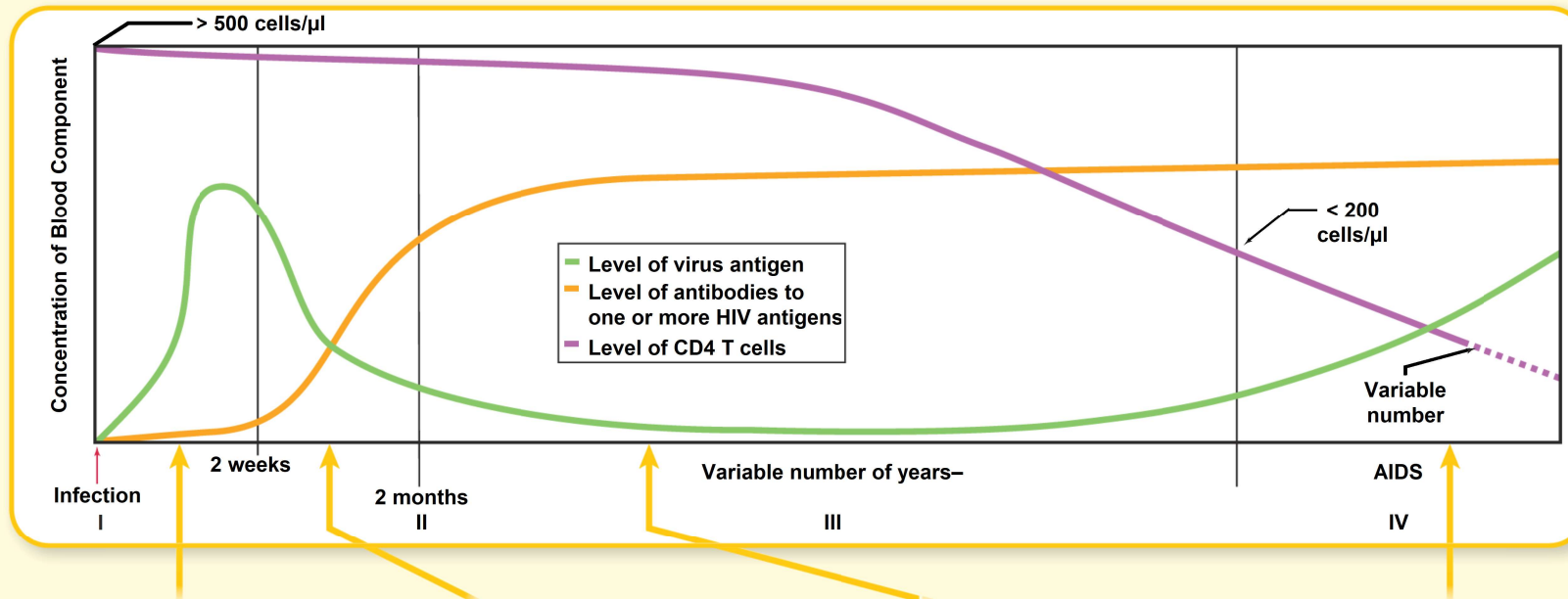
Initial symptoms

fatigue, diarrhea, weight loss, and neurological changes

opportunistic infections or neoplasms (cancer)

# Dynamics of Virus Antigen, Antibody, and T Cells in Circulation

Table 18.2



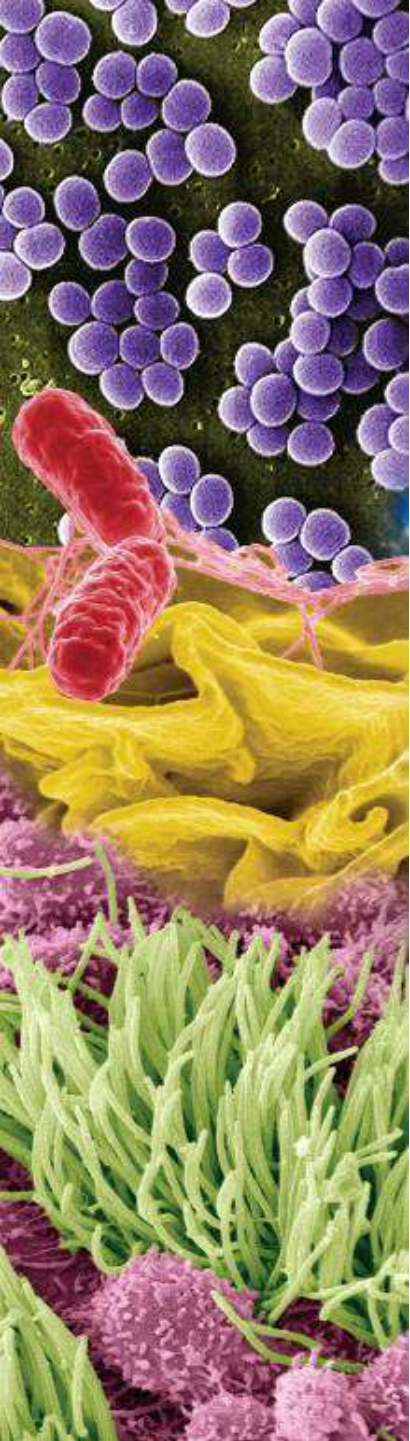
Initial infection is often attended by vague, mononucleosis-like symptoms that soon disappear. This phase corresponds to the initial high levels of virus (the green line above). Antibodies are not yet abundant.

In the second phase, virus numbers in blood drop dramatically and antibody begins to appear. CD4 T cells begin to decrease in number.

A long period of mostly asymptomatic infection ensues. During this time, which can last from 2 to 15 years, lymphadenopathy may be the prominent symptom. During the mid- to late-asymptomatic period, the number of T cells in the blood is steadily decreasing. Once the T-cell level reaches a (low) threshold, the symptoms of AIDS ensue.

Once T cells drop below 200 cells/ $\mu$ l, AIDS results. Note that even though antibody levels remain high, virus levels in the blood begin to rise.





## AIDS-defining illnesses (ADIs)

• Other disease-related symptoms appear to  
accompany severe immune deregulation, hormone  
imbalances, and metabolic disturbances

pronounced wasting of body mass:  
consequence of weight loss, diarrhea, and  
poor nutrient absorption

the virus is particularly hard on the GI tract

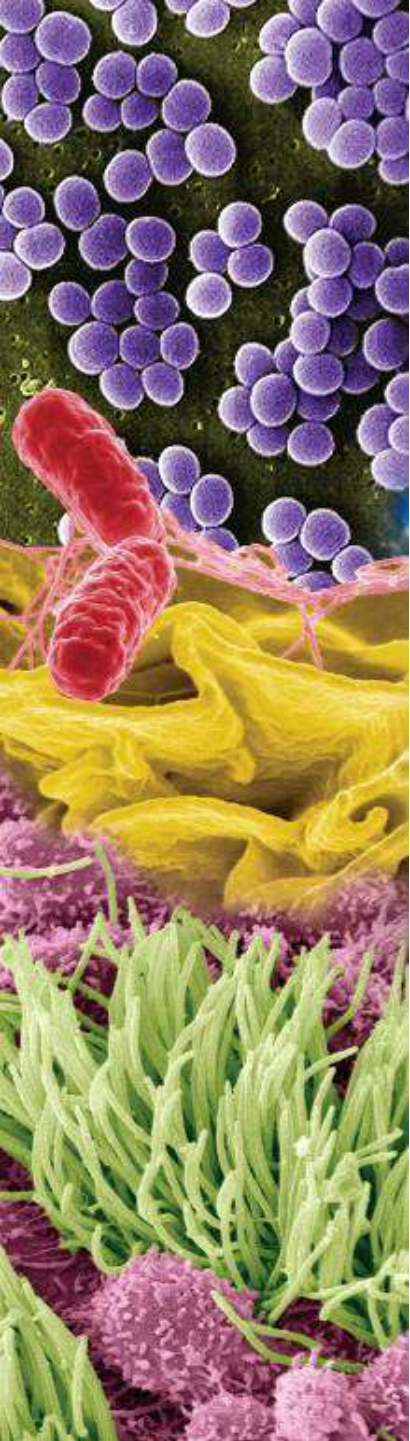
protracted fever, fatigue, sore throat, and  
night sweats

rash and generalized lymphadenopathy in  
several chains of lymph nodes

# AIDS-Defining Illnesses

AIDS-Defining Illnesses					
Skin and /or Mucous Membranes (includes eyes)	Nervous System	Cardiovascular and Lymphatic System or Multiple Organ Systems	Respiratory Tract	Gastrointestinal Tract	Genitourinary and/ or Reproductive Tract
Cytomegalovirus retinitis (with loss of vision)	Cryptococcosis, extrapulmonary	Coccidioidomycosis, disseminated or extrapulmonary	Candidiasis of trachea, bronchi, or lungs	Candidiasis of esophagus, GI tract	Invasive cervical carcinoma (HPV)
Herpes simplex chronic ulcers (>1 month duration)	HIV encephalopathy	Cytomegalovirus (other than liver, spleen, nodes)	Herpes simplex bronchitis or pneumonitis	Herpes simplex chronic ulcers (>1 month duration) or esophagitis	Herpes simplex chronic ulcers (>1 month duration)
Kaposi's sarcoma	Lymphoma; primarily in brain	Histoplasmosis	Mycobacterium avium complex	Isosporiasis, intestinal	
	Progressive multifocal leukoencephalopathy	Burkitt's lymphoma	Tuberculosis (Mycobacterium tuberculosis)	Cryptosporidiosis, chronic intestinal (>1 month duration)	
	Toxoplasmosis of the brain	Mycobacterium kansasii, disseminated or extrapulmonary	Pneumocystis jiroveci pneumonia		
		Mycobacterium tuberculosis, disseminated or extrapulmonary	Pneumonia, recurrent		
		Salmonella septicemia, recurrent			
		Wasting syndrome			



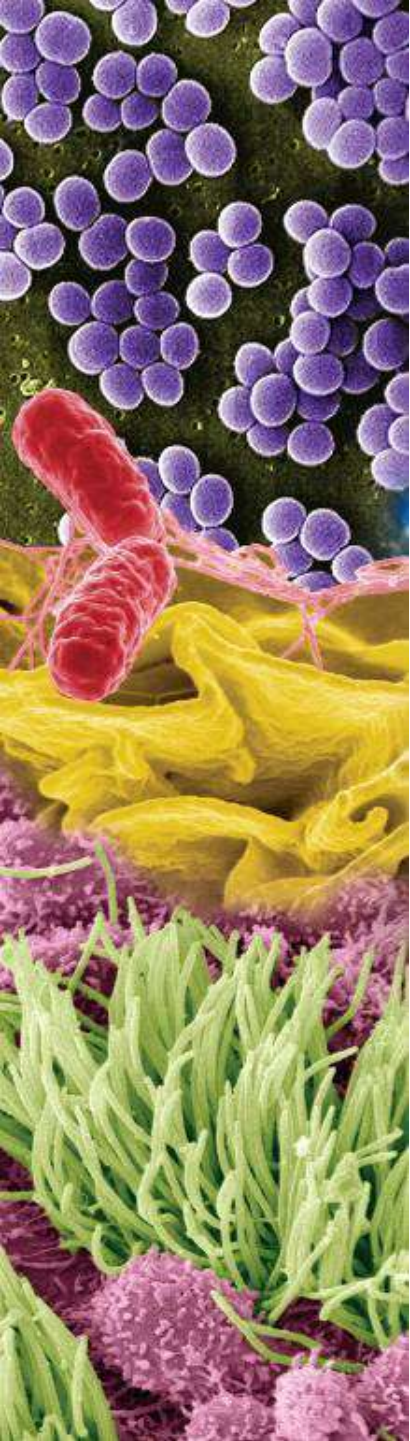


## Human Immunodeficiency Virus Infection (HIV) and AIDS // Signs and Symptoms

Some of the **most virulent complications are neurological**

lesions in the brain, meninges, spinal column, and peripheral nerves

patients with nervous system involvement show some degree of withdrawal, **persistent memory loss**, spasticity, sensory loss, and progressive **AIDS dementia**



