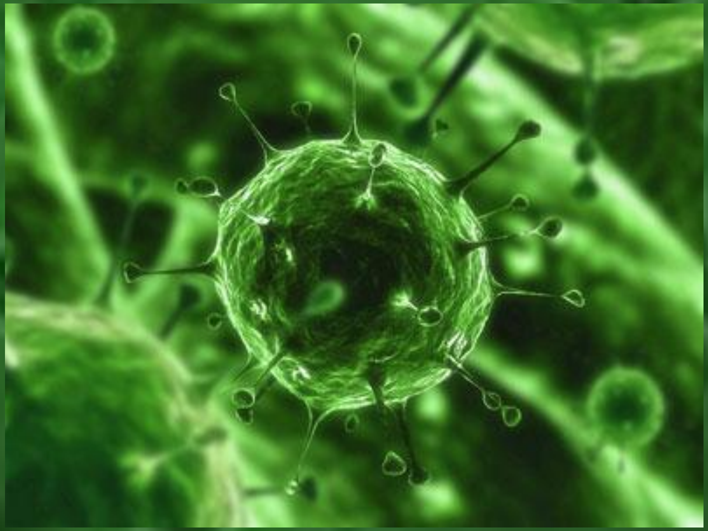
BIOLOGY I

Chapter 19: VIRUSES



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Instructor

What is a Virus?

- ☺ A virus is a **microscopic, noncellular, parasitic agent** consisting of ***one type*** of **nucleic acid** (**DNA** or **RNA**) surrounded by a **protein coat (capsid)**, which multiplies only within a cell of a living organism (the host).
  - ✓ Parasite = an agent or organism living in another organism (the host), and obtaining benefits from it, while harming it.
- ☺ A virus is **not** considered a cellular organism because it does not have all the structures and metabolic machinery found in cells.
- ☺ ***Virus*** is the Latin word for ***poison***.

DNA = deoxyribonucleic acid
RNA = ribonucleic acid

Viruses: Are They Living or Non-Living?

☺ The question of whether viruses are living organisms has an ambiguous answer. Life can be defined as a complex set of processes resulting from the actions of proteins specified by nucleic acids. The nucleic acids of living cells are in action all the time.

☺ ***Because viruses are inert (inactive or dormant) outside living host cells (of another organism) and do not reproduce or carry out metabolism, in this sense they are not considered ‘living’ organisms***. However, once a virus enters a host cell, the viral nucleic acids become active, and viral multiplication results. The virus uses the host cell’s metabolic machinery for making more viral particles. In this sense, ***viruses are considered alive when they multiply in the host cells they infect***.

☺ Viruses are ***obligatory intracellular parasites*** **that cannot reproduce independently:** they **must infect living host cells** in order to multiply by using the synthesizing machinery of the host cell. Viruses exist in a shady area between life-forms and chemicals; they lead **“a kind of borrowed life.”** (*Campbell,* 2008)

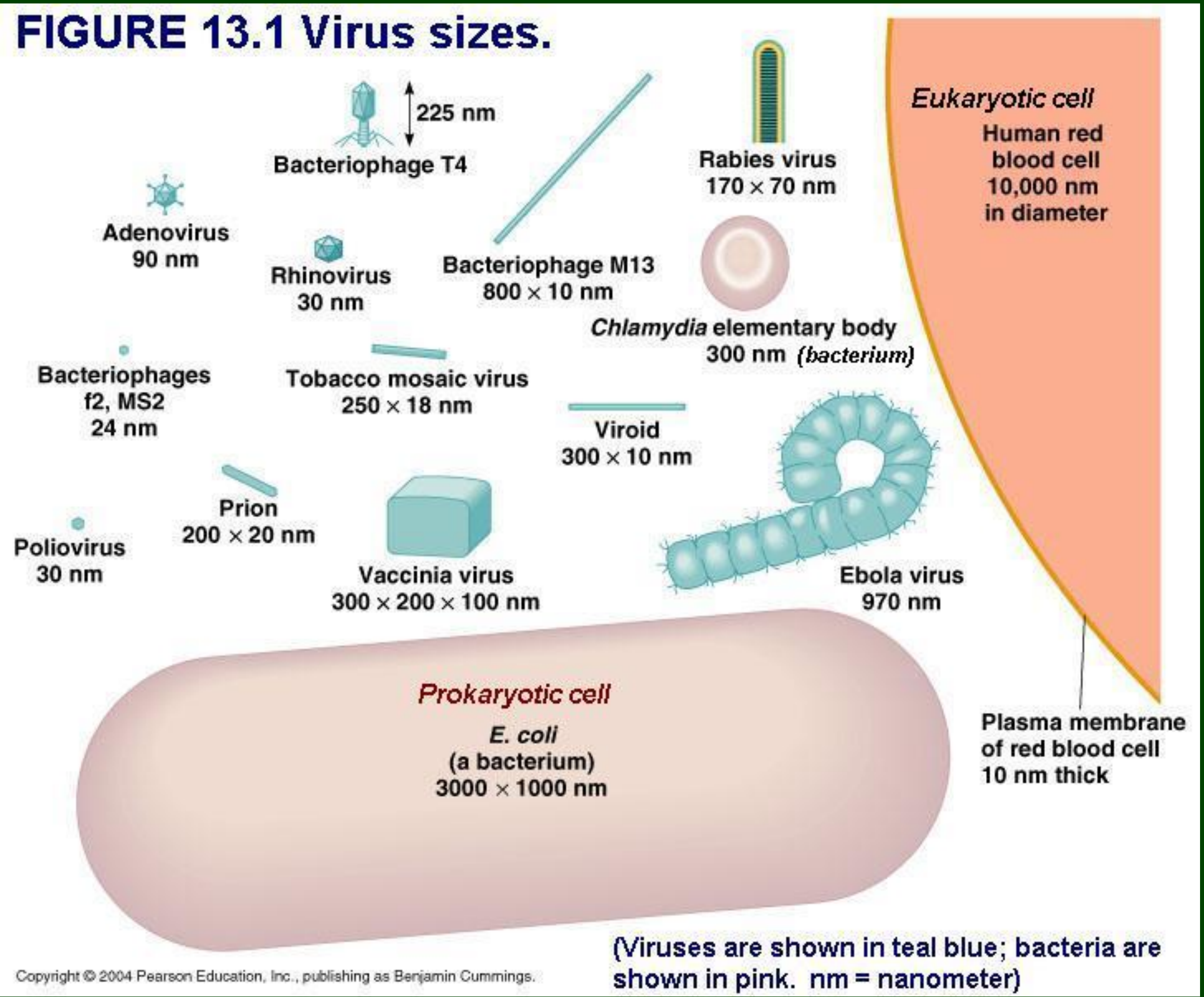
TABLE 6.1 Properties of Viruses

- Are obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter).
- Are not cells; structure is very compact and economical.
- Do not independently fulfill the characteristics of life.
- Are inactive macromolecules outside the host cell and active only inside host cells.
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.
- Nucleic acid can be either DNA or RNA but not both.
- Nucleic acid can be double-stranded DNA, single-stranded DNA, single-stranded RNA, or double-stranded RNA.
- Molecules on virus surface impart high specificity for attachment to host cell.
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses.
- Lack enzymes for most metabolic processes.
- Lack machinery for synthesizing proteins.

Host Range and Specificity of Viruses

- ☺ The **host range** is the limited range (spectrum) of host organisms that each type of virus can infect and parasitize.
  - ✓ All types of organisms (animals, plants, protists, fungi, bacteria) can be infected by viruses.
  - ✓ Some viruses have a broad host range and they can infect more than one species or type of organism. Other viruses have a narrow host range and infect only a single species.
  - ✓ **Bacteriophages (phages):** Viruses that infect bacteria.
- ☺ **Viral specificity:** refers to the **specific kinds of cells** a virus can infect (skin cells, blood cells, etc.).
- ☺ Host range and viral specificity are determined by viral surface proteins and specific receptor molecules (attachment sites) on the surface of host cells.

General Characteristics of Viruses: Viral Size



- ☺ The sizes of viruses are determined with the aid of an electron microscope. Most viruses are too small to be seen with a light microscope.
- ☺ ***Most viruses are smaller than bacteria***, but some of the larger viruses (such as the vaccinia virus) are about the same size as some very small bacteria (such as the mycoplasmas, rickettsias, and chlamydias).
- ☺ Viruses range from **20 to 1,000 nm** (nanometers) in length.

TABLE 13.1 Viruses and Bacteria Compared

	Bacteria		Viruses
	Typical Bacteria	Rickettsias/ Chlamydias	
Intracellular parasite	No	Yes	Yes
Plasma membrane	Yes	Yes	No
Binary fission	Yes	Yes	No
Pass through bacteriological filters	No	No/Yes	Yes
Possess both DNA and RNA	Yes	Yes	No
ATP-generating metabolism	Yes	Yes/No	No
Ribosomes	Yes	Yes	No
Sensitive to antibiotics	Yes	Yes	No
Sensitive to interferon	No	No	Yes

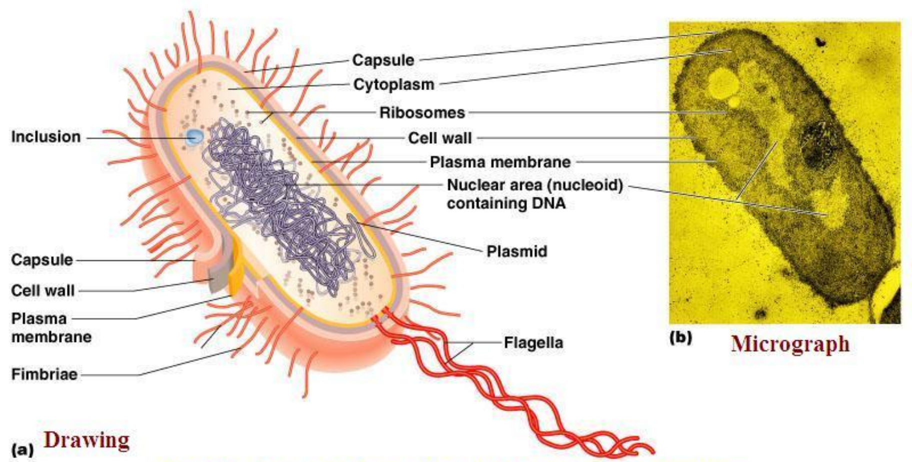


FIGURE 4.6 - A prokaryotic cell showing typical structures.

Structure of a Bacterium

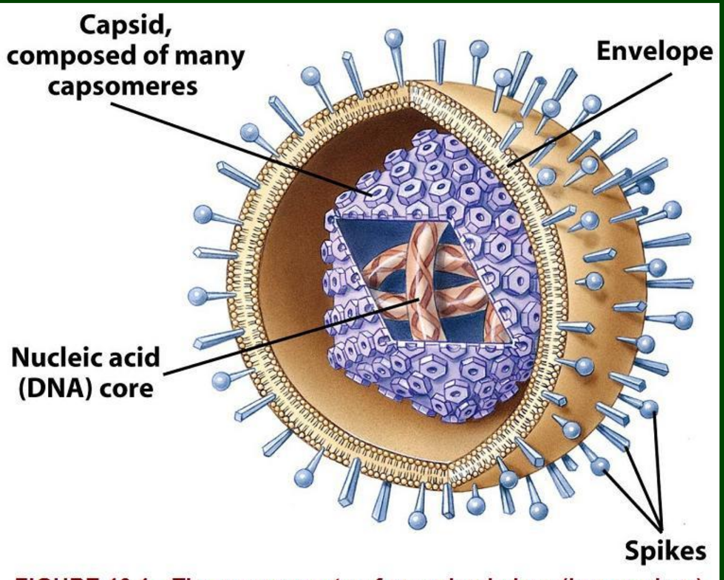


FIGURE 10.1 - The components of an animal virus (herpesvirus)

Structure of a Virus

Viral Structure (Anatomy):
The Inner Core of Nucleic Acid

- ☺ A virus contains ***only one type*** of nucleic acid, **DNA** *or* **RNA**, as part of their inner core.
  - ✓ In contrast, in prokaryotic and eukaryotic cells, DNA is always the primary genetic material and RNA plays an auxiliary role.
- ☺ The nucleic acid can be **single stranded or double-stranded**, and can be a linear or circular molecule.
- ☺ The viral nucleic acid can be from a few thousand to as many as 250,000 nucleotides (the basic building blocks of nucleic acids), but the number of viral genes is quite small compared with that of a cell.

FIGURE 3.21 - DNA Structure.

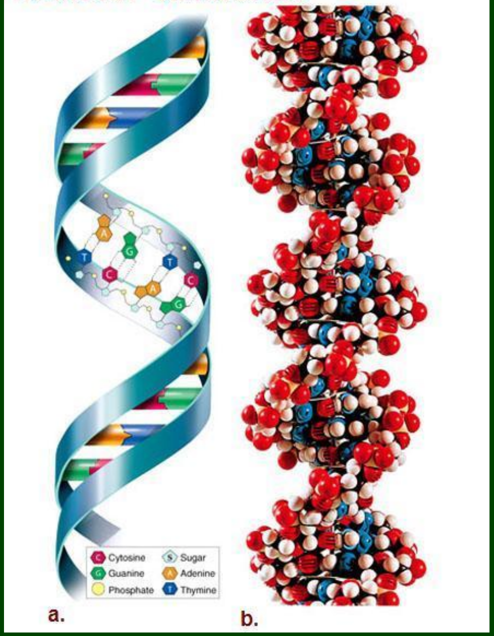
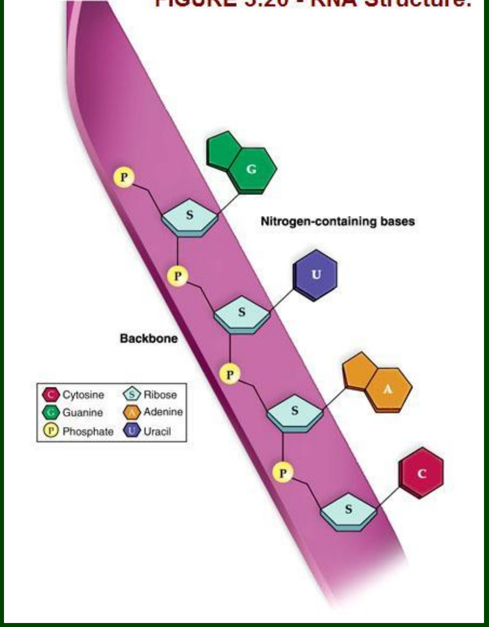


FIGURE 3.20 - RNA Structure.



Characteristics of Viruses: Viral Structure

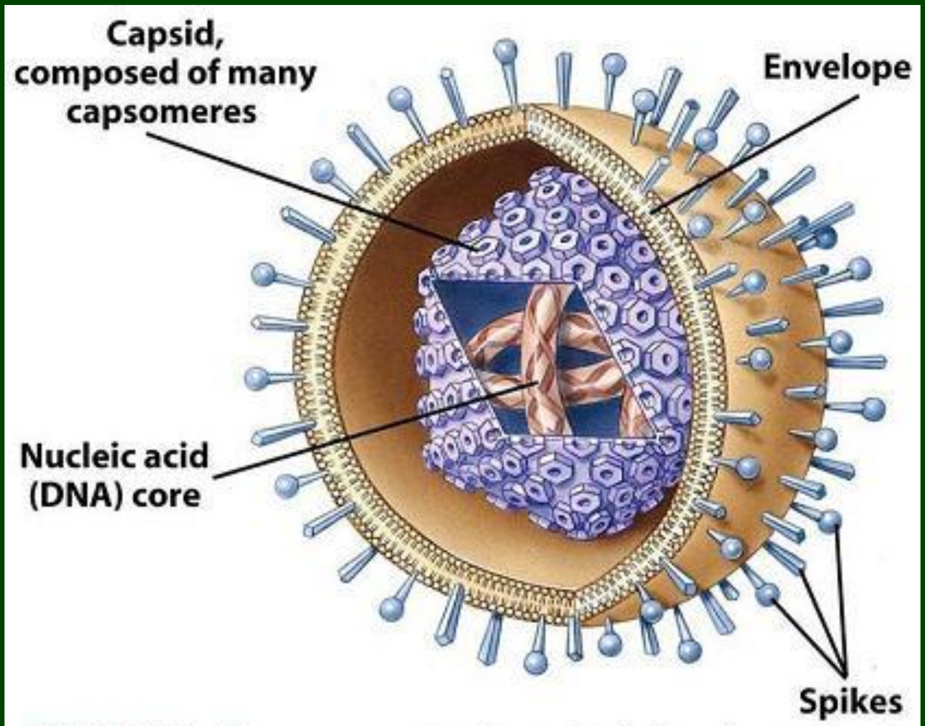


FIGURE 10.1 - The components of an animal virus (herpesvirus)

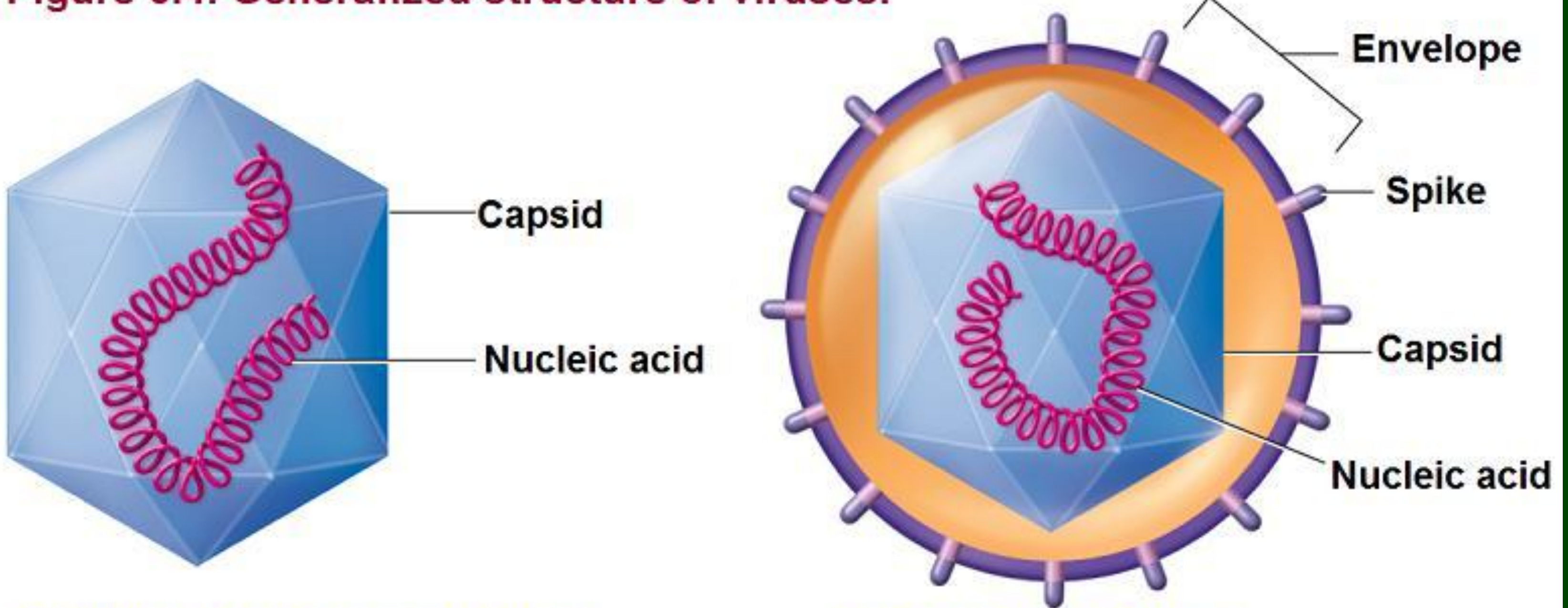
Nucleocapsid: the viral nucleic acid and the capsid.
Virion: A complete virus particle, including its envelope, if it has one.

- ☺ **Nucleic Acid Core:** A virus contains ***only one type*** of nucleic acid, ***DNA or RNA*** (not both) in their inner core.
- ☺ **Capsid** = Outer ***protein coat***, composed of protein subunits called **capsomeres**, that surrounds and protects the nucleic acid; it also determines the **shape** of the viral particle and facilitates **attachment** of virus to host cells.
- ☺ **Envelope:** Extra **outer covering** surrounding the capsid of ***some viruses*** **("enveloped viruses")**; composed of lipids, proteins and carbohydrates. Viruses without envelope are called **"nonenveloped viruses"** or **"naked viruses"**.
- ☺ **Spikes:** ***Glycoproteins*** (carbohydrate-protein complexes) that project from the surface of certain viruses and serve for ***attachment*** of viruses to susceptible host cell surfaces.

Generalized Structure of Viruses

- ☺ A **naked virus** consists of a capsid assembled around a nucleic acid strand or strands (***nucleocapsid***). This is the simplest type of virus.
- ☺ An **enveloped virus** is composed of a nucleocapsid surrounded by a flexible membrane called an ***envelope***. The envelope usually has special receptor **spikes** inserted into it.

Figure 6.4. Generalized structure of viruses.



(a) Naked Nucleocapsid Virus (b) Enveloped Virus

Structure of Viruses: **General Morphology or Shape**

- ☺ Viruses can be classified into several different morphological types on the basis of their ***capsid architecture***.
  - ✓ **Helical viruses:** spiral
  - ✓ **Polyhedral viruses:** many-sided
    - ♦ ***Icosahedral:*** the capsid has 20 triangular faces or sides
  - ✓ **Complex viruses:** more elaborate shape

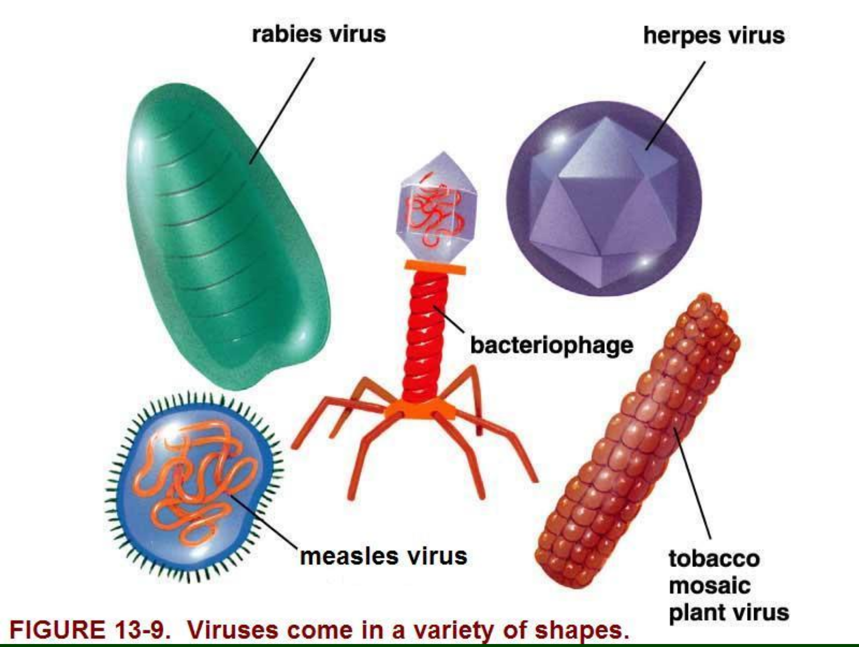


Figure 19-3. Viruses come in a variety of shapes.

The shape is determined by the nature of the viral protein coat.

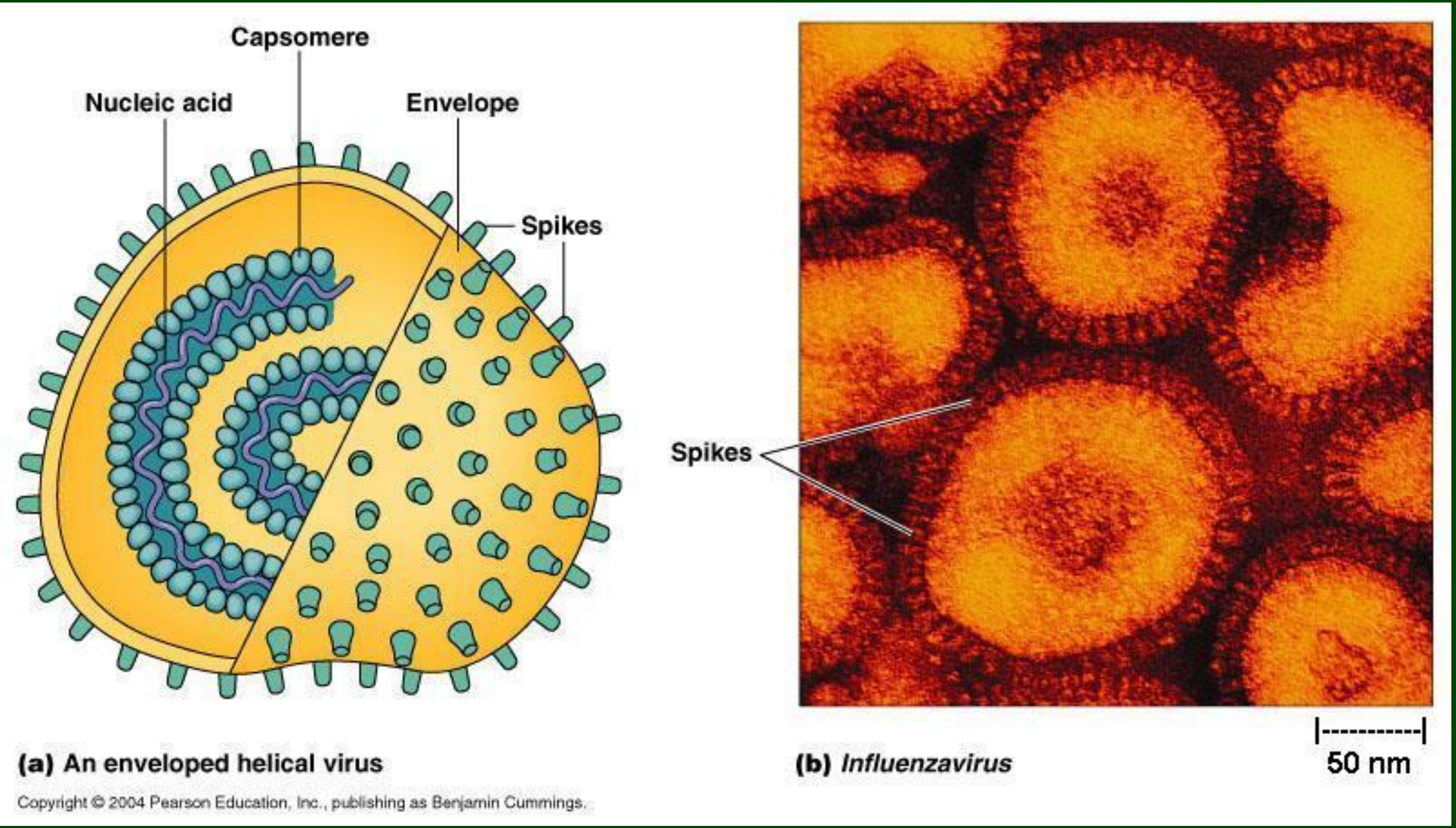


Figure 13.3. Morphology of an enveloped helical virus.

(a) A diagram of an enveloped helical virus. **(b)** A micrograph of *Influenzavirus* A2. Notice the halo of spikes projecting from the outer surface of each envelope. (*spike* = glycoprotein, a carbohydrate-protein complex; *capsomer* = protein subunit).

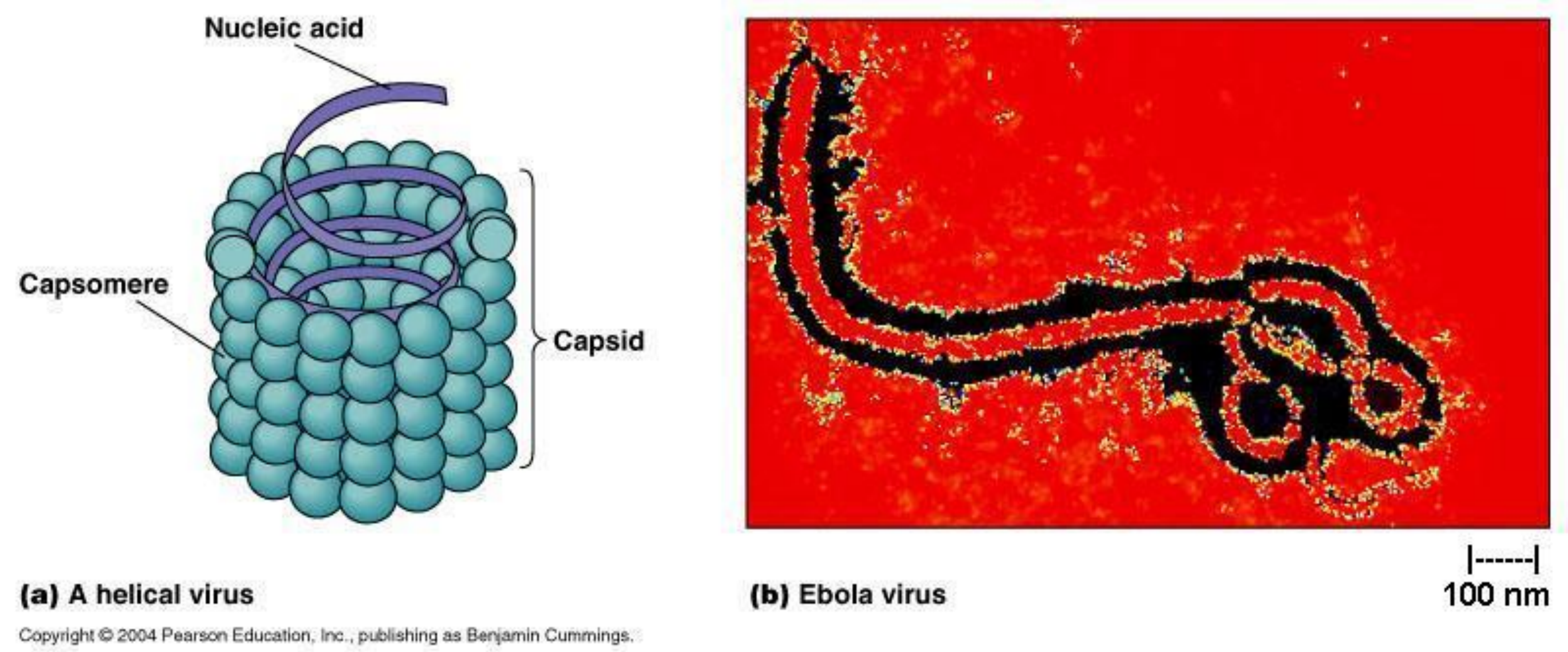
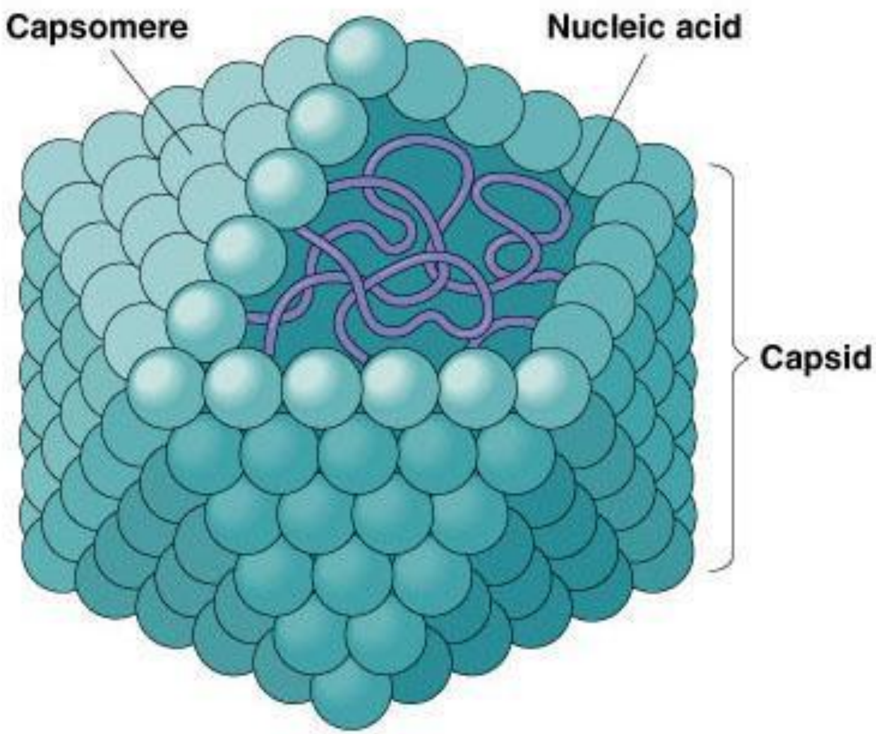


Figure 13.4. Morphology of a helical virus.

(a) A diagram of a portion of a helical virus. Several rows of capsomeres have been removed to reveal the nucleic acid. **(b)** A micrograph of Ebola virus, a filovirus showing helical rows.



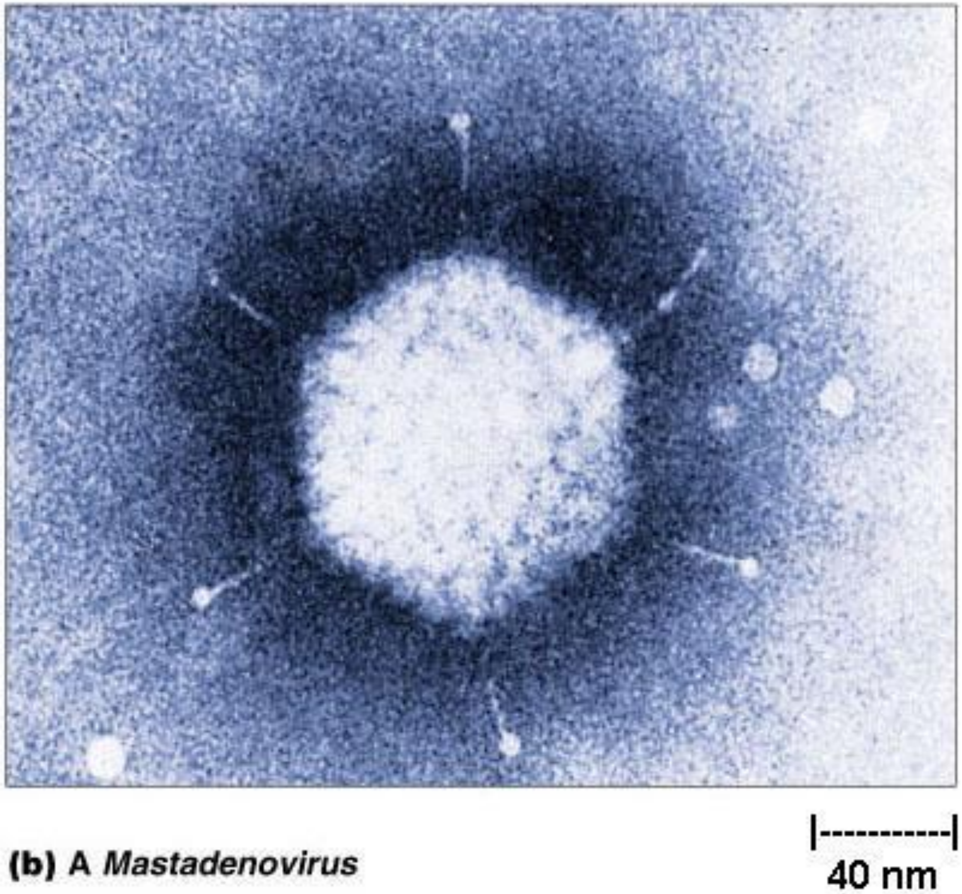


Figure 13.2. Morphology of a nonenveloped polyhedral virus.

(a) A diagram of a polyhedral (icosahedral) virus. **(b)** A micrograph of the adenovirus *Mastadenovirus*. Individual capsomeres in the protein coat are visible.

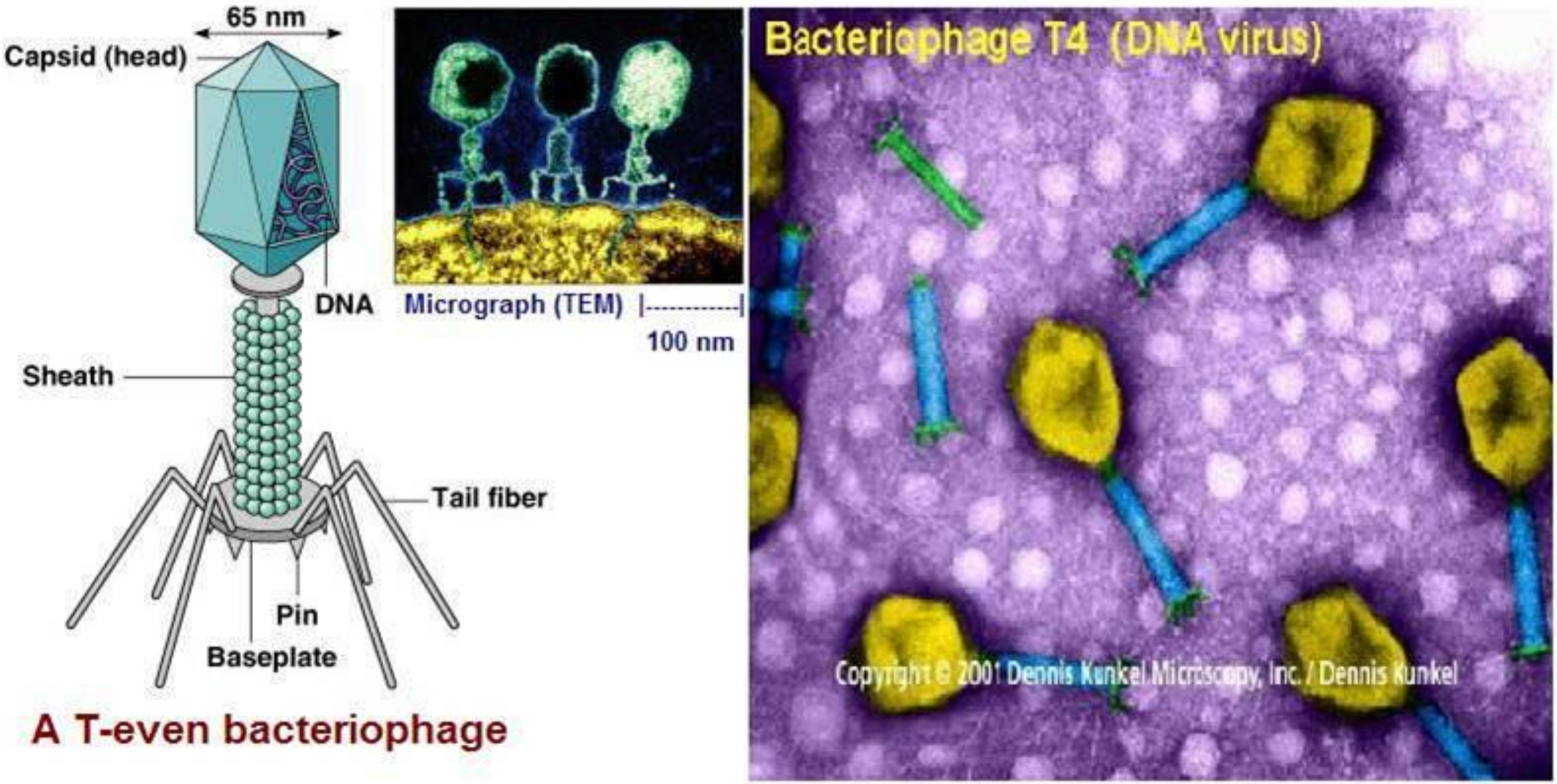


FIGURE 13.5 - Morphology of complex viruses.

☺ **Figure 13.5. Morphology of complex viruses.**
A diagram and micrograph of a T-even bacteriophage, a virus that infects bacteria.