## HIV Infection and AIDS // Causative Agent

HIV is a **retrovirus** in the genus *Lentivirus*

retroviruses have the potential to cause cancer

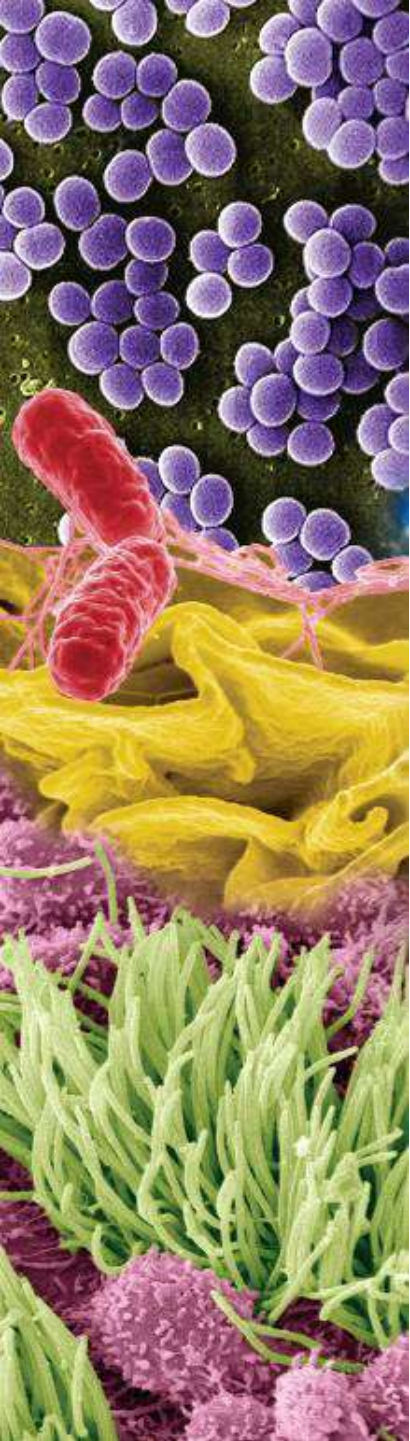
produce dire, often fatal diseases

capable of altering the host's DNA

Contain **reverse transcriptase (RT)**

**catalyzes the replication of double-stranded DNA from single-stranded RNA**

Retroviruses can permanently integrate viral genes into the host genome that is passed on to progeny cells



## HIV Infection and AIDS // Causative Agent

Some retroviruses transform cells (make them malignant) and regulate certain host genes

Enveloped RNA virus

outermost layer is a lipid envelope

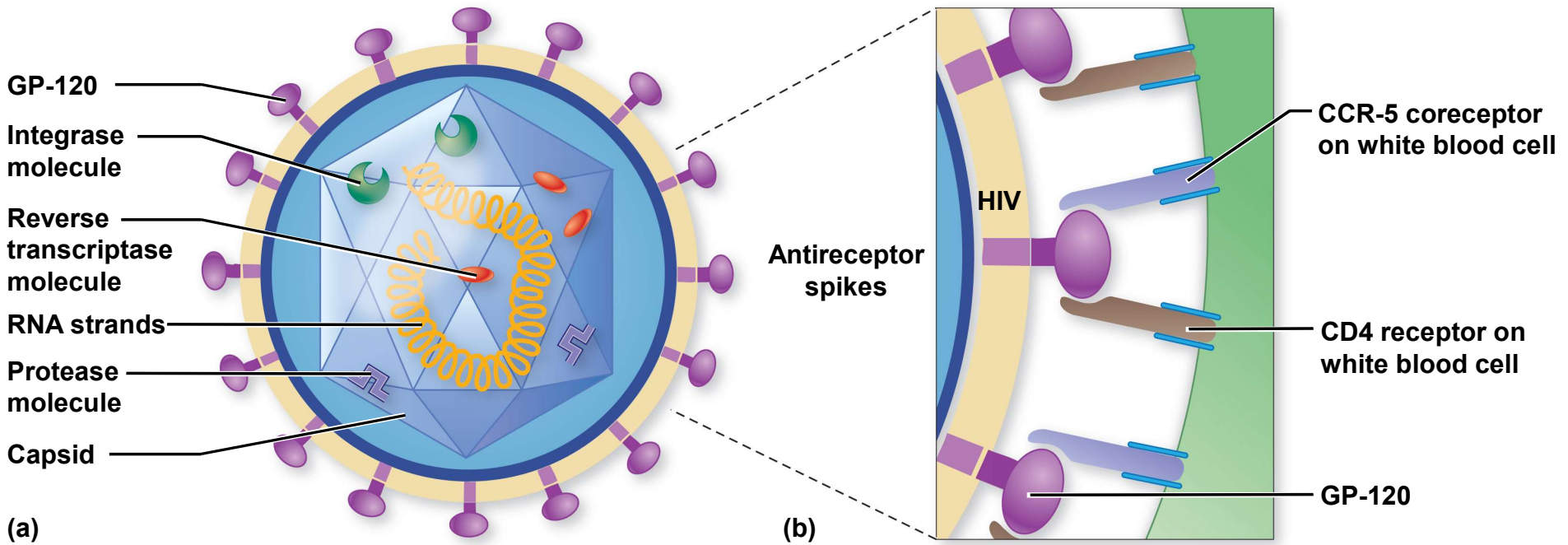
membrane glycoprotein spikes mediate viral adsorption to the host cell

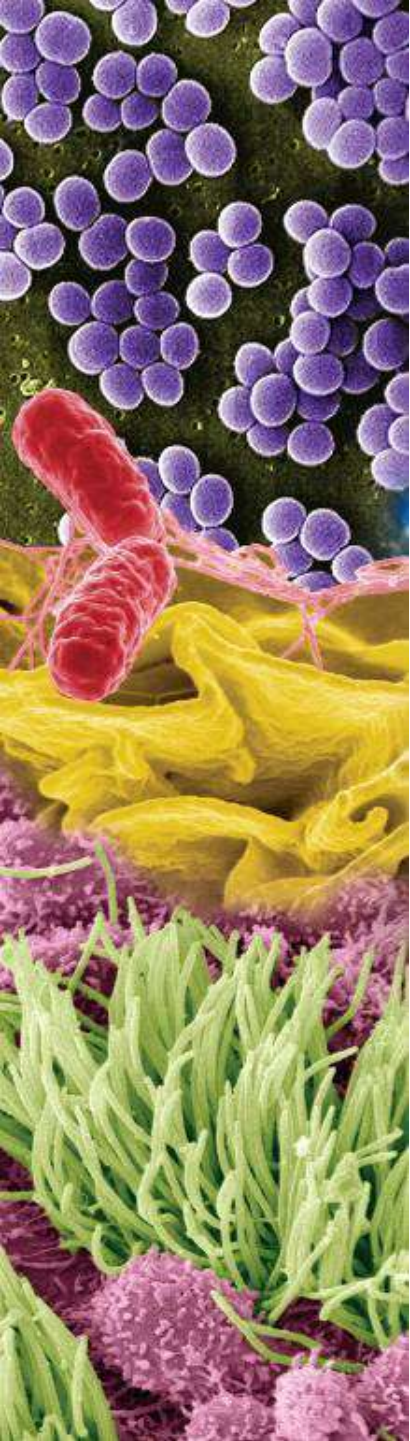
can only infect host cells that display a combination receptor consisting of the CD4 marker plus the coreceptor CCR-5

virus uses these to gain entrance to several types of leukocytes and tissue cells



# The General Structure of HIV





# HIV Infection and AIDS // Pathogenesis and Virulence Factors

## Viral life cycle

HIV enters a mucous membrane or the skin and travels to **dendritic cells** beneath the epithelium

virus **grows inside the dendritic cell and is shed without killing the cell**

virus is **amplified by macrophages** in the skin, lymph organs, bone marrow, and blood

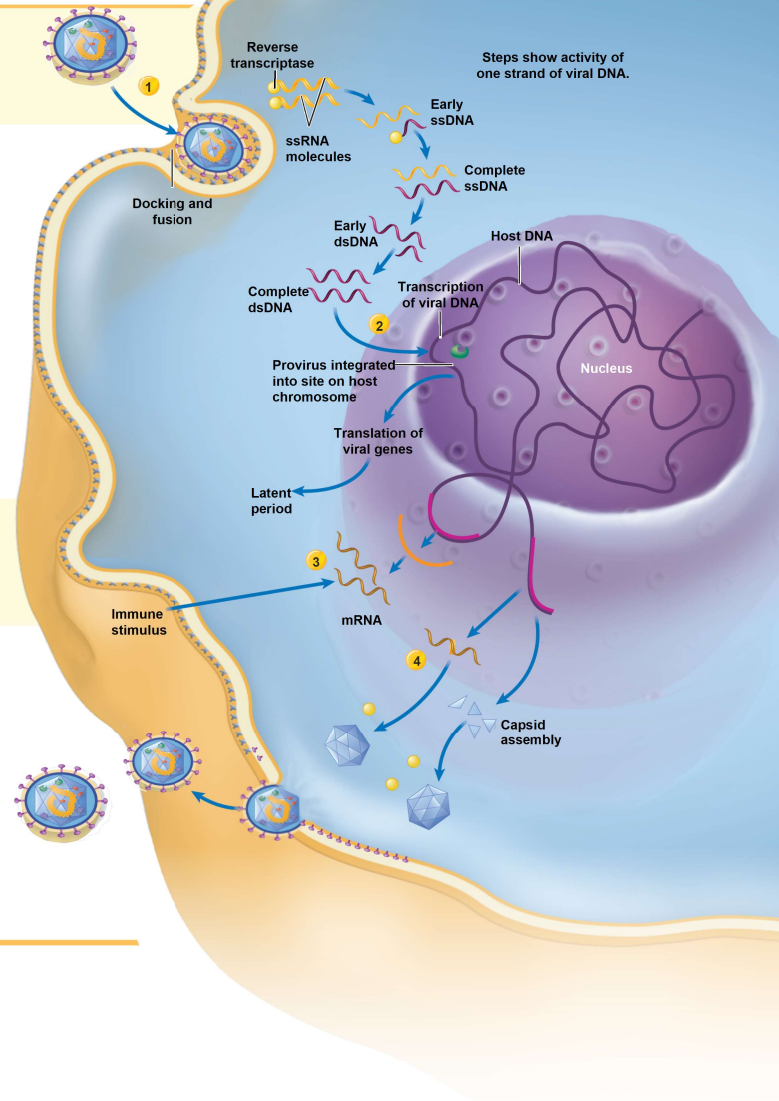
virus **infects and destroys helper T4 and CD4** lymphocytes, monocytes, macrophages, and B lymphocytes

virus docks to host cell surface receptors and induces cell fusion, creating syncytia