Taxonomy (Classification) of Viruses

- ☺ Classification of viruses is based on (1) nucleic acid type, (2) strategy for replication, and (3) morphology.
- ☺ **Family** names end in ***–viridae***.
  - ✓ Family: Herpesviridae
- ☺ **Genus** names end in ***–virus***.
  - ✓ Genus: *Simplexvirus*
- ☺ **Viral species:** A group of viruses sharing ***a number of properties in common but with variations***; for example similar *genetic material* and *host*.
  - ✓ *Common descriptive names are used for viral species*. Subspecies (if any) are designated by a number.
    - ♦ Human herpes virus 1; human herpes virus 2…

TABLE 10.1

Classification of Major Groups of RNA Viruses That Cause Human Diseases

Family	Envelope and Capsid Shape	Typical Size (nm)	Example (Genus or Species)	Infection or Disease
(+) Sense RNA Viruses				
Picornaviridae (1 copy)	Naked, polyhedral	18–30	*Enterovirus* *Rhinovirus* *Hepatovirus*	Polio Common cold Hepatitis A 
Togaviridae (1 copy)	Enveloped, polyhedral	40–90	Rubella virus Equine encephalitis virus	Rubella (German measles) Equine encephalitis 
Flaviviridae (1 copy)	Enveloped, polyhedral	40–90	*Flavivirus*	Yellow fever
Retroviridae (2 copies)	Enveloped, spherical	100	HTLV-I HIV	Adult leukemia, tumors, AIDS 
(−) Sense RNA Viruses				
Paramyxoviridae (1 copy)	Enveloped, helical	150–200	*Morbillivirus*	Measles 
Rhabdoviridae (1 copy)	Enveloped, helical	70–180	*Lyssavirus*	Rabies 
Orthomyxoviridae (1 copy in 8 segments)	Enveloped, helical	100–200	*Influenzavirus*	Influenza A and B 
Filoviridae (1 copy)	Enveloped, filamentous	80	*Filovirus*	Marburg, Ebola 
Bunyaviridae (1 copy in 3 segments)	Enveloped, spherical	90–120	*Hantavirus*	Respiratory distress, hemorrhagic fevers 
Double-Stranded RNA Viruses				
Reoviridae (1 copy in 10–12 segments)	Naked, polyhedral	70	*Rotavirus*	Respiratory and gastrointestinal infections 

Table 10-1 Microbiology, 6/e

TABLE 10.2

Classification of Major Groups of DNA Viruses That Cause Human Diseases

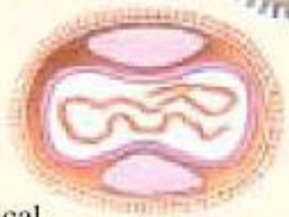
Family	Envelope and Capsid Shape	Typical Size (nm)	Example (Genus or Species)	Infection or Disease
Double-Stranded DNA Viruses				
Adenoviridae (linear DNA)	Naked, polyhedral	75	Human adenoviruses	Respiratory infections 
Herpesviridae (linear DNA)	Enveloped, polyhedral	120–200	*Simplexvirus* *Varicellovirus*	Oral and genital herpes Chickenpox, shingles 
Poxviridae (linear DNA)	Enveloped, complex shape	230 × 270	*Orthopoxvirus*	Smallpox, cowpox 
Papovaviridae (circular DNA)	Naked, polyhedral	45–55	Human papilloma-viruses	Warts, cervical and penile cancers 
Hepadnaviridae	Enveloped, polyhedral	40–45	Hepatitis B virus	Hepatitis B 
Single-Stranded DNA Viruses				
Parvoviridae (linear DNA)	Naked, polyhedral	22	B19	Fifth disease (erythema infectiosum) in children 

Table 10-2 Microbiology, 6/e

DNA VIRUSES: ***The Herpesviruses***

TABLE 10.3

Herpesviruses That Cause Human Disease

Genus	Virus Type	Infection or Disease
Simplexvirus	Herpes simplex type 1 Herpes simplex type 2	Oral herpes (sometimes genital and neonatal herpes), encephalitis Genital and neonatal herpes (sometimes oral herpes), meningoencephalitis
Varicellovirus	Varicella-zoster	Chickenpox (varicella) and shingles (zoster)
Cytomegalovirus	Cytomegaloviruses (salivary gland virus)	Acute febrile illness; infections in AIDS patients, transplant recipients, and others with reduced immune system function; a leading cause of birth defects
Roseolovirus	Roseola infantum (formerly called herpesvirus 6)	Exanthema subitum (roseola infantum), a common disease of infancy, featuring rash and fever
Lymphocryptovirus	Epstein-Barr virus	Infectious mononucleosis and Burkitt's lymphoma (cancer of the jaw seen mainly in African children); also linked to Hodgkin's disease (cancer of lymphocytes) and B cell lymphomas, and to nasopharyngeal cancer in Asians
Human herpesvirus 8	Kaposi's sarcoma virus	Kaposi's sarcoma linked to AIDS

Table 10-3 Microbiology, 6/e

DNA VIRUSES

FIGURE 10.5a - Herpesviruses (pink spheres within a cell)

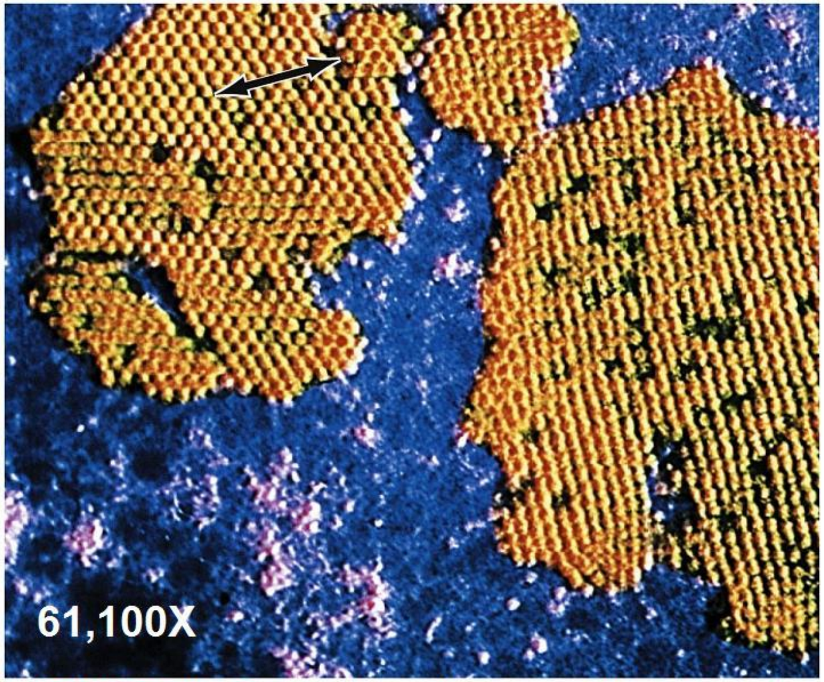


FIGURE 10.5b - Papovaviruses (human papillomaviruses)

Herpesviruses (pink spheres inside the cell) cause various human diseases such as ***chickenpox***, ***shingles***, ***oral and genital ulcers*** and ***infectious mononucleosis***.

Papovaviruses include ***human papillomavirus***, which causes ***genital warts*** (and cervical cancer in some cases).

RNA VIRUSES

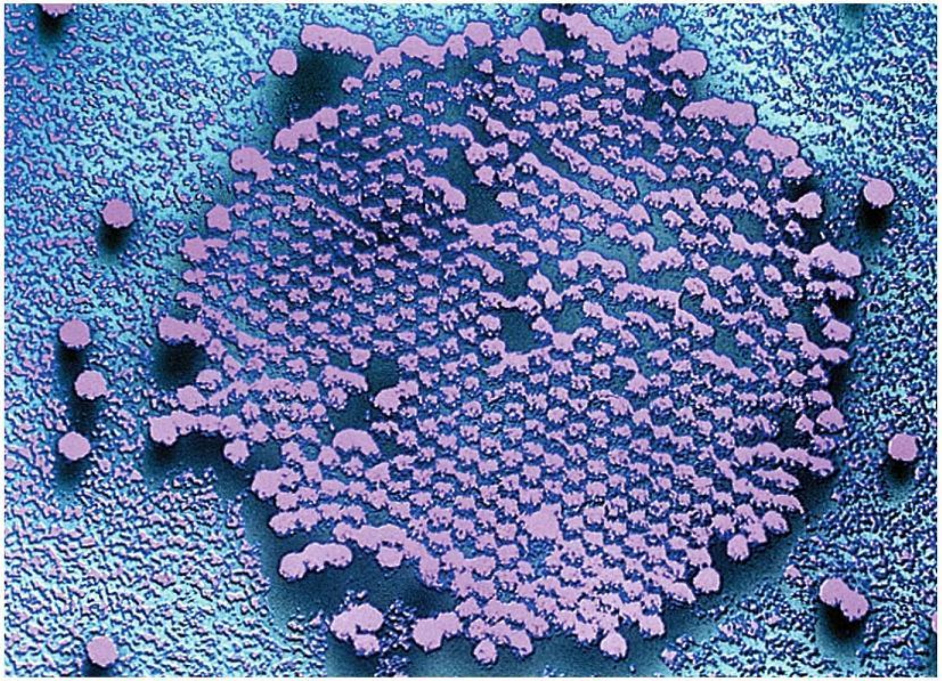


FIGURE 10.3a - Picornaviruses (polioviruses; 71,500X)

Picornaviruses include poliovirus which causes polio, and rhinoviruses that cause the common cold.

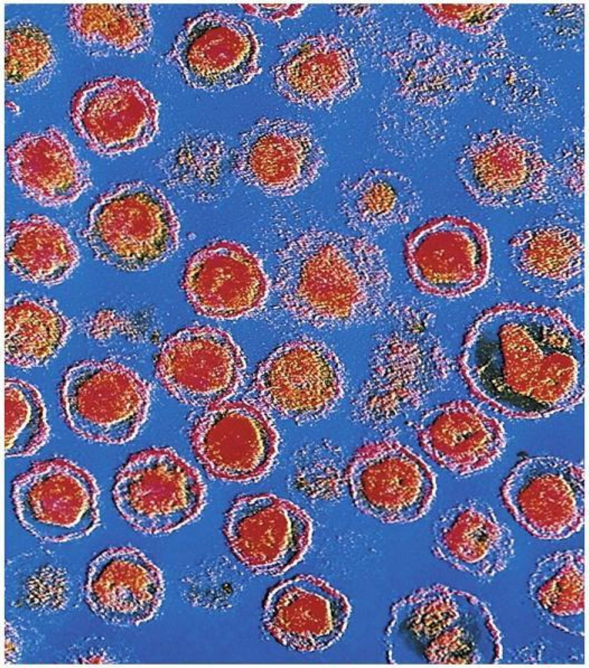


FIGURE 10.3b - retroviruses (oncovirus; 42,500X)

Retroviruses such as oncoviruses, include **HIV (human immunodeficiency virus)**, the cause of AIDS (Acquired Immunodeficiency Syndrome)

RNA VIRUSES

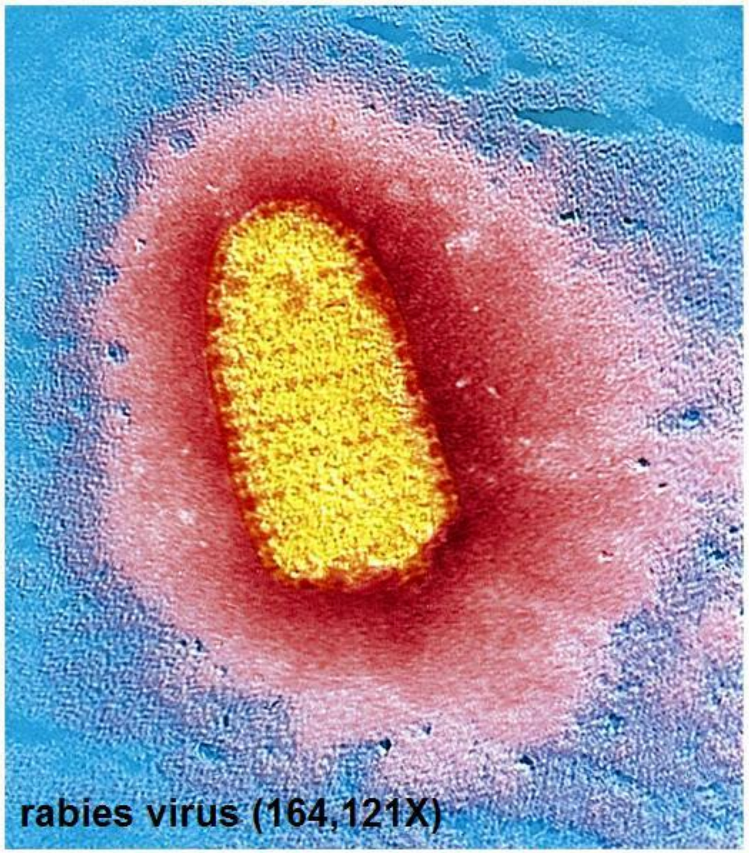


FIGURE 10.3c - rhabdoviruses

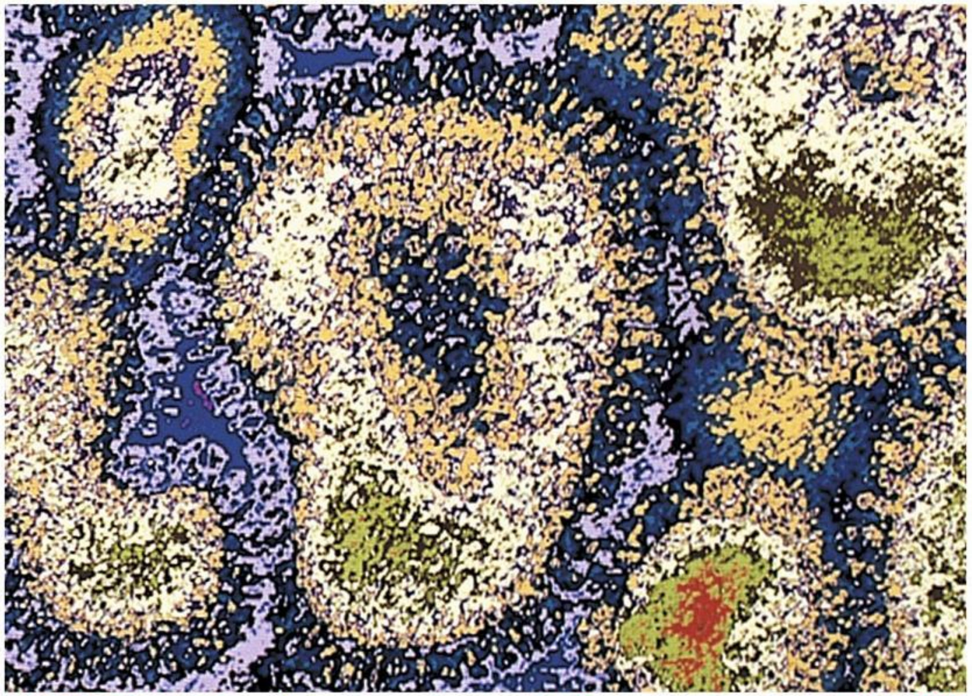


FIGURE 10.3d. orthomyxoviruses (influenza viruses; 186,098X)

Rhabdoviruses include *Lyssavirus,* the rabies virus

Orthomyxoviruses include the influenza viruses

Isolation, Cultivation, and Identification of Viruses

- ☺ Detection, cultivation, and identification of viruses is a very **difficult task** because they cannot multiply outside a living host.
- ☺ **Viruses must be grown (cultured) inside suitable living cells** instead of a fairly simple chemical medium.
- ☺ *Living plants and animals are difficult and expensive to maintain*, and pathogenic viruses that grow only in higher primates or humans cause additional complications.
- ☺ **Bacteriophages** (viruses that infect bacteria) are rather easily grown on **bacterial cultures**. For this reason, bacteriophages are used to study viral multiplication.

Growing Viruses

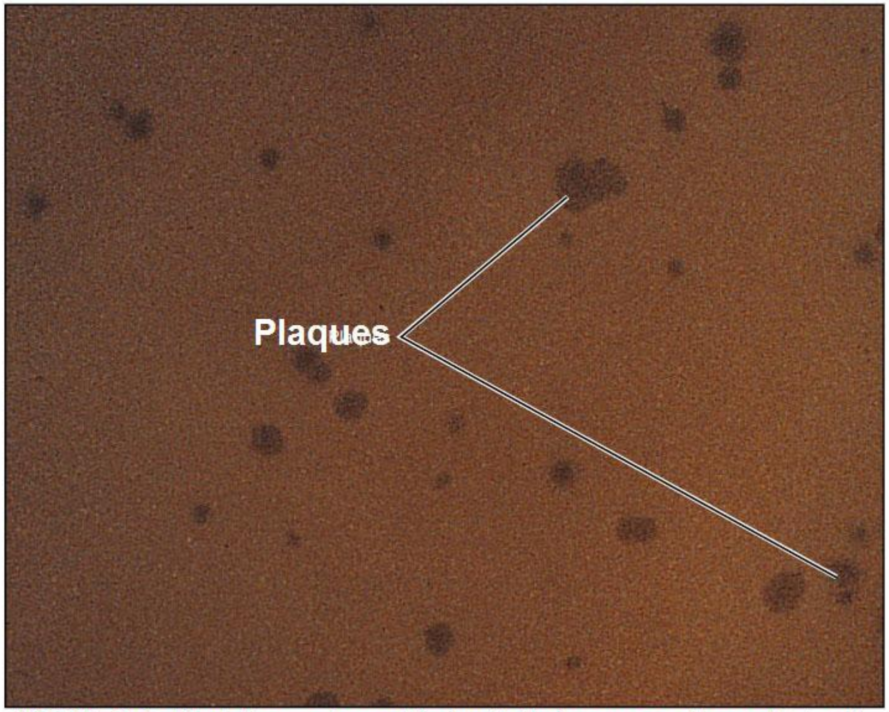
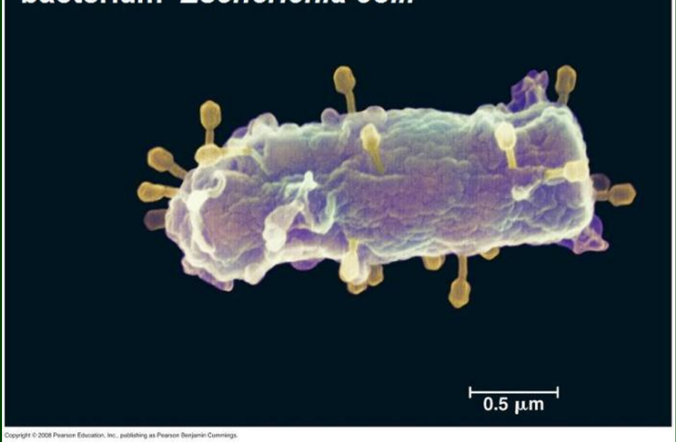


FIGURE 13.6 - Viral plaques formed by bacteriophages on a lawn of *E. coli*.

- ☺ ***Viruses must be grown in living cells***.
  - ✓ **Bacteriophages** (phages) form **plaques**; these are clear areas against a confluent lawn of bacterial growth on the surface of an agar nutrient medium.

Bacteriophages infecting a bacterium →

Viruses (T4 bacteriophage) infecting the bacterium *Escherichia coli.*



Growing Viruses

- ***Animal viruses*** may be grown in **living animals** or in **embryonated eggs**.

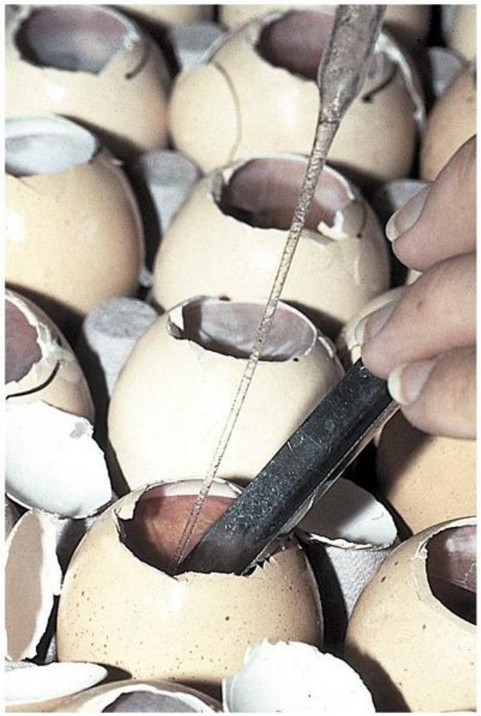


Figure 10-18 Microbiology, 6/e

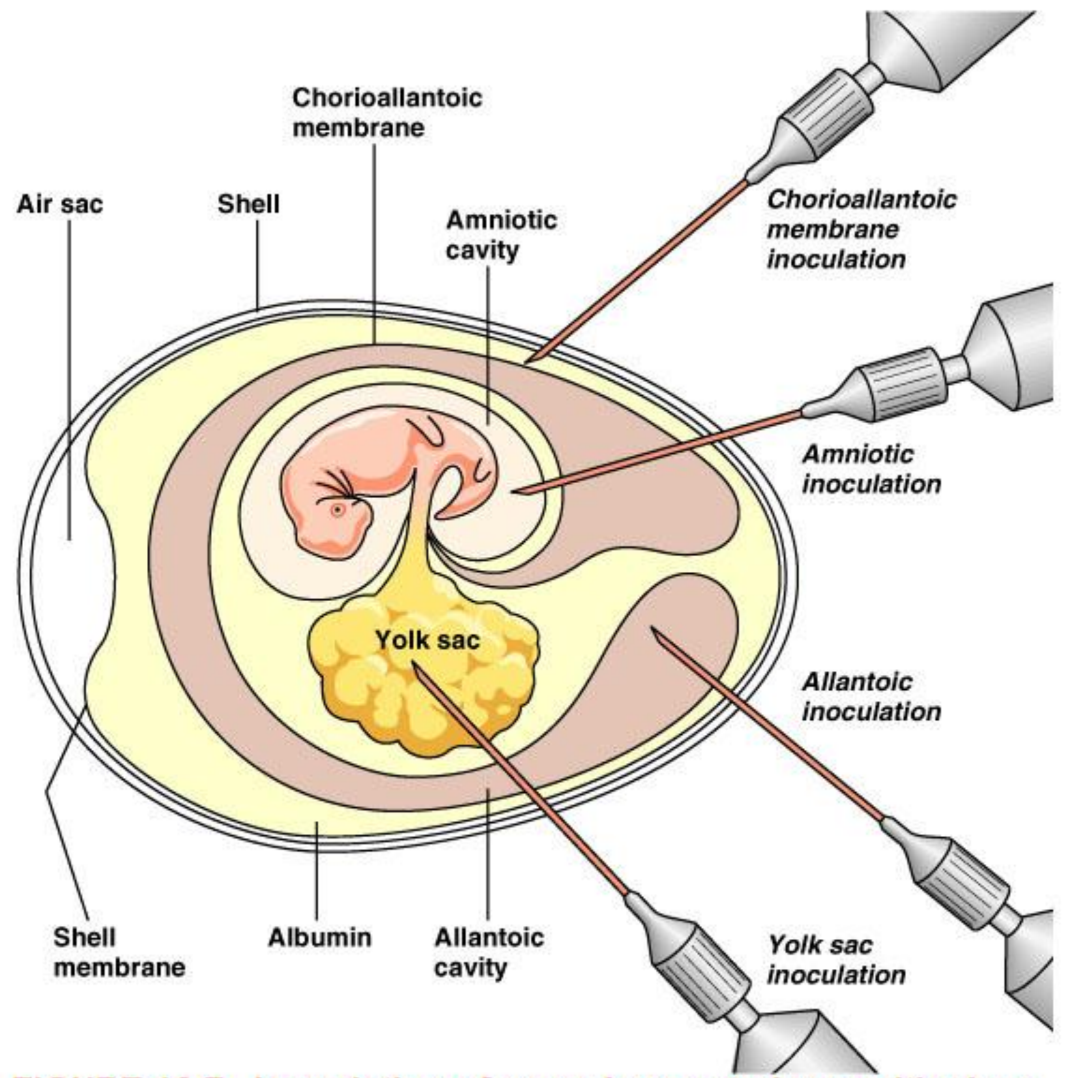


FIGURE 13.7 - Inoculation of an embryonated egg with virus.

Growing Viruses

- ☺ ***Animal and plants viruses*** may be grown in **cell culture**.
  - ✓ Continuous cell lines may be maintained indefinitely.

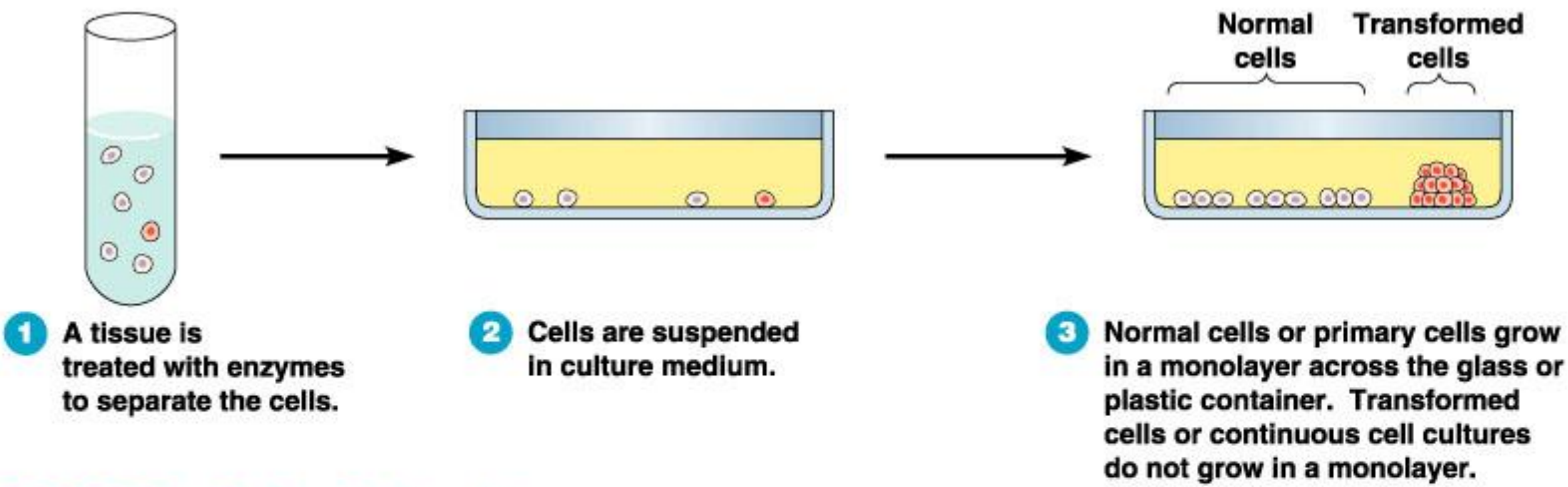
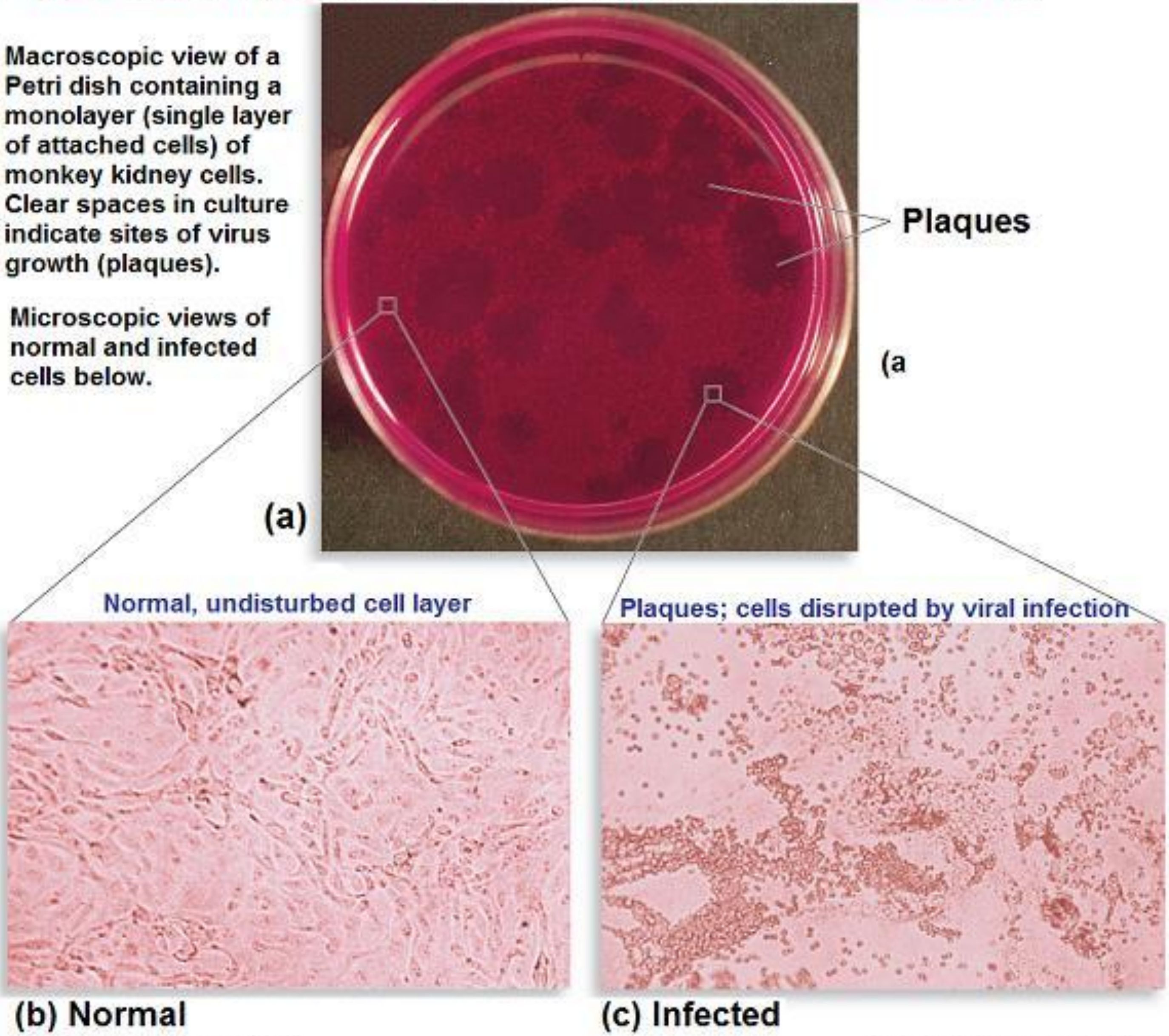


FIGURE 13.8 - Cell cultures.

Figure 6.22. Appearance of normal and infected cell cultures.

Macroscopic view of a Petri dish containing a monolayer (single layer of attached cells) of monkey kidney cells. Clear spaces in culture indicate sites of virus growth (plaques).

Microscopic views of normal and infected cells below.



Techniques for Identification of Viruses

☺ Cytopathic effects observation

✓ Visible effects on a host cell, caused by a virus, that may result in host cell damage or death; for example: cells round up, cells fuse, etc

☺ Serological tests

✓ Detect antibodies against viruses in a patient (antibodies are proteins we produce as defense against antigens, or foreign substances).

✓ Use antibodies to identify viruses in several different tests such as neutralization, viral hemagglutination, and Western blot.

☺ Nucleic acids tests

✓ Detect viral nucleic acids, for example: Restriction Fragment Length Polymorphisms (RFLPs) and Polymerase Chain Reaction (PCR).

Multiplication of Viruses (Viral Reproduction): ***Bacteriophages***

☺ Viruses can multiply by two basic alternative mechanisms:

✓ **Lytic cycle:**

- A mechanism of viral multiplication that ***results in host cell lysis and death***. **"Lytic"** refers to the last stage of infection, during which the host cell lyses (breaks open) and releases the viruses that were produced within the cell.
- A bacterial virus that reproduces only by a lytic cycle is a **virulent phage**. Example: *phage T4*.

✓ **Lysogenic cycle:**

- Stages in viral development that result in the ***incorporation of viral DNA into host DNA*** (referred to as a **provirus** or **prophage**) and the host cells remain alive, sometimes for many years.
- **Lysogenic** or **temperate viruses (or temperate phages)** do not always cause lysis and death of the host cell when they multiply; they remain ***latent*** (inactive). Examples: *phage* λ (lambda), *phage T2*.

Stages of Viral Multiplication (Reproduction): *Lytic Cycle of a Bacteriophage (or Phage) as an Example*	
Attachment (*Adsorption*)	**The virus attaches to host cell**: the virus uses its tails fibers to bind to specific receptor sites on the outer surface of the host cell.
Penetration (*Entry*)	**Virus injects its DNA into the host cell**: viral lysozyme (enzyme) opens bacterial cell wall, tail sheath contracts to force viral DNA into cell, leaving empty capsid outside.
Biosynthesis *(Synthesis)*	**Production of viral nucleic acid and proteins**: directed by the virus nucleic acid using host cell components.
Maturation *(Assembly)*	**Assembly of viral particles** to form virions (complete viral particles); viral genome is packaged inside the capsid.
Release	**New viral particles are released from host cell** as it breaks open (lyses) because of action of an enzyme coded by virus (lysozyme).

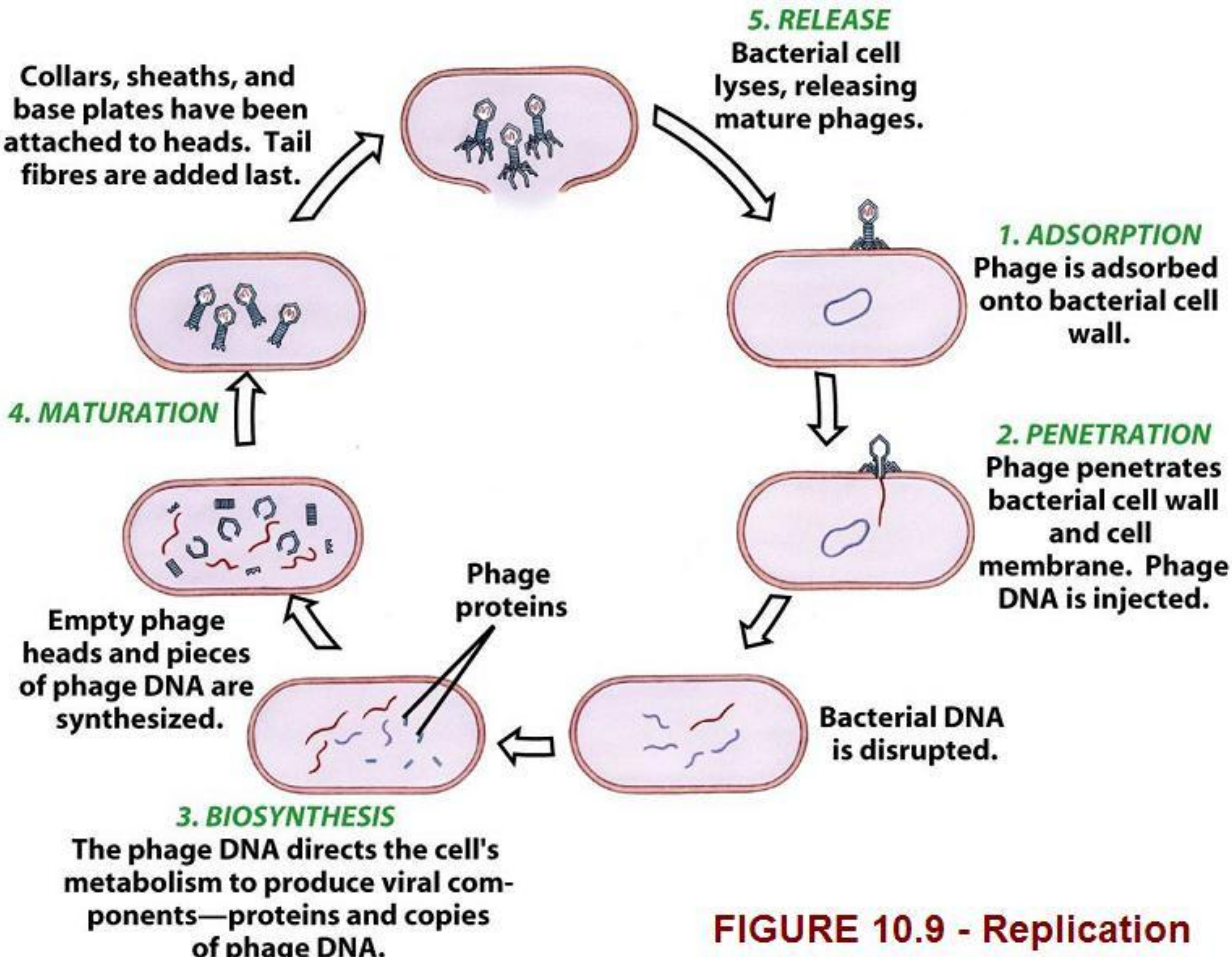


FIGURE 10.9 - Replication of a virulent bacteriophage.

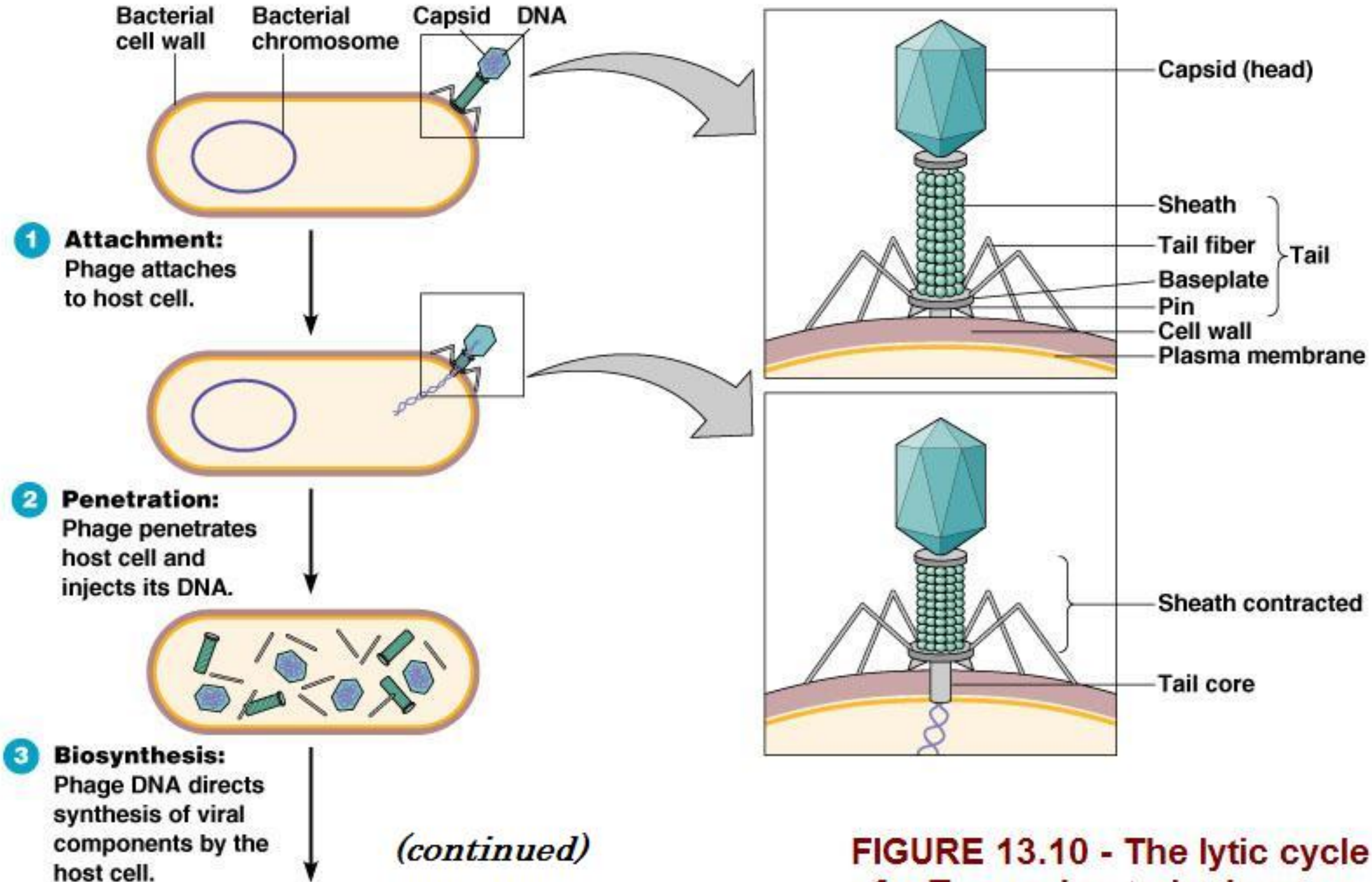


FIGURE 13.10 - The lytic cycle of a T-even bacteriophage.