# The Multiplication Cycle of HIV



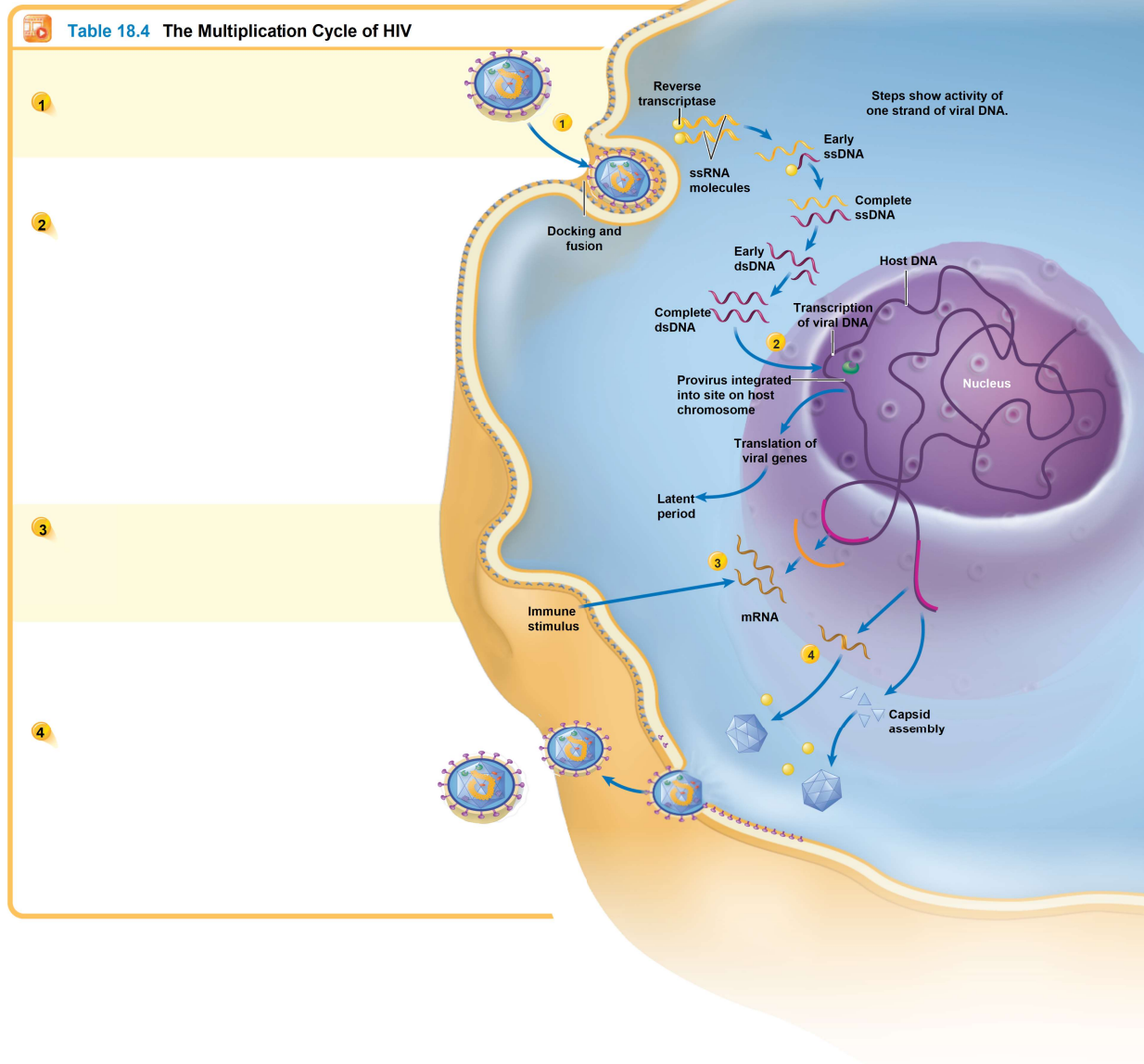
Table 18.4 The Multiplication Cycle of HIV



#1

The virus adsorbs to receptors on the host cell, and is endocytosed. It then uncoats.

# The Multiplication Cycle of HIV



#2

Once the virus is inside the cell, its reverse transcriptase makes its RNA into DNA. Reverse transcriptase catalyzes the synthesis of a single complementary strand of DNA (ssDNA).

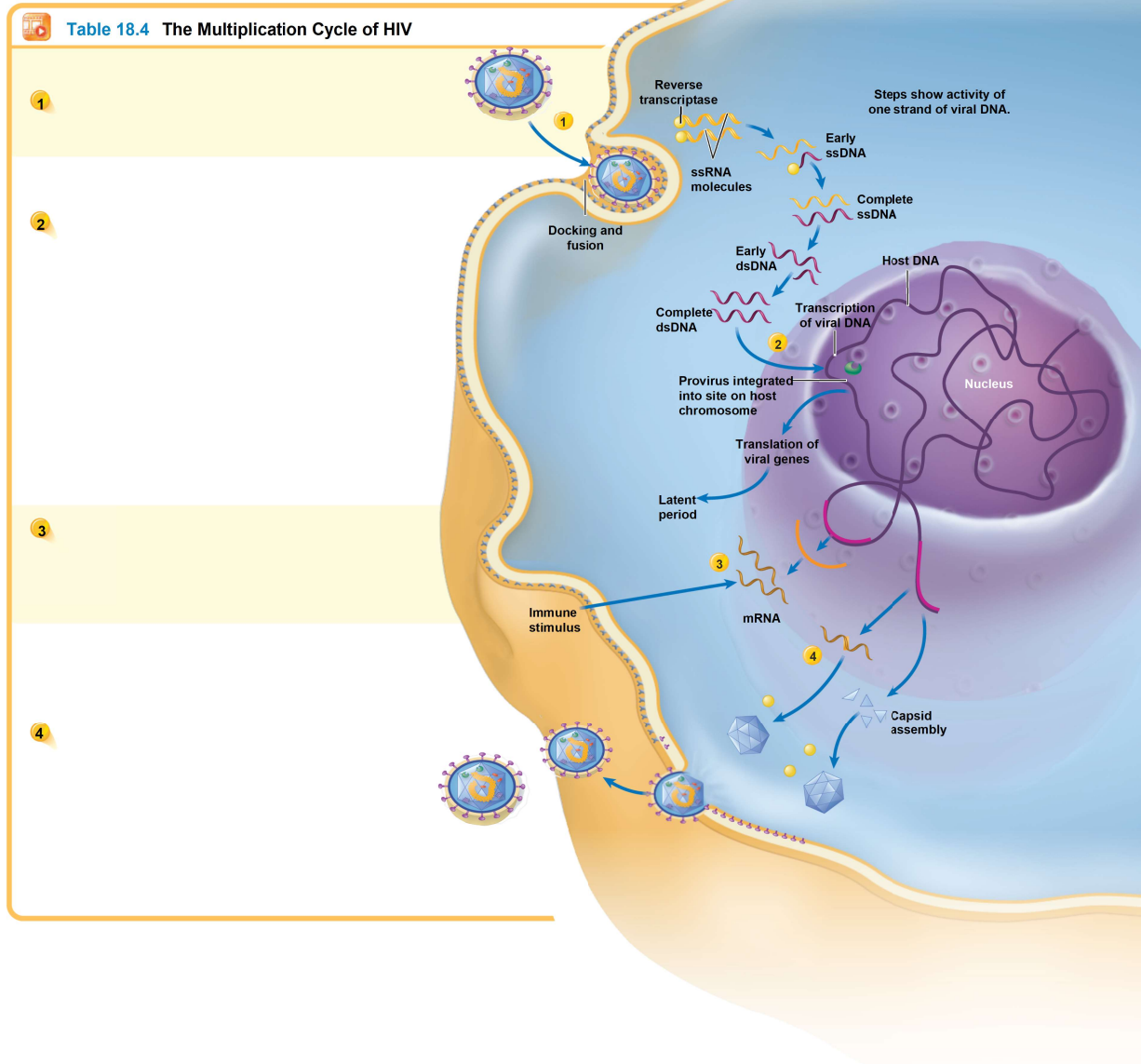
This single strand serves as a template for synthesis of a double strand (ds) of DNA.

Although initially it can produce a lytic infection, in many cells it enters a latent period in the nucleus of the host cell and integrates its DNA into host DNA.

This latency accounts for the lengthy course of the disease.



# The Multiplication Cycle of HIV



#3

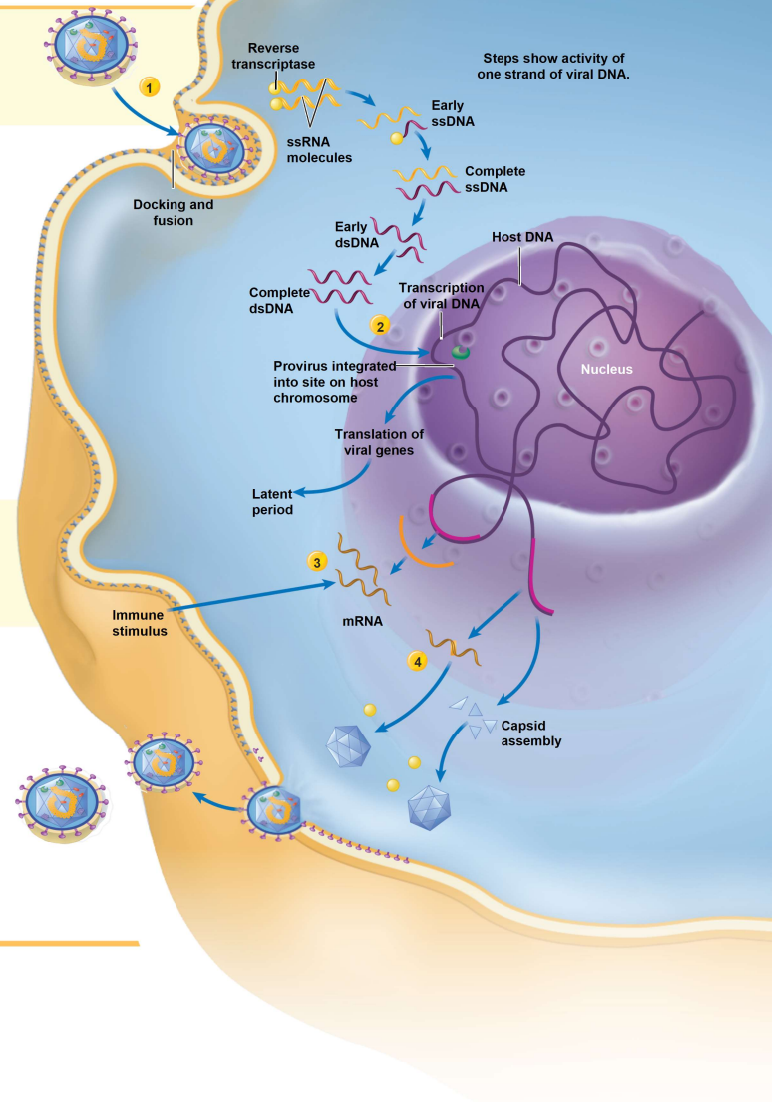
After a latent period, various immune activators stimulate the infected cell, causing reactivation of the provirus genes and production of viral mRNA.



# The Multiplication Cycle of HIV



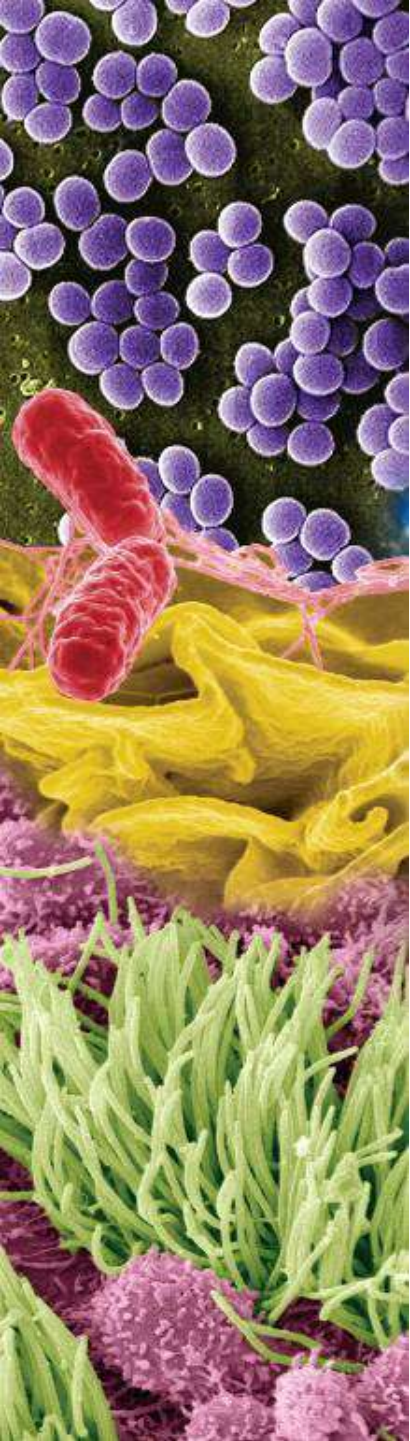
Table 18.4 The Multiplication Cycle of HIV



#4

HIV mRNA is translated by the cell's synthetic machinery into virus components (capsid, reverse transcriptase, spikes), and the viruses are assembled.