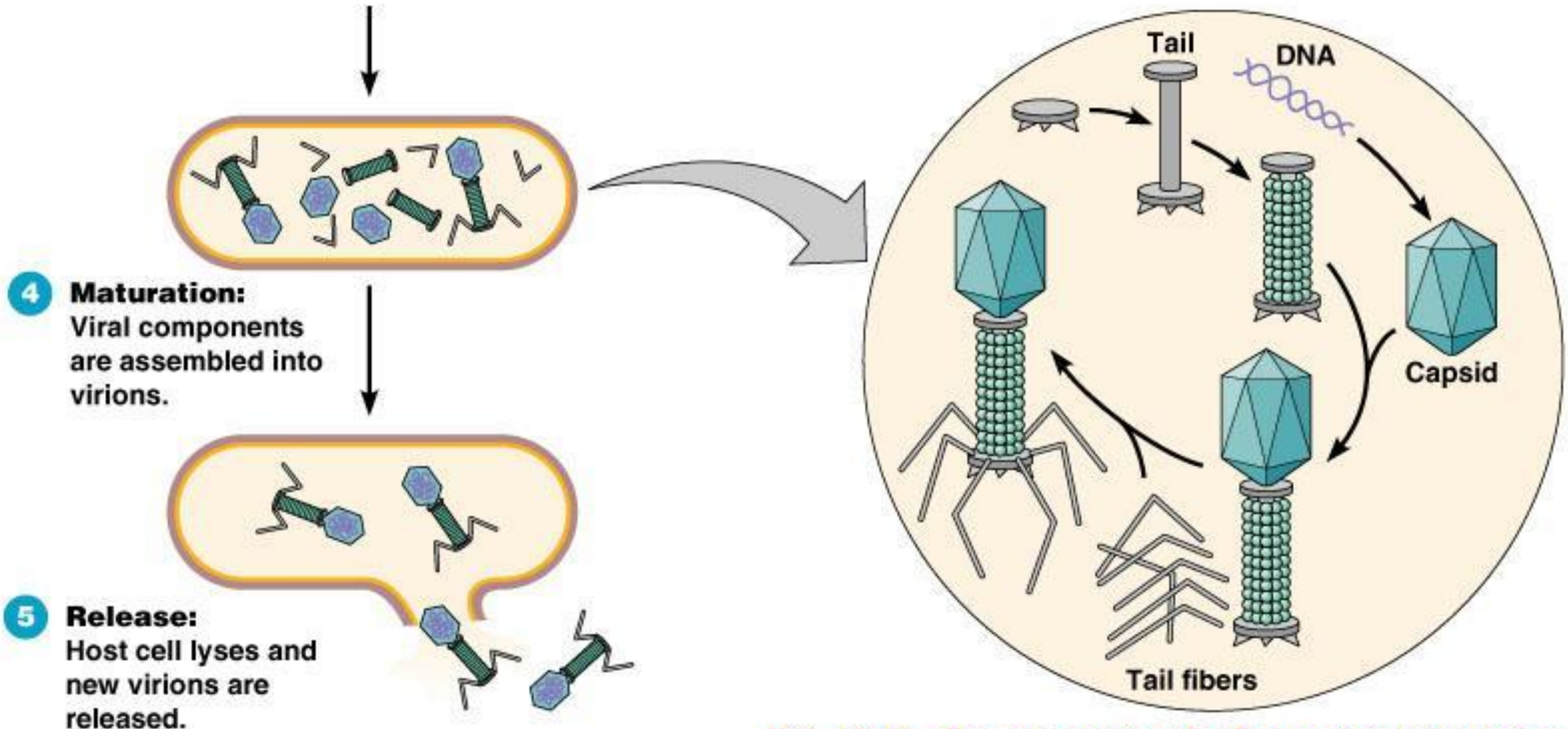


FIG. 13.10 - The lytic cycle of a T-even bacteriophage.

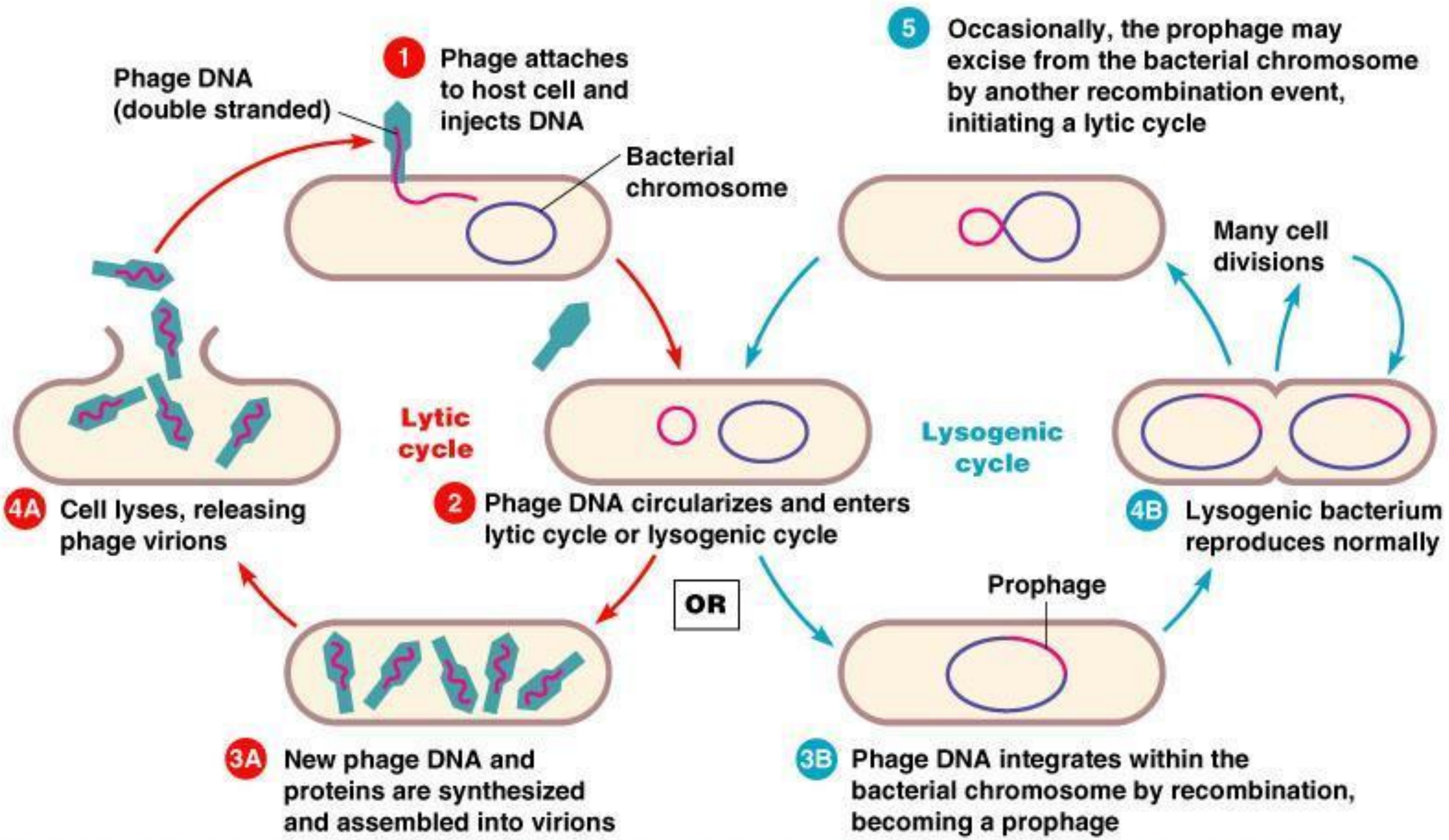


FIGURE 13.12 - The lysogenic cycle of bacteriophage lambda in *E. coli*.

In a lysogenic cycle, the viral genome usually becomes integrated into the host bacterial DNA and is then referred to as a **provirus**, or **prophage**. When the bacterial DNA replicates, the provirus also replicates.

Stages of Multiplication (Reproduction) of Animal Viruses	
Attachment (*Adsorption*)	**The virus attaches to host cell surface** (plasma membrane).
Penetration (*Entry*)	**Virus enters host cell** by endocytosis (formation of a vesicle around the virus) or fusion.
Uncoating	**Viral nucleic acid is uncoated** by viral or host enzymes.
Biosynthesis *(Synthesis)*	**Production of viral nucleic acid and proteins** using the host cell machinery.
Maturation *(Assembly)*	**Assembly of components of viral particles** to form virions. The envelope around the capsid of some viruses is formed by budding of the host plasma membrane.
Release	**New viral particles are released from host cell** by ***budding*** or ***exocytosis*** (for enveloped viruses, enclosed in a portion of the host cell membrane) or by ***lysis*** or rupture (for nonenveloped viruses).

* See animation of viral replication in your textbook's website.

Multiplication of Animal Viruses: **Attachment, Penetration, and Uncoating**

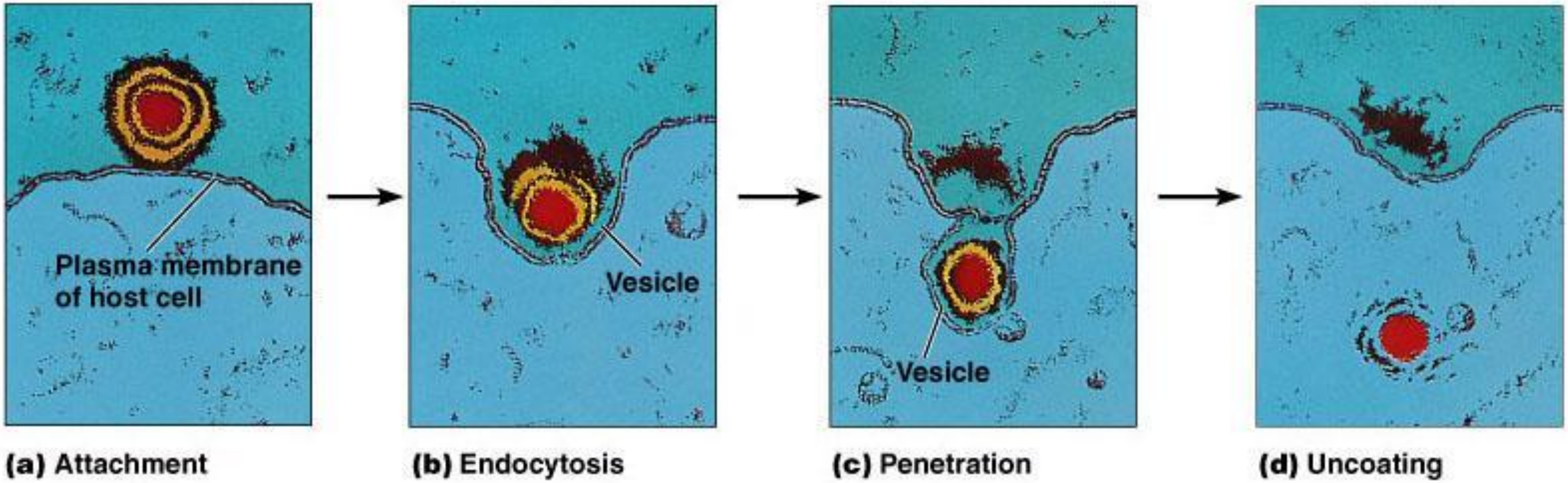
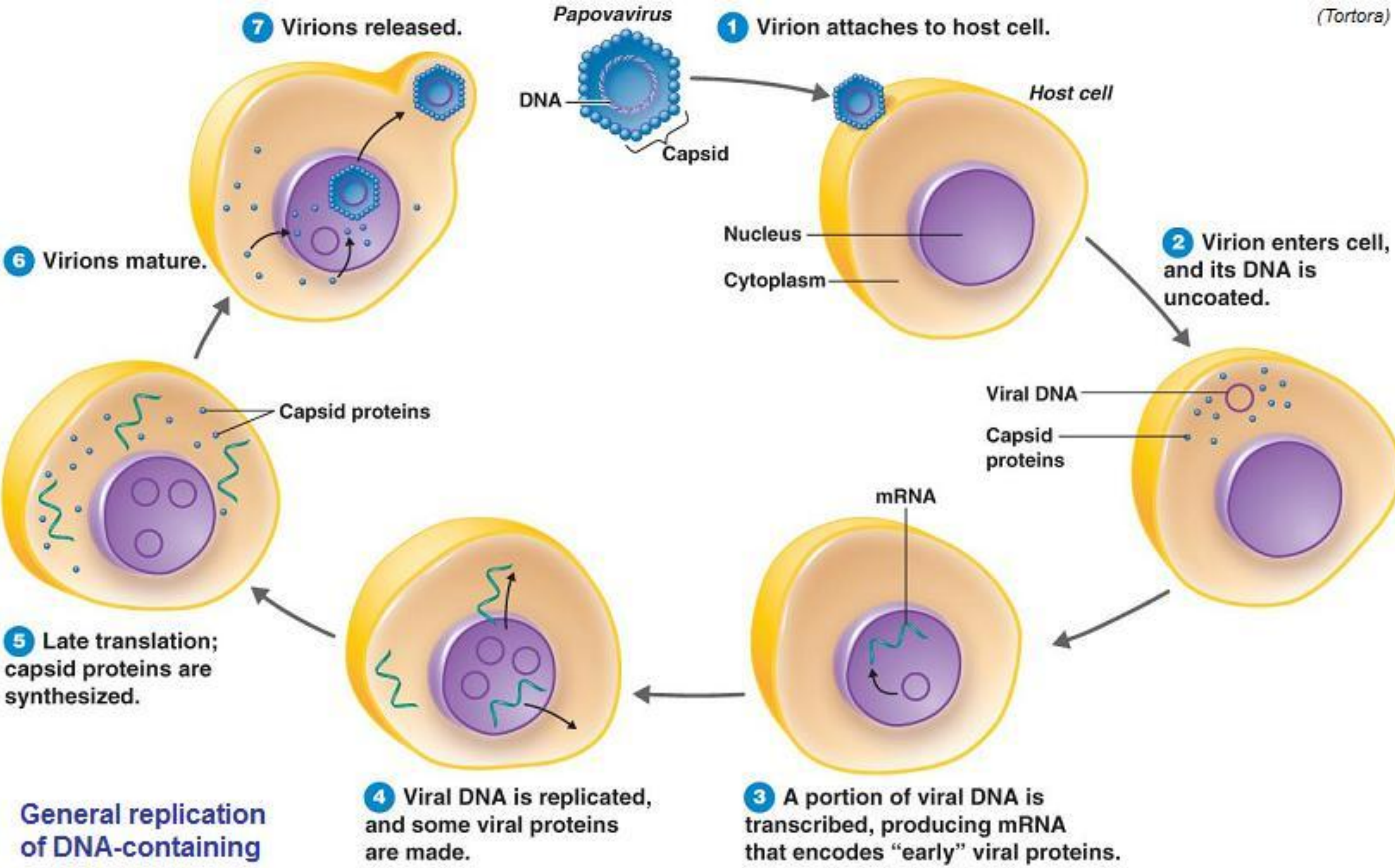


FIGURE 13.14 - The entry of herpes simplex virus (Simplexvirus) into an animal cell.

- ☺ ***Endocytosis:*** The cell's plasma membrane folds inward, forming a vesicle around the virus; this results in the loss of the envelope.

* For an animation of viral replication, see the book's website.



General replication of DNA-containing viruses, using a papovavirus as an example.

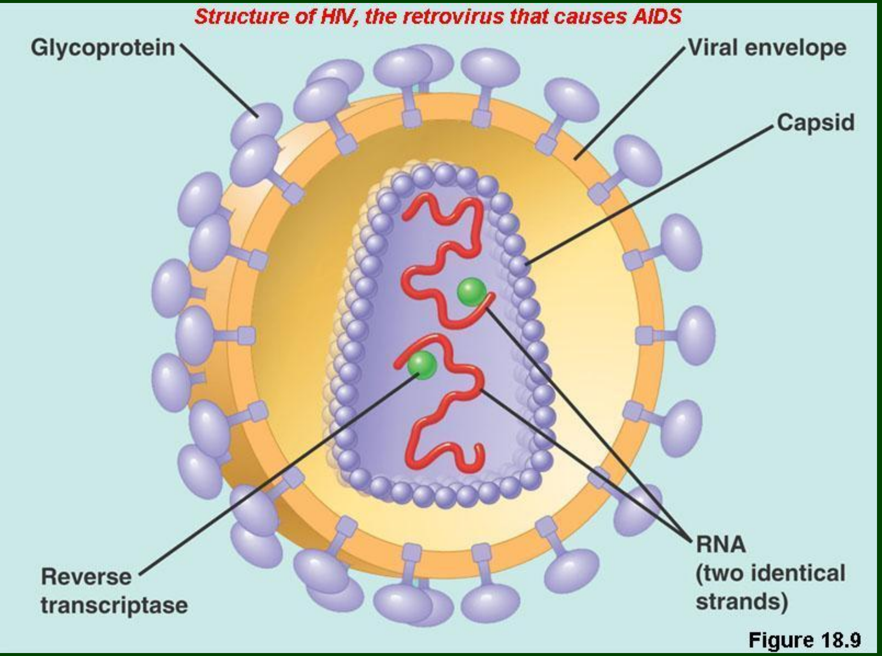
Figure 13.15. Replication of a DNA-Containing Animal Virus

Key Concept

The sequence of events in the replication of all animal viruses illustrates the following general features: attachment, entry, uncoating, biosynthesis of nucleic acids and proteins, maturation, and release.

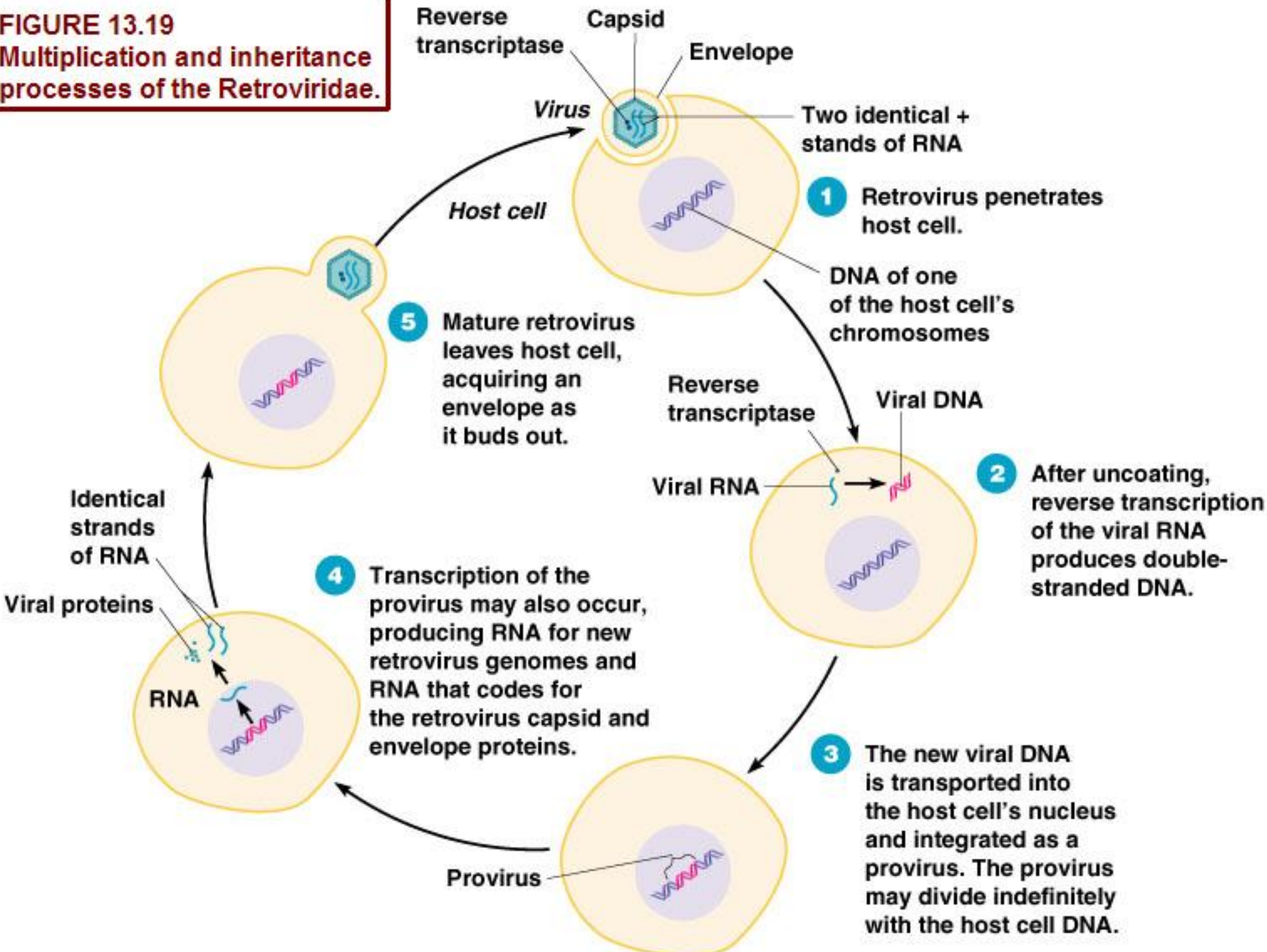
RNA as Viral Genetic Material

- There are variations to the basic mechanism of viral infection and reproduction, especially in **RNA animal viruses**.
- The RNA animal viruses with the most complicated reproductive cycles are the ***retroviruses***.
- **Retroviruses** such as **HIV** (Human Immunodeficiency Virus, the cause of AIDS) use the enzyme ***reverse transcriptase*** to copy their RNA genome into DNA (the opposite of the usual direction), which can be integrated into the host genome.
- The integrated viral DNA is called a **provirus** and it never leaves the host's genome.