Budding of mature viruses lyses the infected cell.



# HIV Infection and AIDS // Transmission

HIV is **mainly** transmitted through

*sexual intercourse*

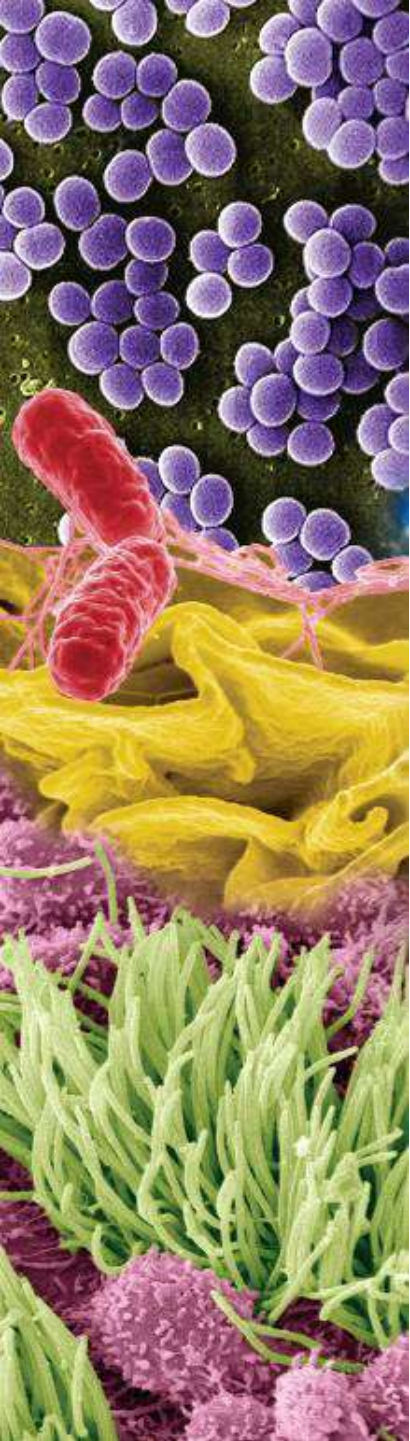
*transfer of blood or blood products*

*babies can be infected before or during birth, or through breastfeeding*

Mode of transmission

similar to the hepatitis B virus, except **HIV does not survive long outside the host and is more sensitive to disinfectants**

virus is not transmitted through saliva



## HIV Infection and AIDS // Transmission

**Health care workers** should be aware of the fluids they may come in contact with during childbirth or invasive procedures that can transmit the virus

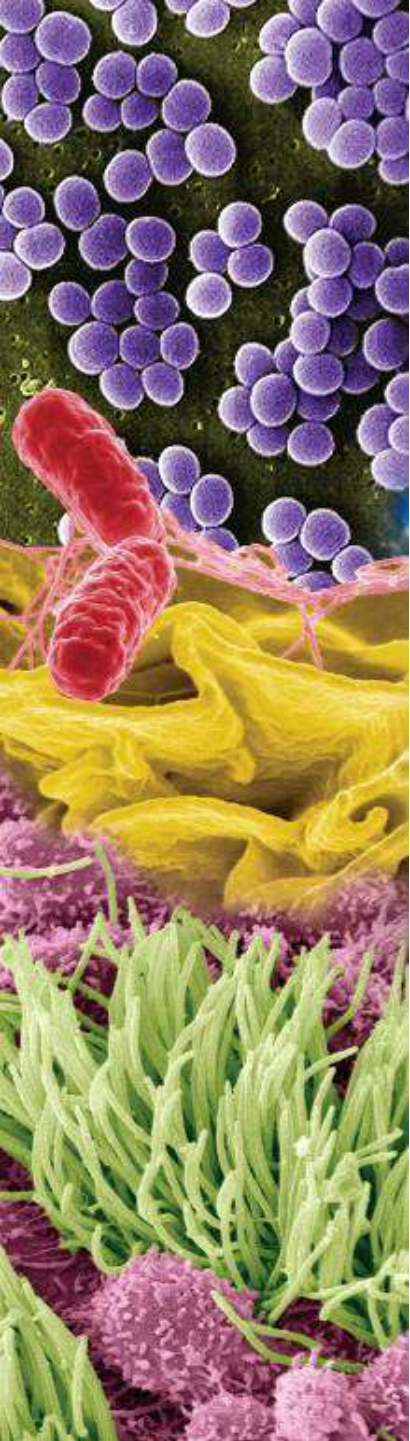
amniotic fluid

synovial fluid

spinal fluid

**Semen and vaginal secretions** harbor free virus and infected white blood cells // significant factors in sexual transmission





## HIV Infection and AIDS // Transmission

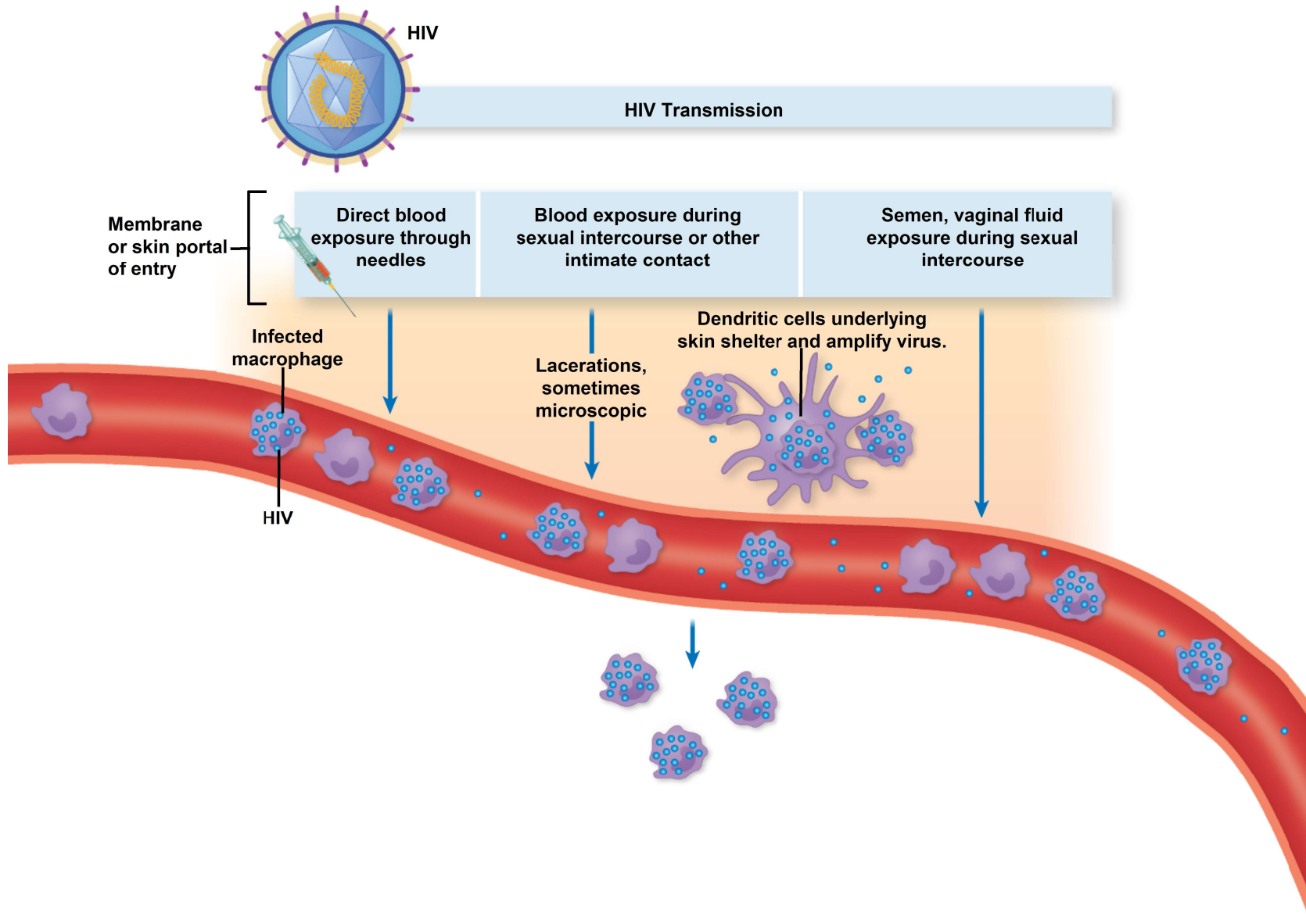
Virus can be isolated from urine, tears, sweat,  
and saliva but *not considered sources of infection*

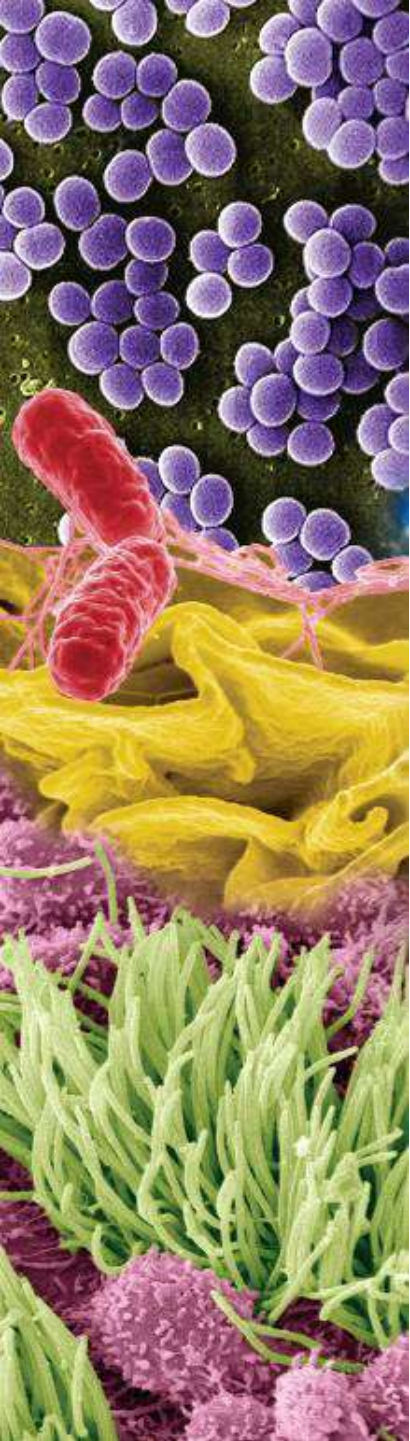
Breast milk

contains significant numbers of  
leukocytes

neonates who have escaped infection  
prior to and during birth can still become  
infected through nursing

# Primary Sources and Suggested Routes of Infection by HIV





## HIV Infection and AIDS // Epidemiology

Since the beginning of the AIDS epidemic in the early 1980s, more than 25 million people have died Worldwide

best global estimate of **individuals infected** is 33 million, with 1 million in the U.S.

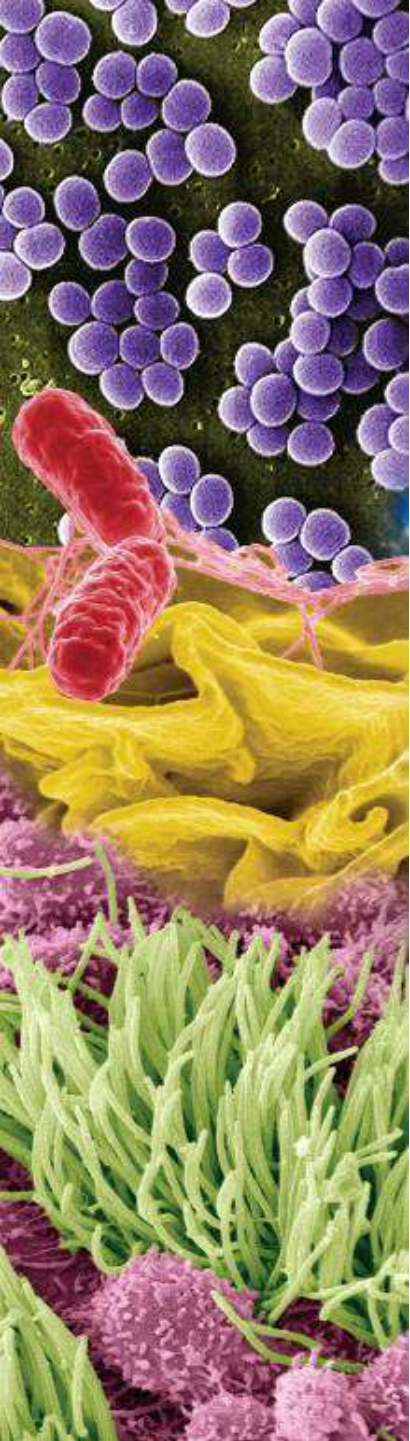
WHO estimates that **2.6 million new infections** occurred in **2009**, and a large number of these people have not begun to show symptoms

Due to global initiatives, more people in the developing world are receiving lifesaving treatments

the number of new infections is still growing faster than access to drugs

**for every two people receiving treatment, five new people are diagnosed**





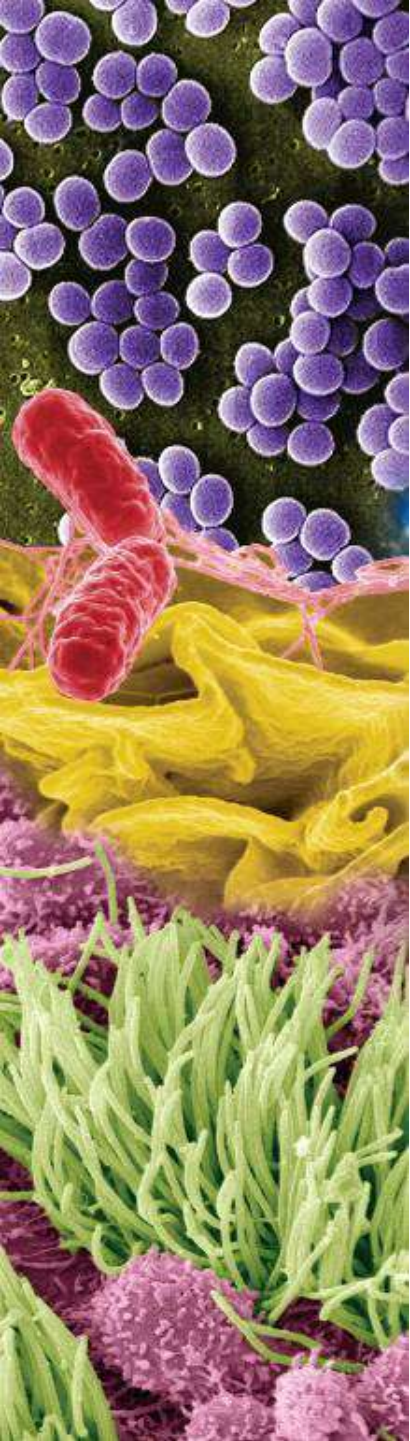
## HIV Infection and AIDS // Epidemiology

In most parts of the world, **heterosexual intercourse is the primary mode of transmission**

In the industrialized world, the overall rate of heterosexual infection has increased dramatically

**highest rates are among adolescents and young adult women**

in the U.S., about 31% of HIV infections arise from unprotected sexual intercourse with an infected partner of the opposite sex



## HIV Infection and AIDS // Epidemiology

About 1% of people who are antibody positive  
remain free of the AIDS

functioning **immunity to the virus** can  
develop

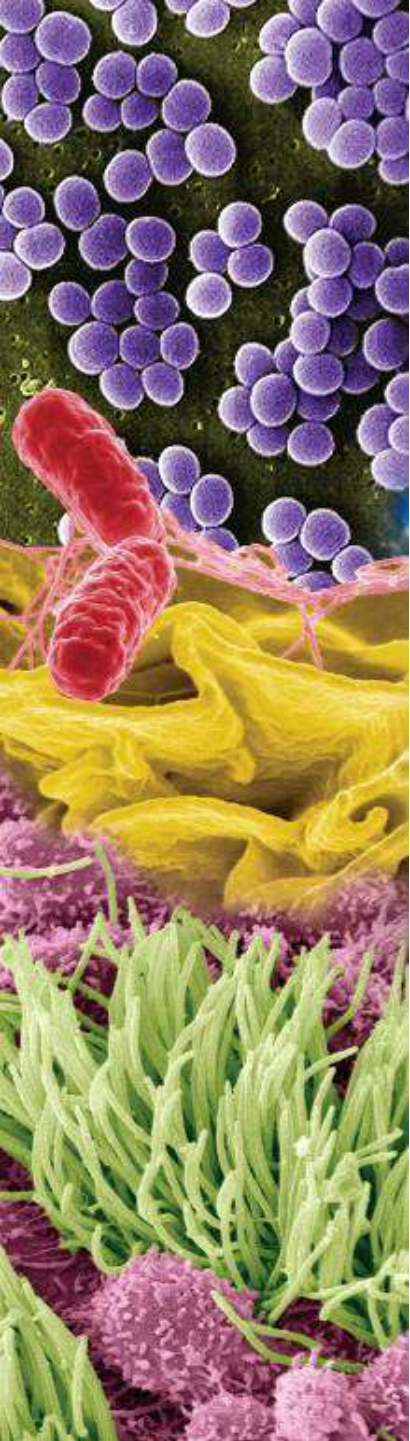
### Non-progressor

**any person who remains healthy despite  
HIV infection**

some lack the cytokine receptors that  
HIV requires for entry

others are infected with a weakened  
mutant strain of the virus





## HIV Infection and AIDS // Epidemiology

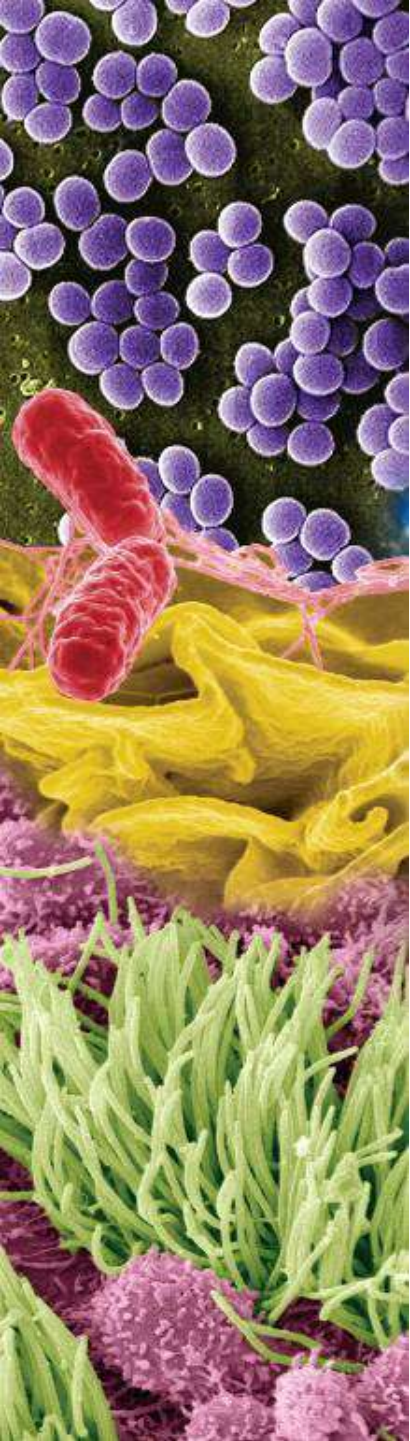
Treatment of HIV-infected mothers with a simple anti-HIV drug has dramatically **reduced the rate of maternal-to-infant transmission of HIV during pregnancy**

current treatment regimens result in a transmission rate of 11%

some studies with multidrug regimens claim transmission rates as low as 5%

evidence suggests that giving mothers **protease inhibitors** can reduce the transmission rate to around 1%

untreated mothers pass the virus to their babies at a rate of 33%



## HIV Infection and AIDS // Culture and Diagnosis

A person is diagnosed as having an HIV infection if they have tested positive for the human immunodeficiency virus

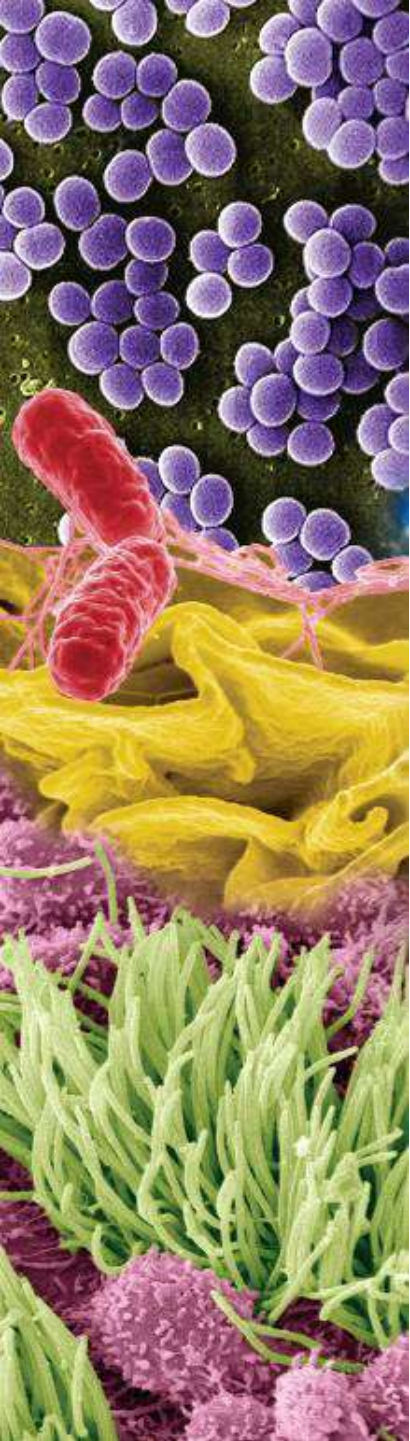
this diagnosis is not the same as having AIDS

Most viral testing is based on detection of antibodies specific to the virus in serum and other fluids