- The host's **RNA polymerase** transcribes the proviral DNA into RNA molecules, which can function both as mRNA for the synthesis of viral proteins and as genomes for new virus particles released from the cell.

FIGURE 13.19 Multiplication and inheritance processes of the Retroviridae.



Comparison of Bacteriophage and Animal Virus Multiplication

TABLE 6.7 Comparison of Bacteriophage and Animal Virus Multiplication

	Bacteriophage	Animal Virus
Adsorption	Precise attachment of special tail fibers to cell wall	Attachment of capsid or envelope to cell surface receptors
Penetration	Injection of nucleic acid through cell wall; no uncoating of nucleic acid	Whole virus is engulfed and uncoated, or virus surface fuses with cell membrane, nucleic acid is released
Synthesis and Assembly	Occurs in cytoplasm Cessation of host synthesis Viral DNA or RNA is replicated and begins to function Viral components synthesized	Occurs in cytoplasm and nucleus Cessation of host synthesis Viral DNA or RNA is replicated and begins to function Viral components synthesized
Viral Persistence	Lysogeny	Latency, chronic infection, cancer
Release from Host Cell	Cell lyses when viral enzymes weaken it	Some cells lyse; enveloped viruses bud off host cell membrane
Cell Destruction	Immediate	Immediate or delayed

TABLE 13.3 Multiplication of Bacteriophage and Animal Viruses Compared

Stage	Bacteriophage	Animal Viruses
Attachment	Tail fibers attach to cell wall proteins	Attachment sites are plasma membrane proteins and glycoproteins
Penetration	Viral DNA injected into host cell	Capsid enters by endocytosis or fusion
Uncoating	Not required	Enzymatic removal of capsid proteins
Biosynthesis	In cytoplasm	In nucleus (DNA viruses) or cytoplasm (RNA viruses)
Chronic infection	Lysogeny	Latency; slow viral infections; cancer
Release	Host cell lysed	Enveloped viruses bud out; nonenveloped viruses rupture plasma membrane

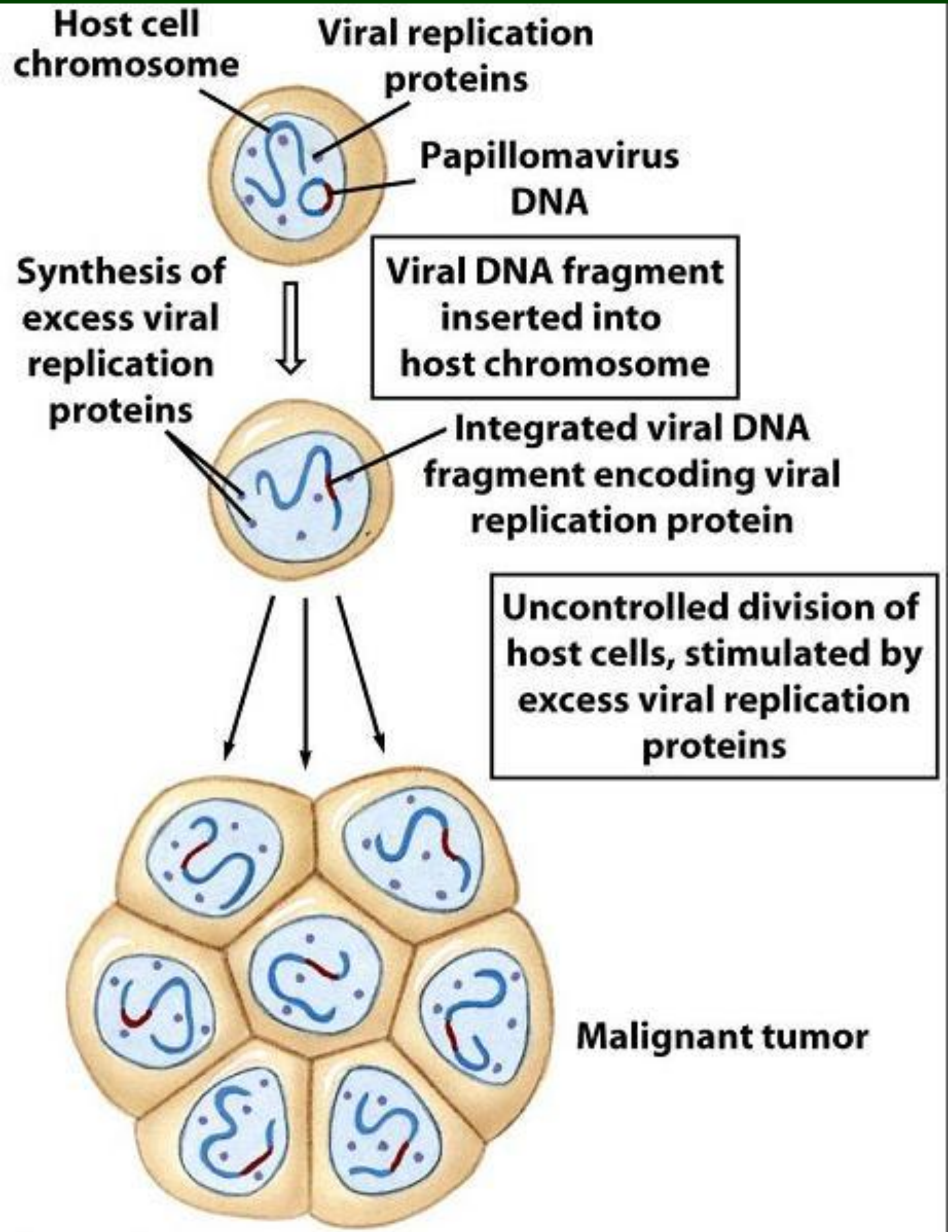


FIGURE 10.22 - Malignant tumor formation.

Viruses and Cancer

- ☺ Several types of cancer are now known to be caused by certain viruses that are capable of activating **oncogenes**.
- ☺ **Oncogene:** A gene that can bring about malignant transformation (cancer). ***Activated oncogenes transform normal cells into cancerous cells***.
- ☺ Transformed cells have properties that are distinct from the properties of normal cells: they are less round, they exhibit uncontrolled division, and they tend to exhibit chromosomal abnormalities.
- ☺ The genetic material of **oncogenic viruses (oncoviruses)** becomes integrated into the host cell's DNA.

Some Oncogenic Viruses

- ☺ DNA Oncogenic Viruses
  - ✓ Herpesviridae
    - ♦ **Epstein-Barr virus** (human herpesvirus 4) is associated with Burkitt's lymphoma (mainly in children). It also causes almost all cases of infectious mononucleosis (the term refers to lymphocytes with unusual lobed nuclei that proliferate in the blood during the acute infection).
  - ✓ Papovaviridae
    - ♦ **Human papillomavirus (HPV)** causes genital warts and uterine (cervical) cancer.
- ☺ RNA Oncogenic Viruses
  - ✓ Retroviridae
    - ♦ **Human T-cell leukemia viruses**: HTLV 1, HTLV 2 (T cells are a type of white blood cell involved in the immune response to defend the body against invading microorganisms.)

Latent and Persistent Viral Infections

- ☺ Latent Viral Infections
  - ✓ Virus remains in asymptomatic host cell for long periods; in some cases for a lifetime. Examples are:
    - ♦ **Herpes simplex viruses 1 and 2 (HSV-1** and **HSV-2):** HSV-1 causes oral ulcers (cold sores or fever blisters); HSV-2 causes genital ulcers.
    - ♦ **Varicella-zoster herpesvirus:** Causes chickenpox (varicella; skin vesicles) and shingles (on the skin and nervous system).
- ☺ Persistent (Chronic) Viral Infections
  - ✓ Disease process occurs gradually over a long period, generally fatal. Example:
    - ♦ **Measles virus:** A virus affecting the skin, but can also lead to subacute sclerosing panencephalitis with severe neurological symptoms.

TABLE 13.5 – Examples of Latent and Persistent Viral Infections in Humans

Disease	Primary Effect	Causative Virus
Latent		
Cold Sores	Skin and mucous membrane lesions; genital lesions	Herpex simplex 1 and 2
Shingles	Skin lesions	*Varicella-zoster virus* (*Herpesvirus*)
HIV / AIDS	Decreased CD4 cells	HIV-1 and 2 (*Lentivirus*)
Leukemia	Increased white blood cell growth	HTLV-1 and 2
Persistent		
Subacute sclerosing panencephalitis (SSPE)	Mental deterioration	Measles virus
Progressive encephalitis	Rapid mental deterioration	Rubella virus
Cancer	Increased cell growth	Epstein Barr (EB) virus
AIDS-dementia complex	Brain degeneration	HIV (*Lentivirus*)
Persistent enterovirus infection	Mental deterioration associated with AIDS	Echoviruses
Liver cancer	Increased cell growth	Hepatitis B virus
Cervical cancer	Increased cell growth	Human papillomavirus (HPV)

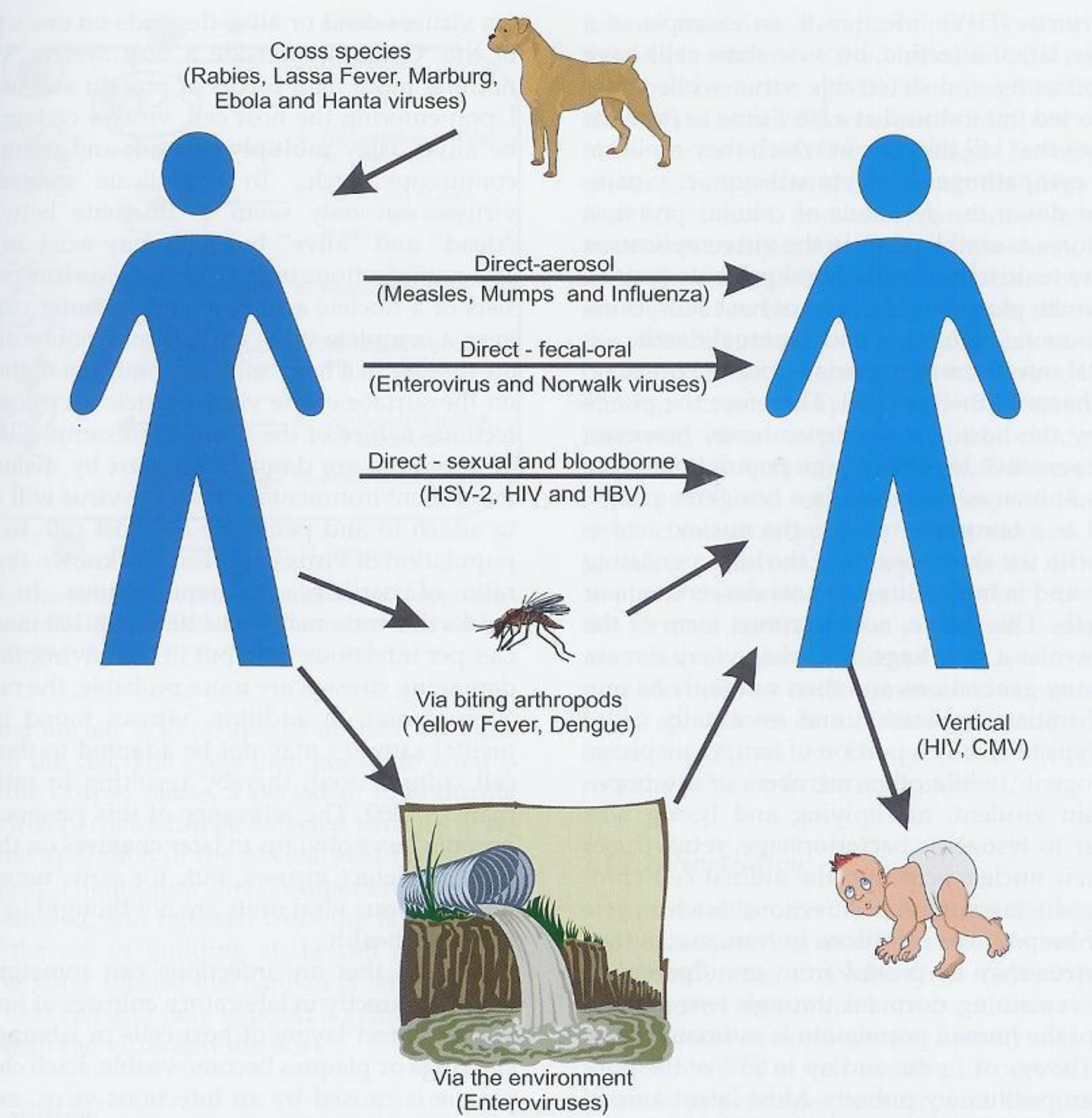


FIGURE 2.5 A schematic representation of the transmission routes of viral infections in humans with some examples. (Environmental Microbiology; Maier, Pepper, Gerba. (2000)

Viral Infections: Transmission Routes

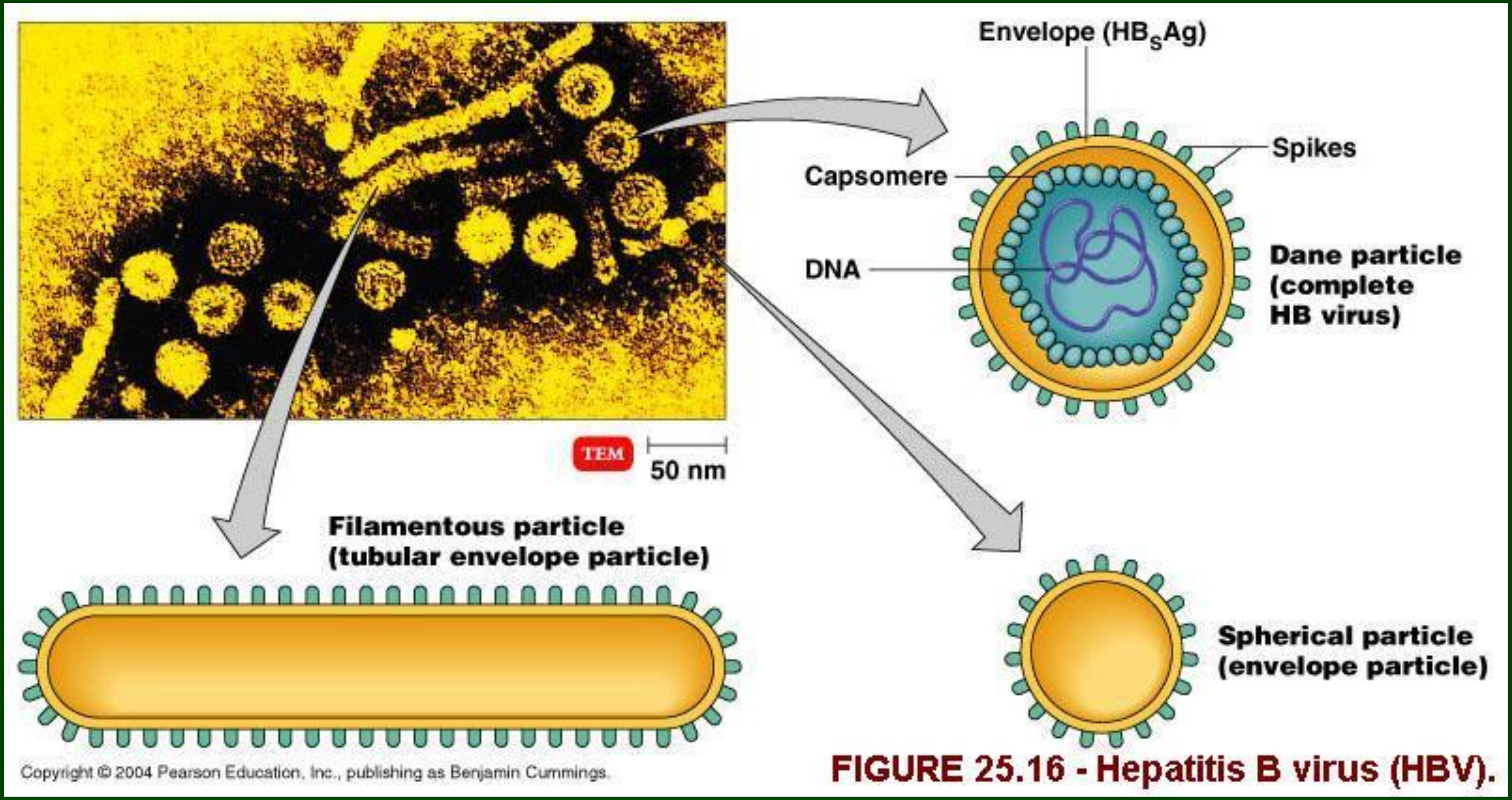
- ☺ Aerosols
- ☺ Vectors (arthropods)
- ☺ Contaminated food
- ☺ Contaminated water
- ☺ Contaminated objects
- ☺ Direct contact: person to person
- ☺ Vertical transmission (mother to fetus)

*** EXAMPLES OF VIRUSES THAT INFECT HUMANS ***		
Virus	**Cells, Organs, or Tissues Affected**	**Disease**
Rhinovirus (family Picornaviridae)	Mucous membranes of the respiratory tract	Common cold
Hepatitis B virus (family Hepadnaviridae)	Liver	Hepatitis B (inflammation of the liver) and liver tumors
Herpes Simplex Virus 1 (family Herpesviridae)	Mucous membranes of the mouth and lips	Oral herpes: ulcers in mouth and lips ("cold sores" or "fever blisters")
Herpes Simplex Virus 2 (family Herpesviridae)	Genital organs	Genital herpes: genital ulcers
HIV (Human Immunodeficiency Virus, family Retroviridae)	Leukocytes (white blood cells of the immune system)	AIDS (Acquired Immunodeficiency Syndrome)

Rhinovirus

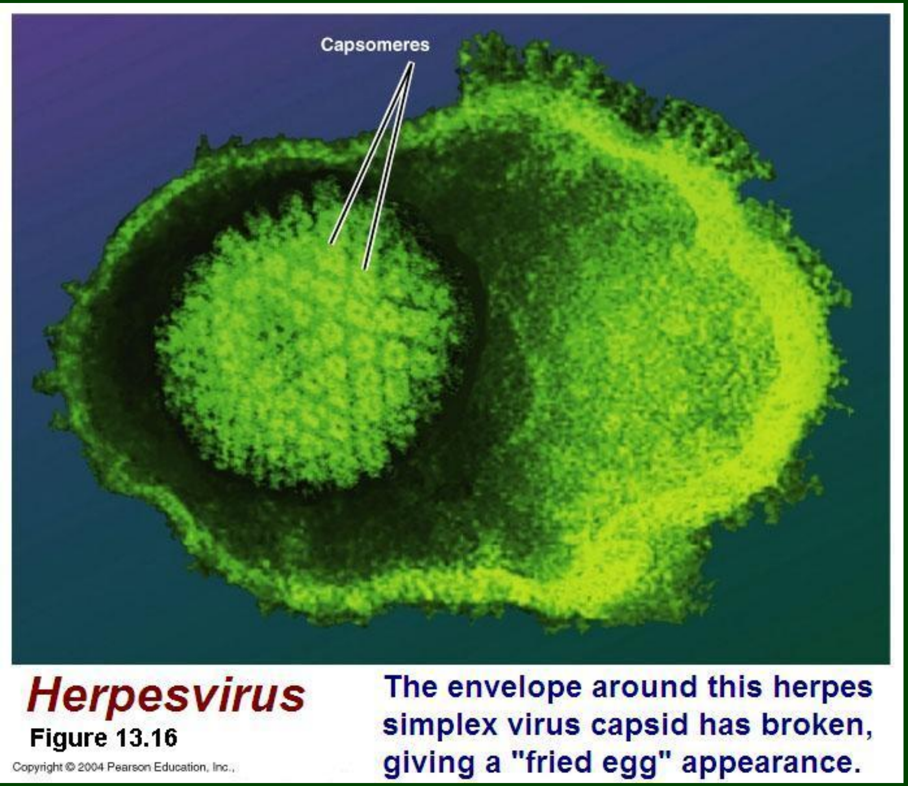
- ☺ The rhinovirus group contain viruses that cause the **common cold**. These viruses affect the mucous membranes of the respiratory tract.

Hepatitis B Virus



- ☺ **Figure 25.15. Hepatitis B Virus (HBV).**
- ☺ The micrograph and illustrations depict the distinct types of HBV particles. This virus is transmitted through blood and damages the liver.

Herpesvirus



Herpesvirus. The envelope around the capsid is broken, giving it the appearance of a "fried egg".

Cold sores, or fever blisters, caused by **herpes simplex virus 1** (HSV-1).

Human Immunodeficiency Virus (HIV)

- **HIV** causes **AIDS (Acquired Immuno-deficiency Syndrome)**, a condition in which a person experiences an assortment of infections due to the progressive destruction of immune system cells by HIV. **Immunodeficiency** is the absence of a sufficient immune response.
- The HIV virus mainly damages **helper T cells ($CD4^+$)**, a type of T lymphocytes, or white blood cells of the immune system.
- These cells are initially replaced as fast as they are destroyed, but after several years, the body's ability to replace $CD4^+$ T cells is slowly exhausted, and the ***number of $CD4^+$ T cells in circulation progressively declines*****.**
- **Transmission of HIV** is by sexual contact, contaminated needles, blood transfusions, mother-to-fetus.

HIV (Human Immunodeficiency Virus) in a Human T Cell

Figure 1.1e

Opportunistic infections such as pneumocystosis or malignancies such as Kaposi's sarcoma can signal the final stage of HIV infection, AIDS.

HIV (Human Immunodeficiency Virus)

- **Retroviruses** such as **HIV** (Human Immunodeficiency Virus, the cause of AIDS) use the enzyme ***reverse transcriptase*** to copy their RNA genome into DNA (the opposite of the usual direction), which can be integrated into the host cell's genome.
- The integrated viral DNA is called a **provirus** and it never leaves the host's genome.

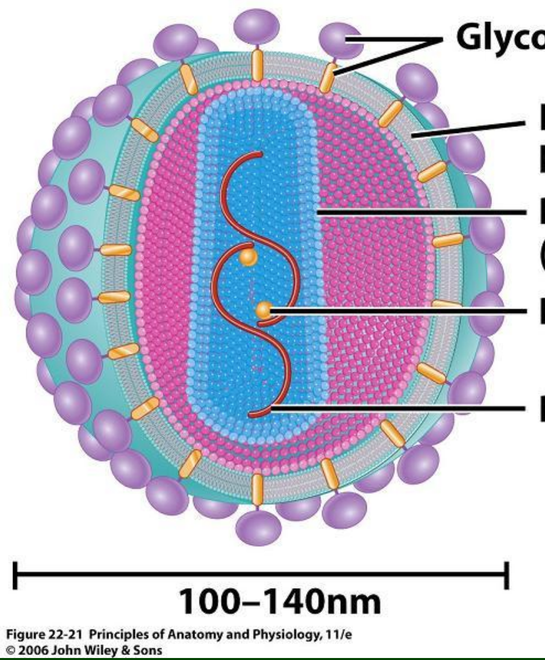
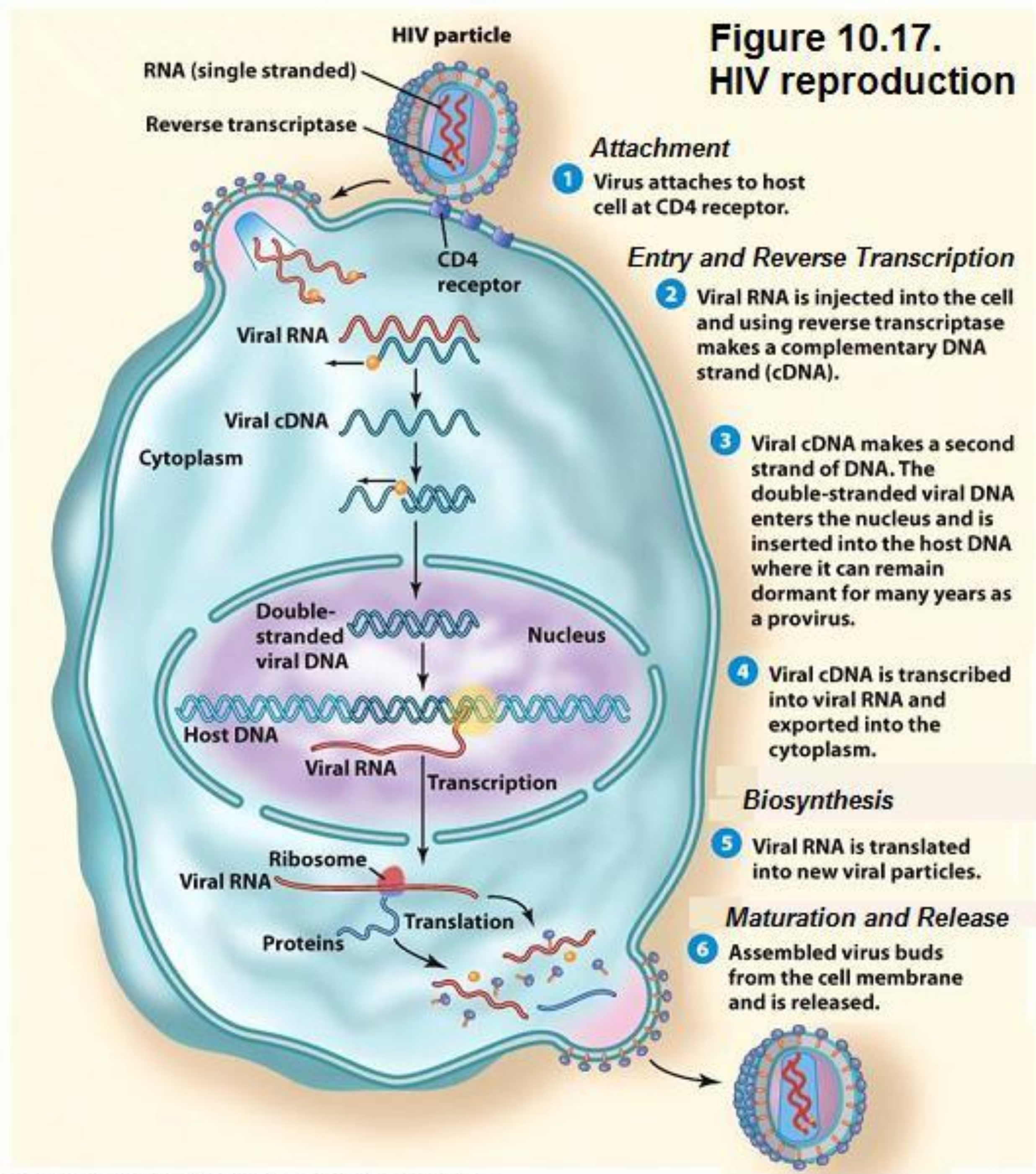


FIGURE 22.21 - Human Immunodeficiency Virus (HIV), the causative agent of AIDS.

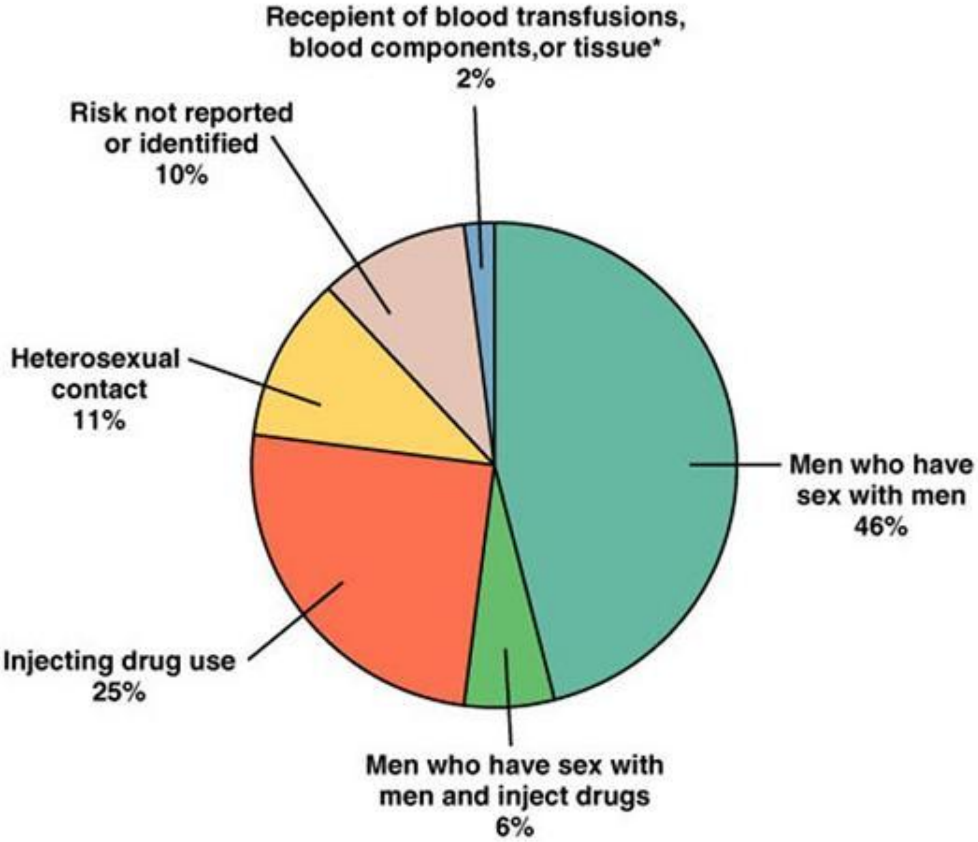
- The host cell's **RNA polymerase** transcribes the proviral DNA into RNA molecules, which can function both as mRNA for the synthesis of viral proteins and as genomes for new virus particles released from the cell.



Reproduction of the Retrovirus HIV, the Cause of AIDS

- ☺ **HIV (Human Immuno-deficiency Virus)** is a ***retrovirus*** that uses a process called ***reverse transcription*** to produce DNA from viral RNA genes. Double stranded DNA integrates into the host cell's chromosomes before the virus reproduces and buds from the cell.
- ☺ HIV causes **AIDS (Acquired Immuno-deficiency Syndrome)** in humans.

Transmission of HIV, the Virus that causes AIDS



* Most cases of AIDS resulting from transfusion of blood or tissue occurred before proper testing methods for HIV were in place. Hemophiliacs, who require regular infusion of blood-clotting factors, were an early group contracting HIV infections. Transfused blood, blood products, and transplanted tissue are now rigorously tested for HIV contamination and the risk is very low.

FIGURE 19.17 - Modes of HIV transmission in the U.S.

TABLE 20.1 AIDS Cases in the United States by Exposure Category**

Exposure Category	Percentage of New AIDS Cases in 2004	Percentage of All AIDS Cases Through 2004
Male-to-Male Sexual Contact	41	47
Injection Drug Use	22	27
Male-to-Male Sexual Contact and Injection Drug Use	5	7
Heterosexual Contact	31	17
Other*	1	2

*Includes hemophilia, blood transfusion, perinatal, and risk not reported or identified.

**Data from the Centers for Disease Control and Prevention.

(Cowan)

- ☺ In most of the world, transmission is primarily by heterosexual sex. In the **United States**, this form of transmission is much lower but is growing rapidly. Transmission in western Europe is similar to that in the United States.

Source: UNAIDS; World Health Organization (Tortora)

Figure 19.17. Distribution of HIV infection and AIDS in regions of the world.

HIV (Human Immunodeficiency Virus) causes **AIDS (Acquired Immunodeficiency Syndrome)**, a disease that has become a worldwide epidemic (pandemic) since the disease was first described in 1981 and the virus was isolated in 1983.

Spread of Human Immunodeficiency Virus (HIV)

☺ **Reported AIDS cases in the United States.** Notice that the first 250,000 cases occurred over a 12-year period, whereas the second through fourth 250,000 cases in this epidemic occurred in just 3 to 6 years. Much of the increase shown for 1993 is due to an expanded definition of AIDS cases adopted in that year. (*Source:* CDC).

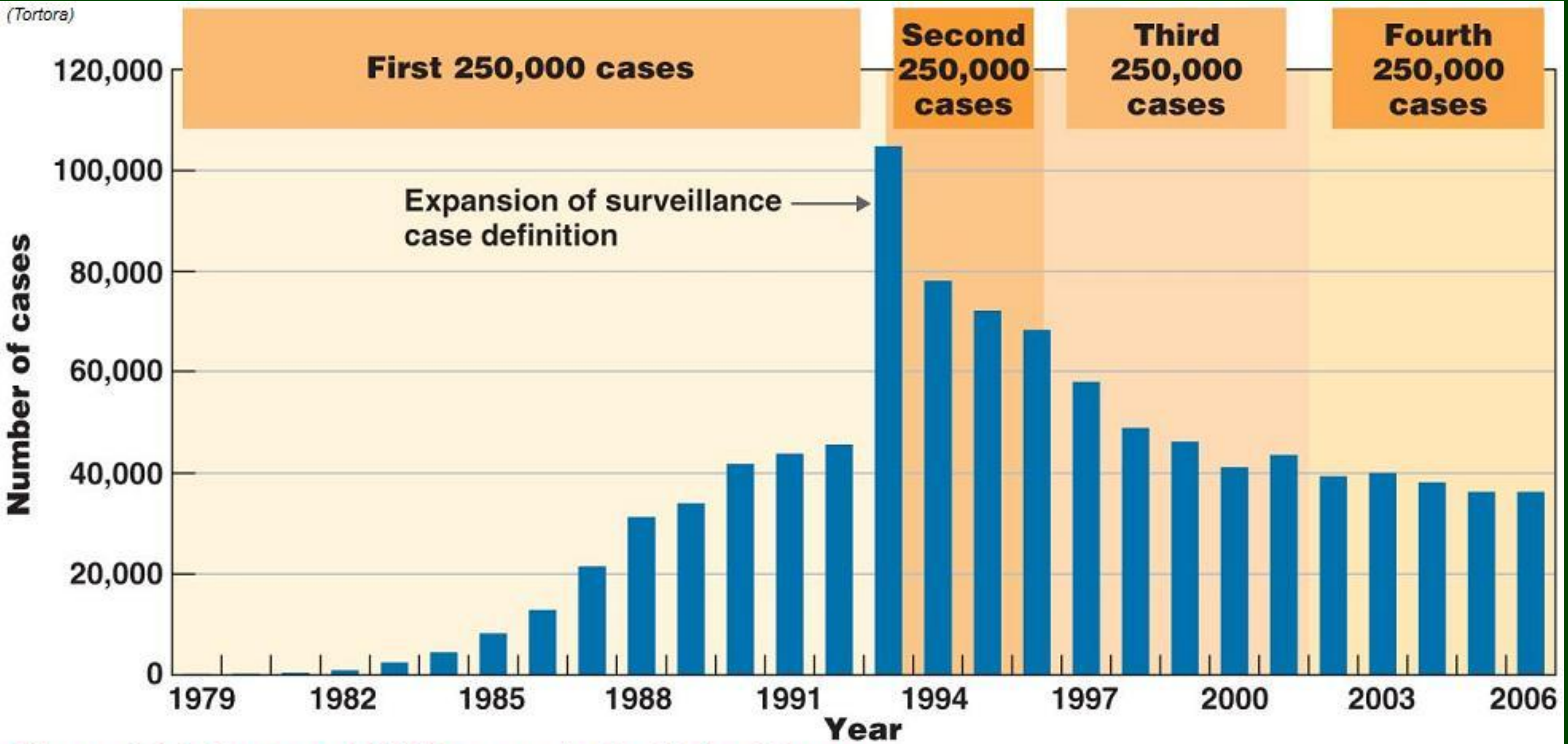


Figure 14.4. Reported AIDS cases in the United States.

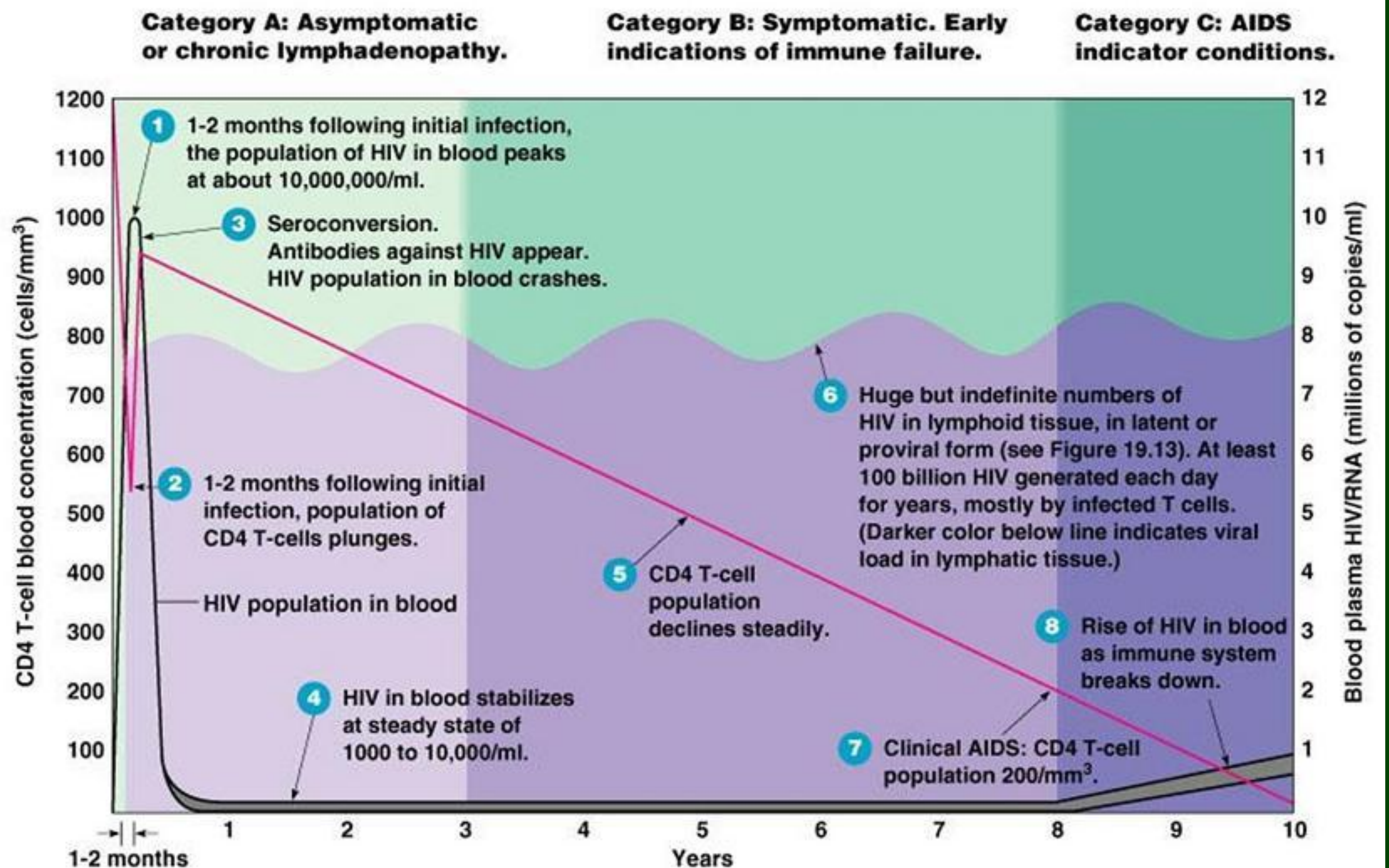


FIGURE 19.15 - The progression of HIV infection.