ELISA: older screening method

latex agglutination and rapid antibody tests: newer methods

an at-home testing kit is also available



## HIV Infection and AIDS // Culture and Diagnosis

These tests are largely accurate, but **1% of results are false positives**

**Western blot** analysis is used to follow up

- detects several different anti-HIV antibodies

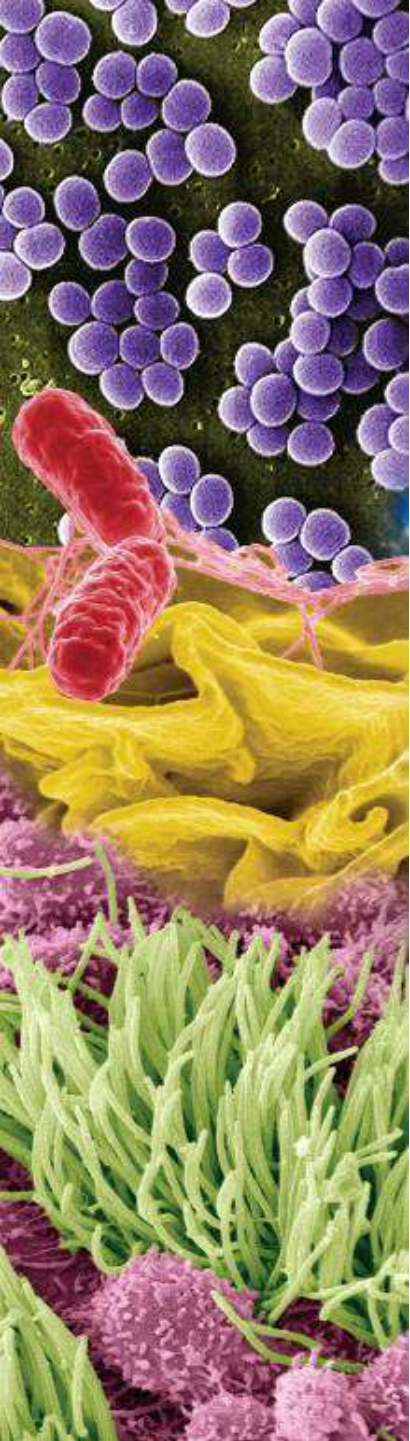
- can rule out false-positive results

False negative results

- can occur when testing is performed before the onset of detectable antibody production**

- persons who are negative, but feel that they have been exposed, should be tested 3 – 6 months later





## HIV Infection and AIDS // Culture and Diagnosis

Blood and blood products are sometimes tested for HIV antigens rather than HIV antibodies

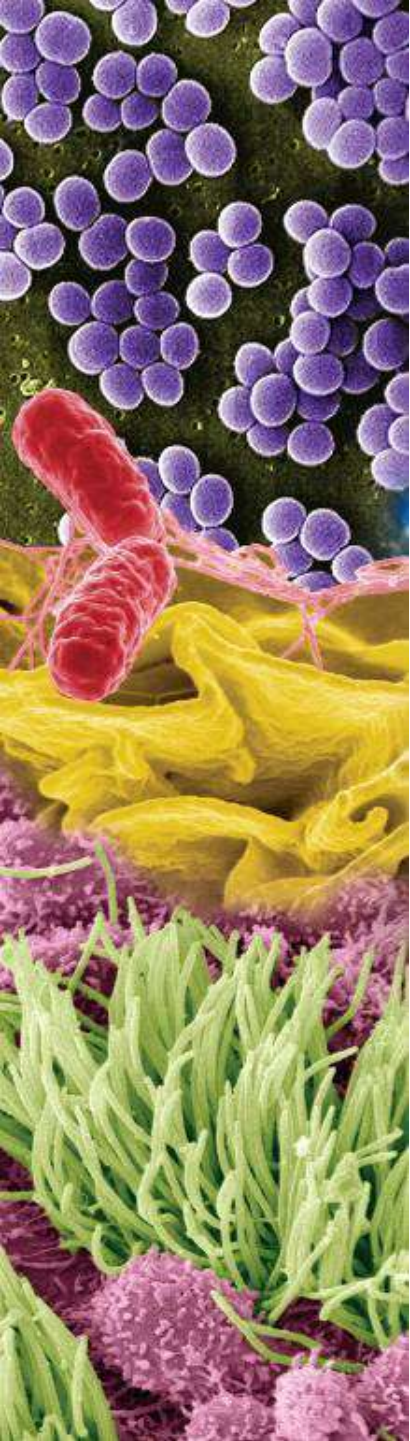
closes the window of time between infection and detectable levels of antibodies when contamination could be missed

**In the U.S, diagnosis with AIDS requires //** 1) testing positive for the virus and // **2) meeting one of the following criteria**

CD4 cells below 200 cells/microliter of blood

CD4 cells account for fewer than 14% of lymphocytes

experience one or more AIDS-defining illness



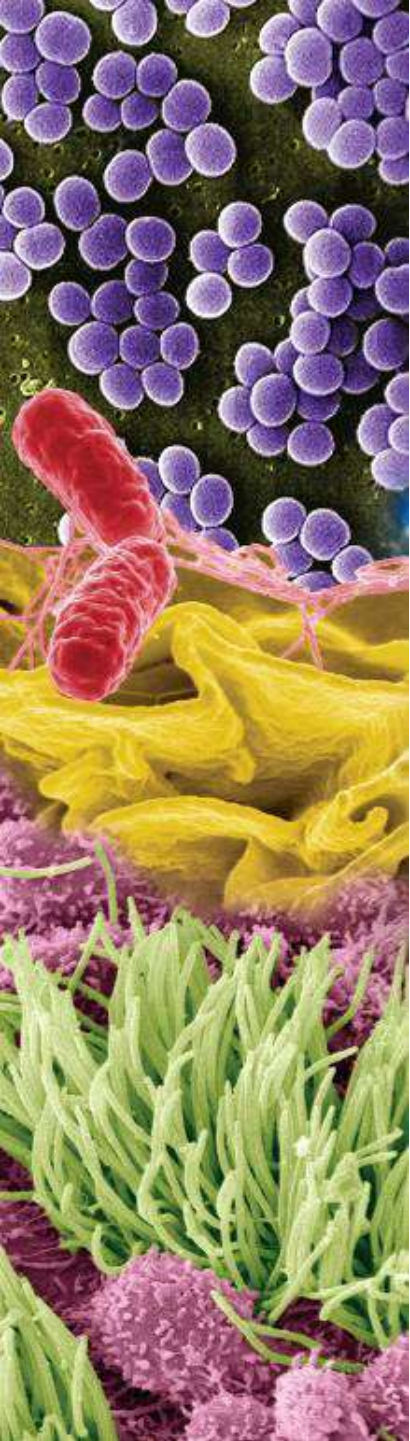
## HIV Infection and AIDS // Prevention

### Avoidance of sexual contact with infected persons

abstaining from sex is an obvious prevention method

sexually active individuals should consider that every partner is infected unless proven otherwise

barrier protection should be used when having sex with anyone whose HIV status is not known with certainty to be negative



# HIV Infection and AIDS // Prevention

## Avoiding intravenous drugs

risk decreased by not sharing needles or  
cleaning needles with a bleach solution

New research has shown that **treating uninfected  
or newly-infected people with antiretrovirals** can  
prevent the progression to AIDS

## Problems with creating a vaccine

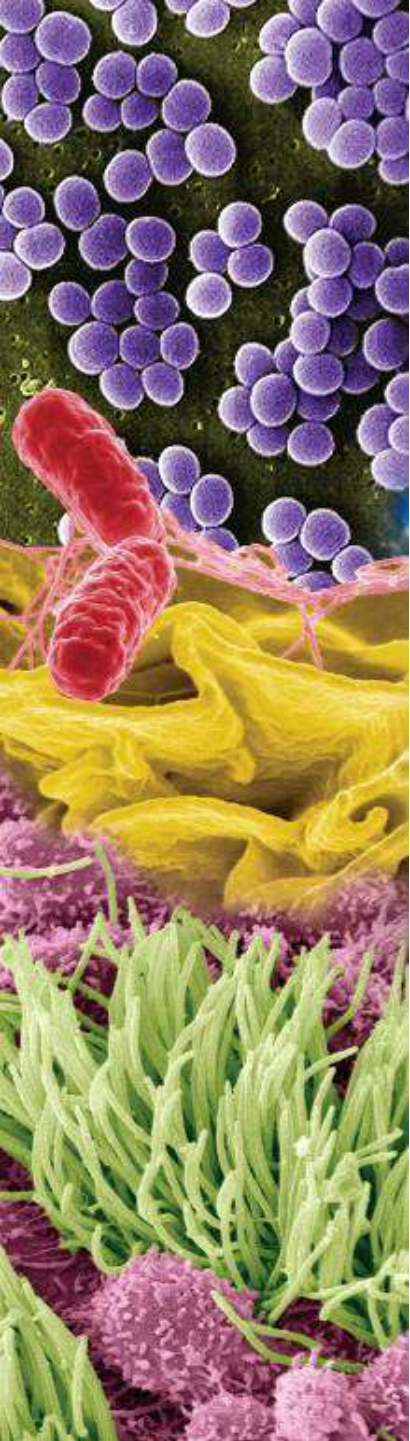
HIV is latent in cells

**surface antigens mutate rapidly**

not completely controlled by immune responses

research continues





## HIV Infection and AIDS // Treatment

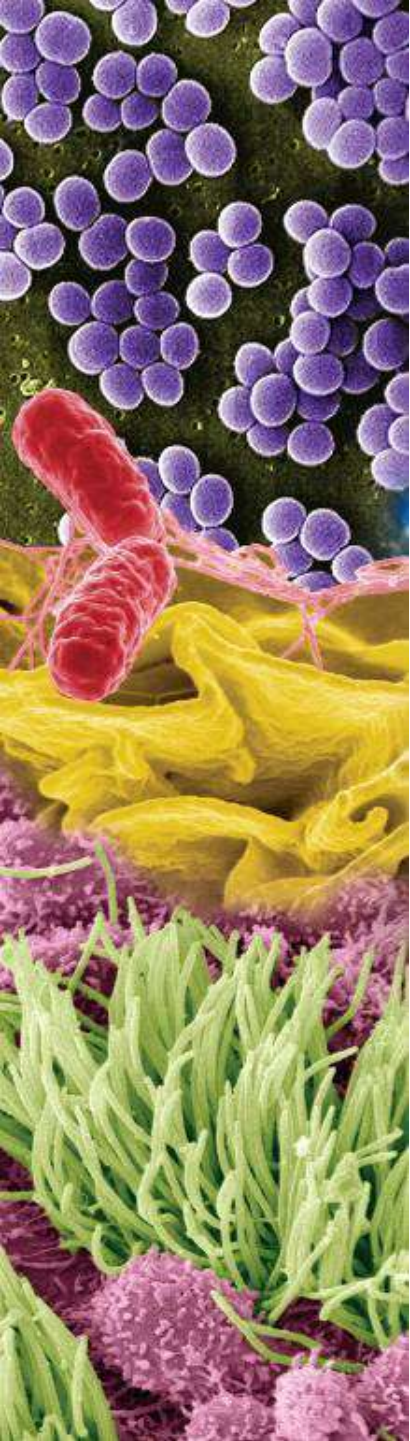
There is **no cure for HIV**

therapies only prolong life and diminish symptoms

As of mid-2011, **only one person in the history of the epidemic had been declared cured of HIV** after receiving a stem cell transplant

further research is needed

even if this is repeatable, it is not a practical approach for the millions who are infected



# HIV Infection and AIDS // Treatment

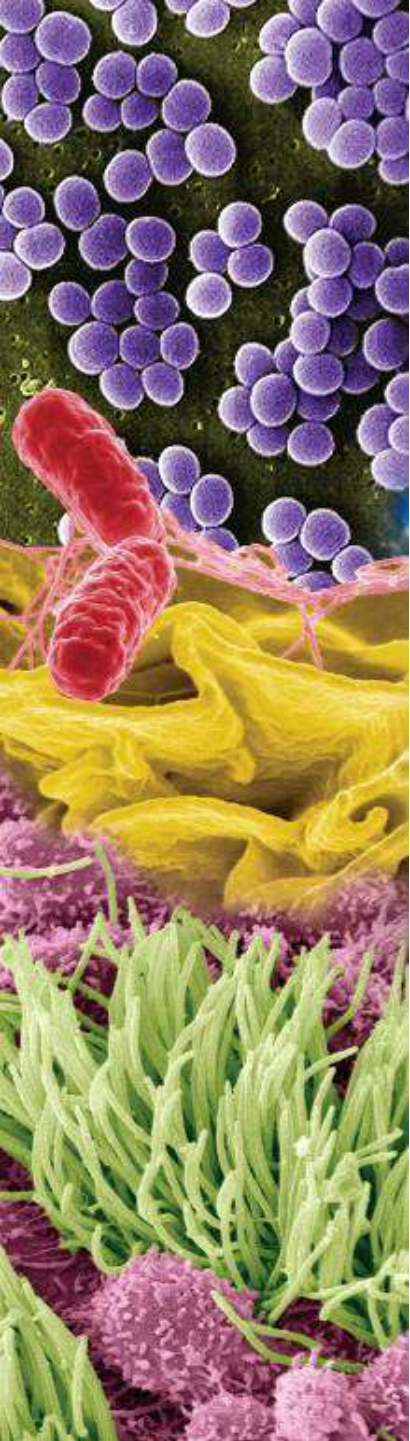
**Clear-cut guidelines** that are updated regularly exist for treatment of people who test HIV positive

1 - treatment should begin soon after HIV diagnosis, not after AIDS manifests, as previously recommended

2 - HIV-positive individuals should receive a wide array of drugs to treat or prevent opportunistic infection in addition to antiviral chemotherapy

3 - treatment regimens vary according to each patient's profile and needs





# HIV Infection and AIDS // Treatment

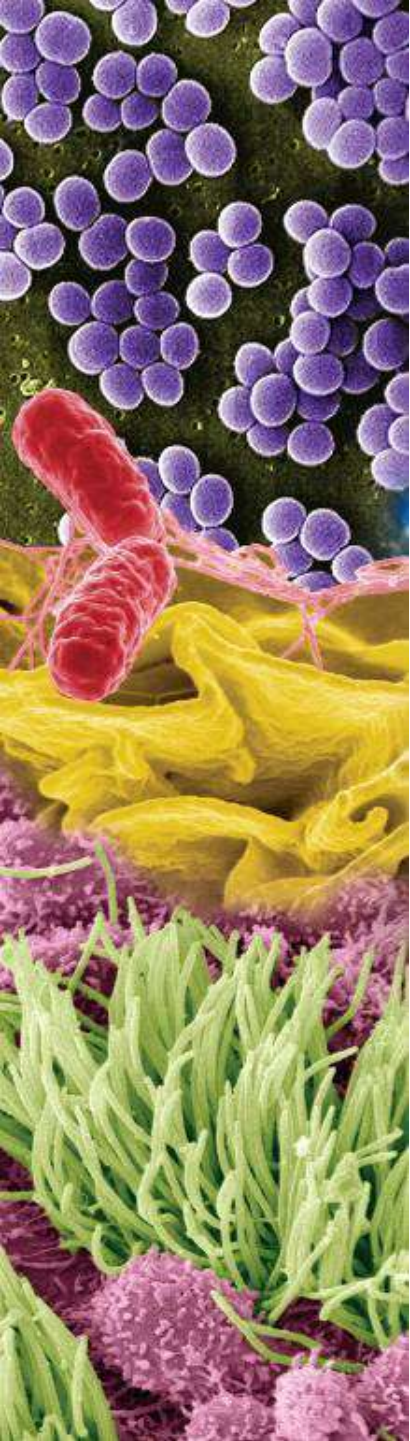
## Highly active antiretroviral therapy (HAART)

regimen has proven to be **highly effective** in controlling AIDS and inevitable drug resistance

combines **two reverse transcriptase inhibitors and one protease inhibitor** in a “cocktail”

*interrupts the virus at two different phases of its cycle*

has been successful in reducing viral load to undetectable levels // facilitates the improvement of immune function



# HIV Infection and AIDS // Treatment

## HAART (cont'd)

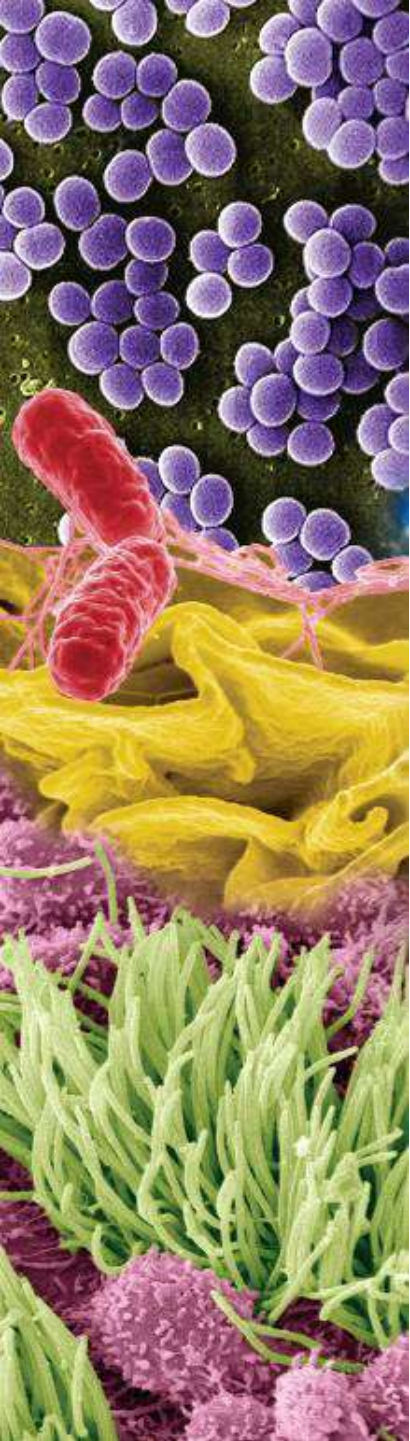
reduced the incidence of viral drug resistance

has been successful in reducing viral load to undetectable levels

facilitates the improvement of immune function

reduced viral drug resistance because the virus would have to undergo three separate mutations simultaneously

*patients who are HIV positive can remain healthy with this therapy*



# HIV Infection and AIDS // Treatment

## Drawbacks of HAART

high cost

toxic side effects

drug failure due to patient  
noncompliance

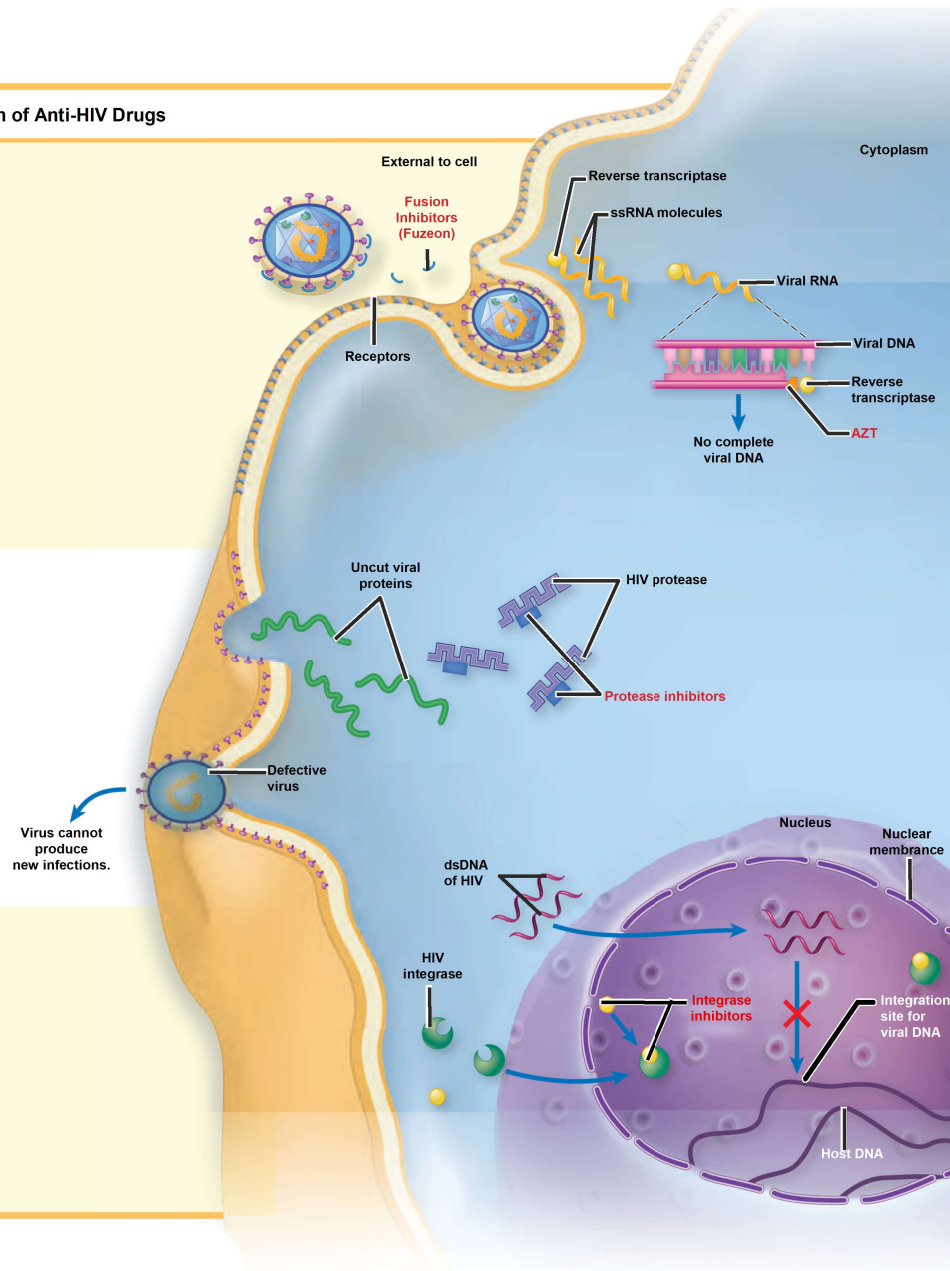
inability to completely eradicate the  
virus

There is no cure for HIV, but there have been  
some promising advances



# Mechanisms of Action of Anti-HIV Drugs

Table 18.5 Mechanisms of Action of Anti-HIV Drugs



#1

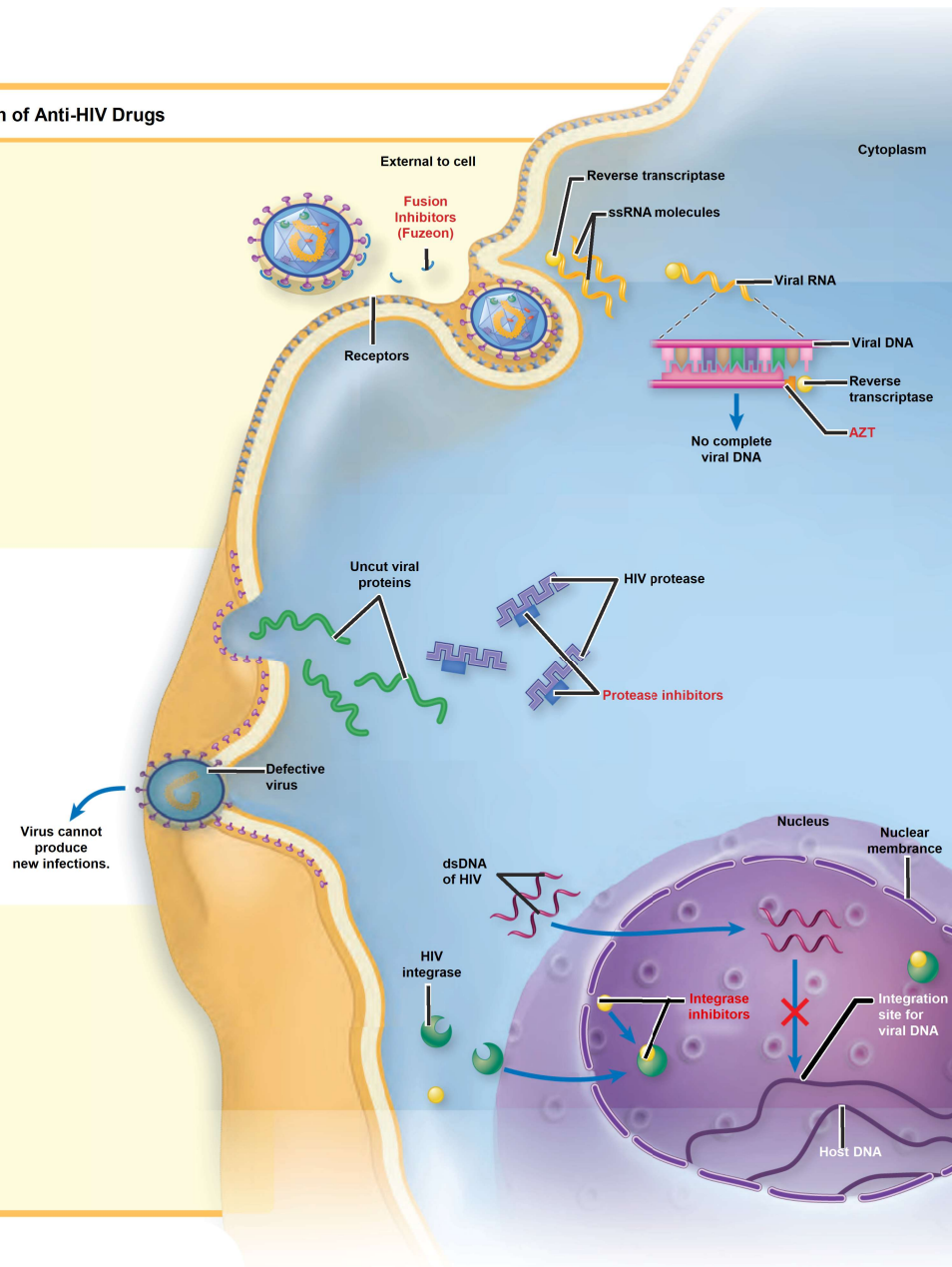
The first effective drugs developed were the synthetic nucleoside analogs (reverse transcriptase inhibitors) azidothymidine (AZT), didanosine (ddI), lamivudine (Epivir) (3TC), and stavudine (d4T).

They interrupt the HIV multiplication cycle by mimicking the structure of actual nucleosides and being added to viral DNA by reverse transcriptase.

Because these drugs lack all of the correct binding sites for further DNA synthesis, viral replication and the viral cycle are terminated. Other reverse transcriptase inhibitors that are not nucleosides are nevirapine and efavirenz (**Sustiva**), both of which bind to the viral enzyme and restructure it.

# Mechanisms of Action of Anti-HIV Drugs

Table 18.5 Mechanisms of Action of Anti-HIV Drugs



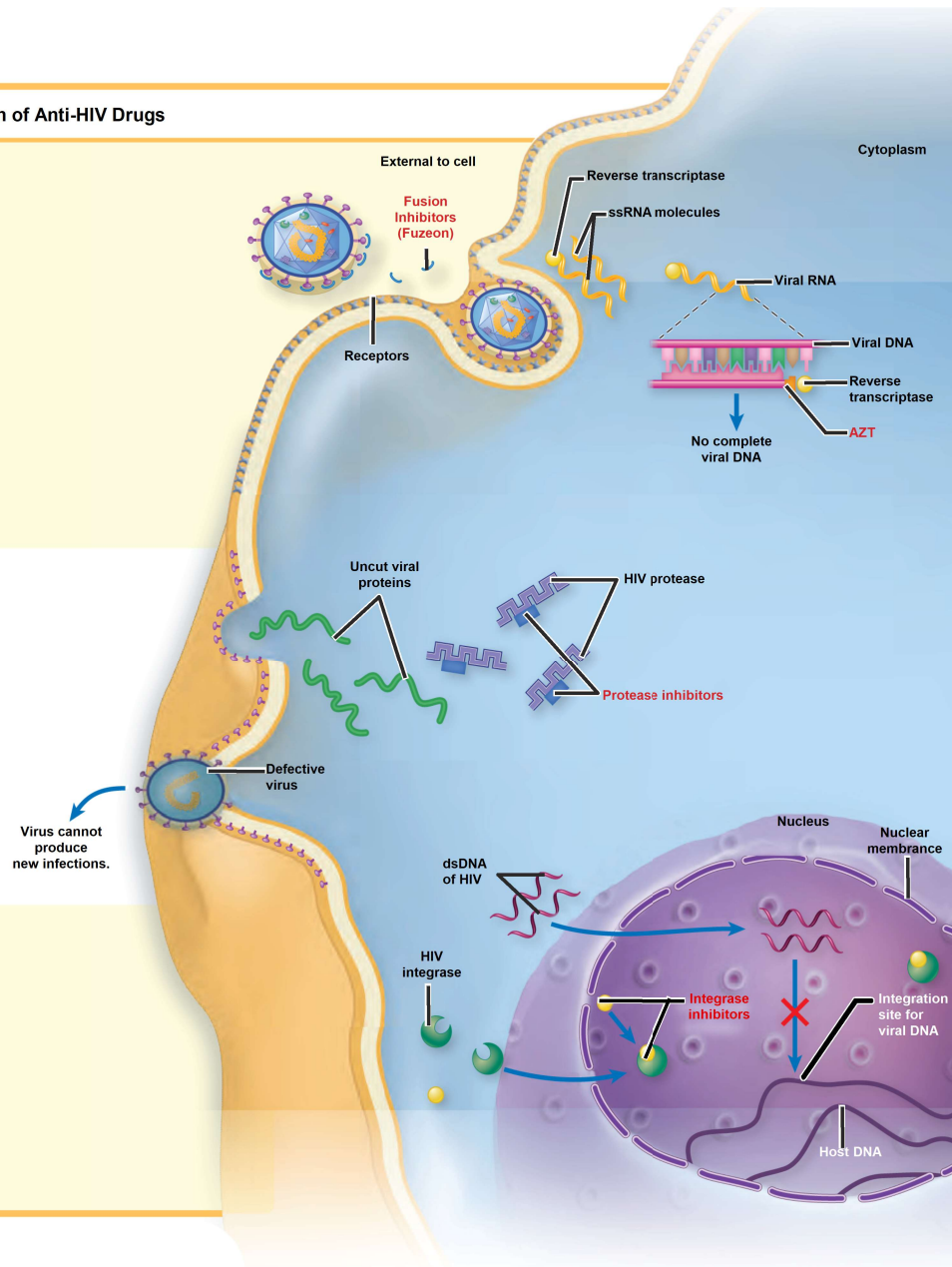
#2

Also seen here is one of the latest additions to the arsenal, enfuvirtide (Fuzeon), a drug classified as a fusion inhibitor.

It prevents the virus from fusing with the membrane of target cells, thereby stopping infection altogether.

# Mechanisms of Action of Anti-HIV Drugs

Table 18.5 Mechanisms of Action of Anti-HIV Drugs



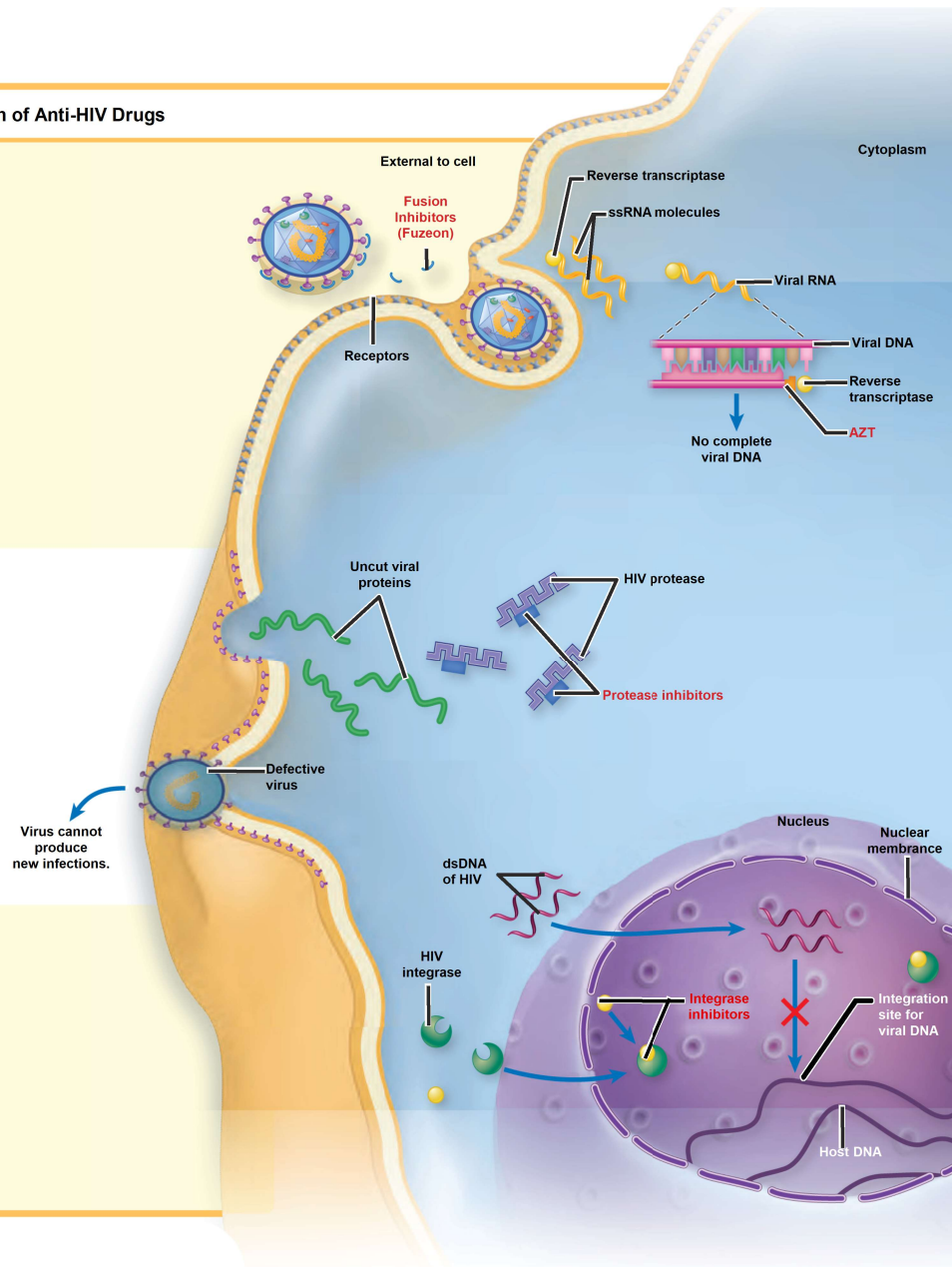
#3

Another important class of drugs is the protease inhibitors, which block the action of the HIV enzyme (protease) involved in the final assembly and maturation of the virus.

Examples of these drugs include indinavir (Crixivan), zidovudine (AZT), and zalcitabine (ddC).

# Mechanisms of Action of Anti-HIV Drugs

Table 18.5 Mechanisms of Action of Anti-HIV Drugs



#4

A class of drugs called integrase inhibitors provides a means to stop virus multiplication.



# HIV Infection and AIDS

<b>Causative Organism(s)</b>	Human immunodeficiency virus 1 or 2
<b>Most Common Modes of Transmission</b>	Direct contact (sexual), parenteral (blood-borne), vertical (perinatal and via breast milk)
<b>Virulence Factors</b>	Attachment, syncytia formation, reverse transcriptase, high mutation rate
<b>Culture / Diagnosis</b>	Initial screening for antibody followed by Western blot confirmation of antibody
<b>Prevention</b>	Avoidance of contact with infected sex partner, contaminated blood, breast milk
<b>Treatment</b>	HAART (reverse transcriptase inhibitors plus protease inhibitors), Fuzeon, nonnucleoside RT inhibitors