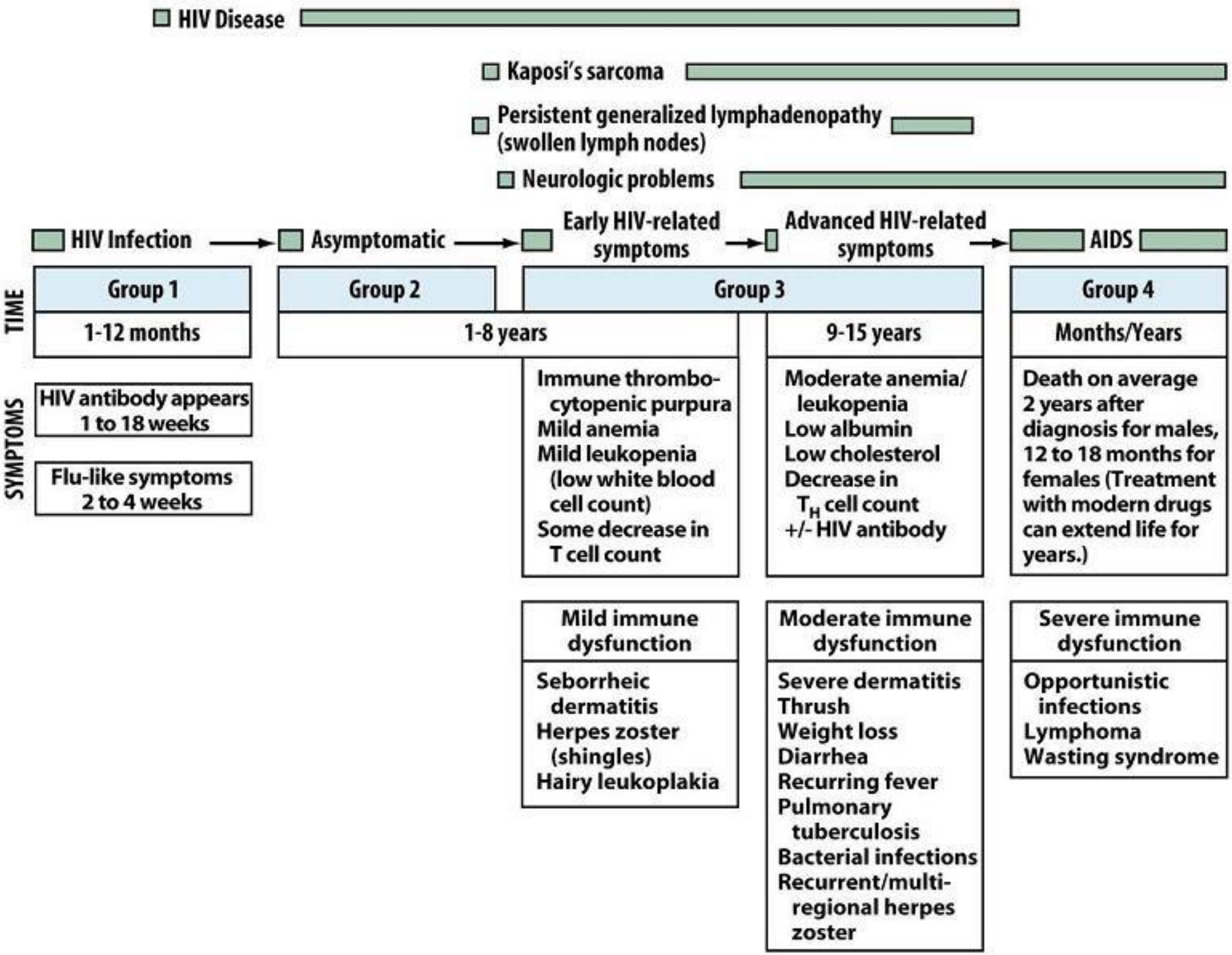


FIGURE 18.24 - CDC classification of HIV disease and AIDS.

Emerging Viruses

☺ Viruses that appear suddenly or that suddenly come to the attention of medical scientists are referred to as ***emerging viruses***.

✓ **Examples:** HIV, ebola virus, H5N1 avian flu virus, H1N1 influenza A virus.

☺ Emerging viruses are generally not new. **Three processes contribute to the emergence of viral diseases:**

✓ Mutation of existing viruses

✓ Dissemination of a viral disease from a small, isolated human population

✓ Spread of existing viruses to new host species (from other animals)

☺ **Factors** that contribute to emerging viral diseases include changes in host behavior or environmental changes.

✓ Global commerce, destruction of forests, increased travel, new roads, overpopulation, progress, sexual promiscuity, teeming cities.

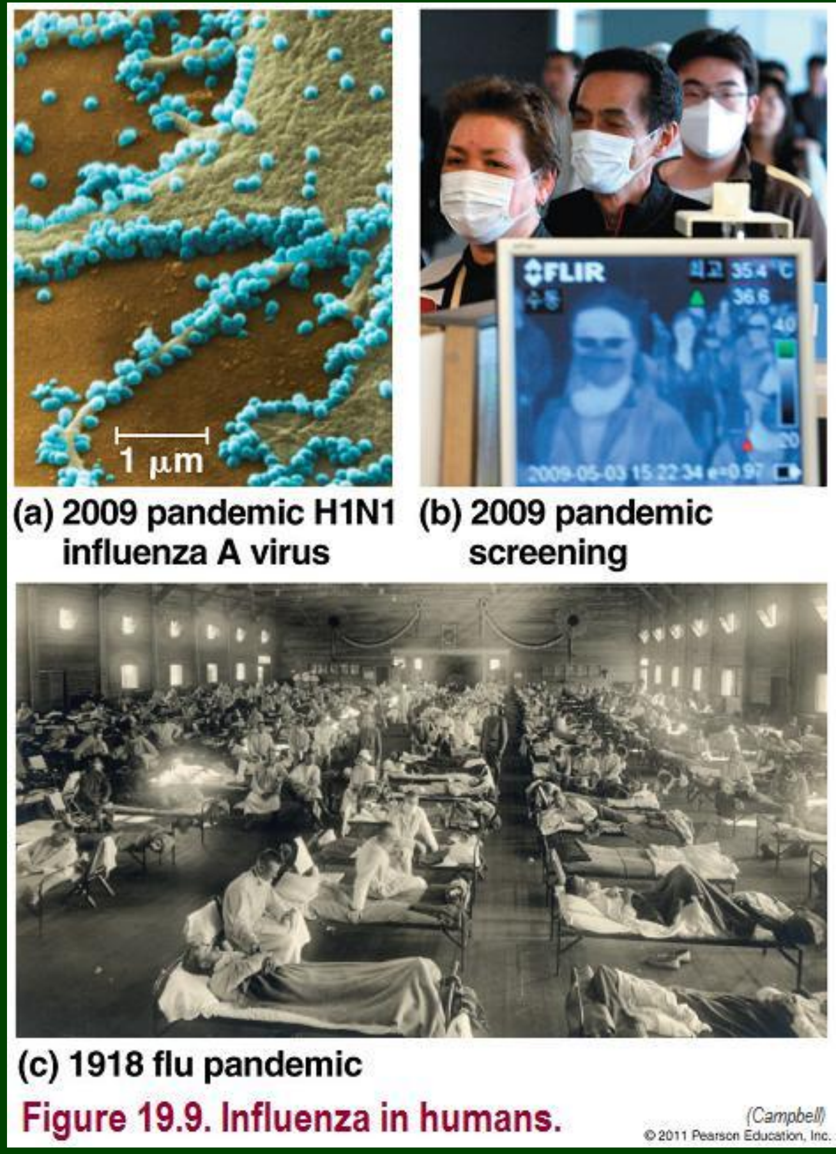
Emerging Viruses

- ☺ **Ebola hemorrhagic fever**
  - ✓ Caused by **Ebola virus**.
  - ✓ Causes fever, hemorrhaging, blood clotting, vomiting.
  - ✓ High mortality.
  - ✓ First identified near Ebola River, Congo (central Africa) in 1976.
  - ✓ Outbreak every few years.
  - ✓ Human-to-human transmission by contact with infectious blood, other body fluids or tissue.

FIGURE 13.4 - Ebola virus.

Emerging Viruses: **H1N1 Influenza A Virus**

- **H1N1** is related to viruses that cause the seasonal flu.
- Several types of influenza viruses exist: A, B and C.
  - ✓ **A** infects a wide range of animals, including birds, pigs, horses, and humans.
  - ✓ **B** and **C** infect only humans and have never caused an epidemic.
- 2009 flu **epidemic** (general outbreak) in Mexico and United States. It spread rapidly to other countries and became a **pandemic** (global epidemic), infecting over 600,000 people and killing almost 8,000. It was called "swine flu" because it was likely passed to humans from pigs.
- This virus caused the *"Spanish flu"* pandemic of **1918-1919**, which killed about 40 million people, including many World War I soldiers.

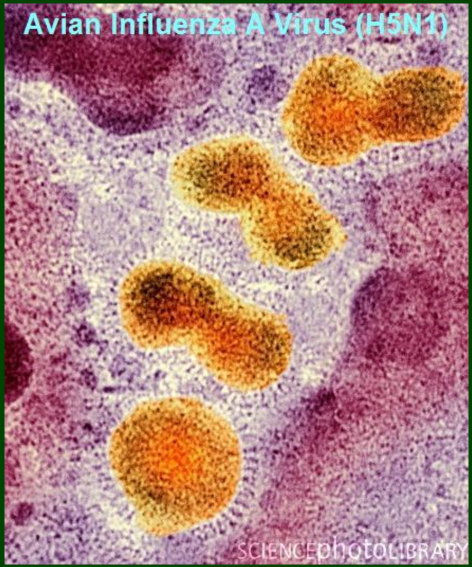


(a) 2009 pandemic H1N1 influenza A virus (b) 2009 pandemic screening

(c) 1918 flu pandemic

Figure 19.9. Influenza in humans. (Campbell)

Emerging Viruses



- ☺ **Avian Influenza A Virus or H5N1 Virus (also known as Avian or Bird Flu Virus)**
  - ✓ **2003:** Killed millions of poultry and 24 people in southeast Asia (with respiratory disease).
  - ✓ **Influenza A viruses** are found in many different animals (ducks, chickens, pigs, horses, seals, whales). These viruses can sometimes cross from one species to another, causing illness.
  - ✓ Human infections with avian influenza viruses have not resulted in human-to-human transmission, but these viruses have the **potential to change** and spread easily between people; therefore, monitoring them is important.

TABLE 10.4

Some Major Outbreaks of Avian Flu

1983	1993	1995	1997	1999	2002	2004

Pennsylvania: Birds destroyed; 17 million commercial egg-laying hens. The cost to destroy the birds was about $60 million, with $300 million in additional damages.

Maryland: Birds destroyed: Tens of thousands of game birds. Strain of virus is unavailable.

Pakistan: Birds destroyed: 3.2 million broiler chickens and broiler breeder chickens.

Hong Kong: Birds destroyed: 1.4 million chickens and an unspecified number of other domestic birds. Humans were infected for the first reported time: 18 people were hospitalized; six of them died.

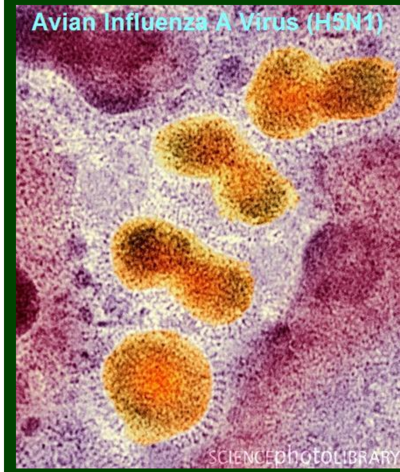
Italy: 413 farms affected; birds destroyed: 8.1 million egg-laying hens; 2.7 million meat and breeder turkeys; 2.4 million broiler breeder chickens and broiler chickens; 247,000 guinea fowl; 260,000 quail; ducks and pheasants; 1,737 backyard poultry; 387 ostriches.

Virginia: 4.7 million birds killed, including chickens and turkeys; cost to poultry companies and growers was $135 million to $150 million.

Hong Kong, 10 other Asian countries and 5 states in U.S.: 10's of millions of birds destroyed; minor problem in U.S.; at least 12 human deaths in Asia.

Source: Diseases of Poultry, 11th Edition, edited by W. M. Saif, Iowa State Press 2003; Virginia state officials; Maryland Department of Agriculture

Table 10-4 Microbiology, 6/e



- ☺ EMERGING VIRUSES: Example – **Avian Influenza A Virus**
  - ✓ Many emerging diseases are caused by viruses which had been endemic at low levels in localized areas, but which have "jumped" species and acquired a new host range and spread; sometimes due to human activities as well, e.g. colonizing previously inhabited jungles. Global commerce, overpopulation, teeming cities, progress, and increased travel influence viral emergence.

Plant Viruses and Viroids

- **Plant viruses** resemble animal viruses in their structure and mode of reproduction.
- In ***horizontal transmission***, a plant is infected from an external source of the virus, for example through **wounds** or via **insects**.
- In ***vertical transmission***, a plant **inherits** a viral infection from a parent plant.
- Plant viruses cause disease in important agricultural crops. For example:
  - ✓ **bean mosaic virus:** in beans
  - ✓ **potato yellow dwarf virus:** in potatoes
  - ✓ **wound tumor virus:** in sugar cane

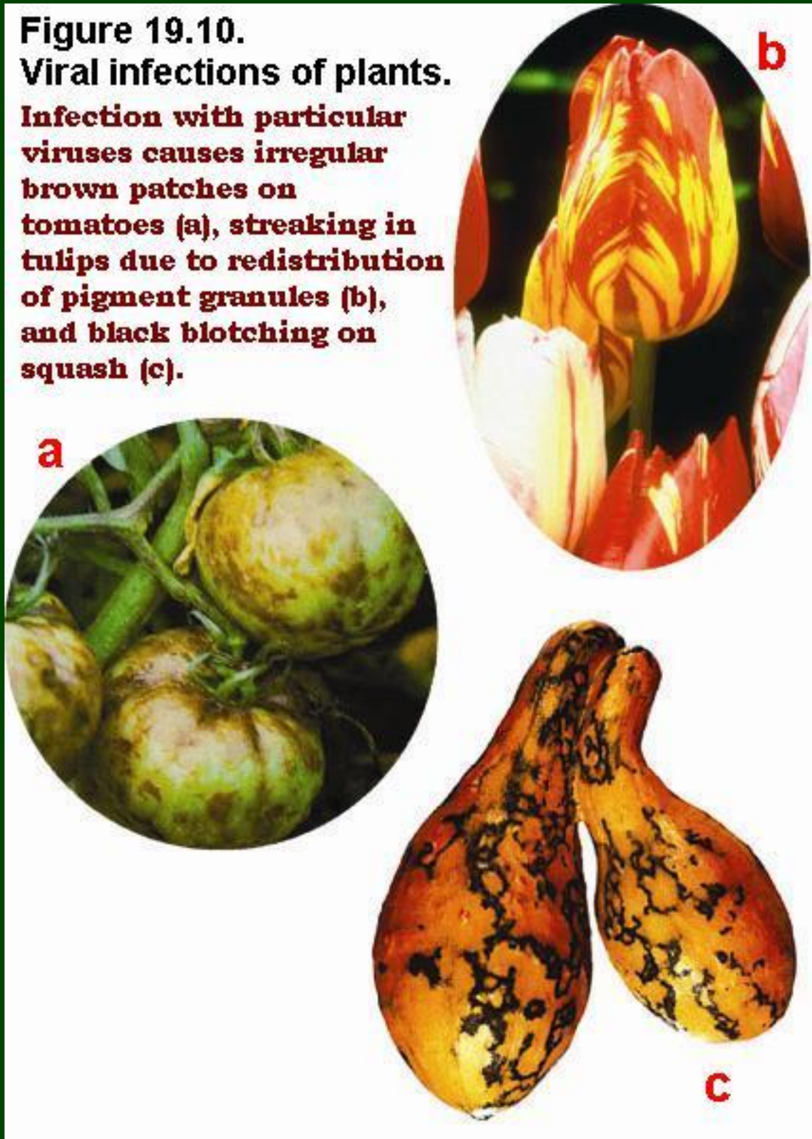


Figure 19.10. Viral infections of plants. Infection with particular viruses causes irregular brown patches on tomatoes (a), streaking in tulips due to redistribution of pigment granules (b), and black blotching on squash (c).

Plant Viruses and Viroids

- ☺ **Viroid:** A short viruslike infectious particle of **naked RNA, without a protein coat** (“***infectious RNA***”).
- ☺ Viroids seem to cause errors in the regulatory systems that control plant growth, and the typical signs of viroid diseases are abnormal development and stunted growth.
- ☺ So far, only viroids pathogenic for plants have been found, but it is possible that there are viroids pathogenic for animals.
- ☺ Example:
  - ✓ Potato spindle tuber viroid

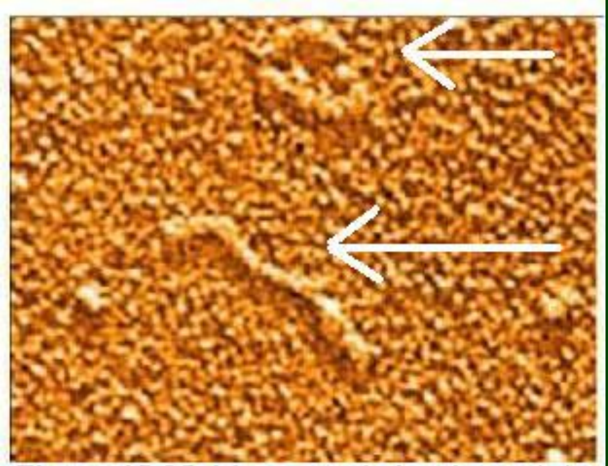
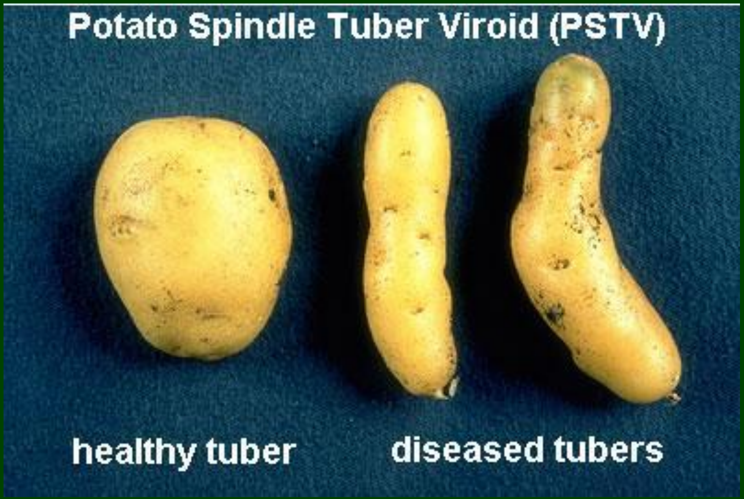
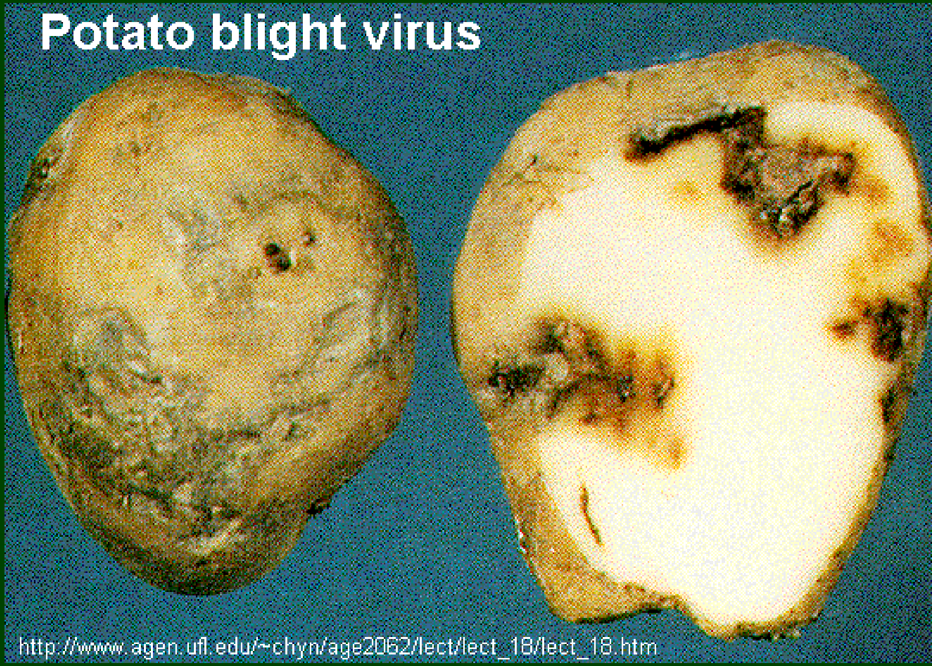


Figure 13.23. Linear and circular potato spindle tuber viroid (PSTV).



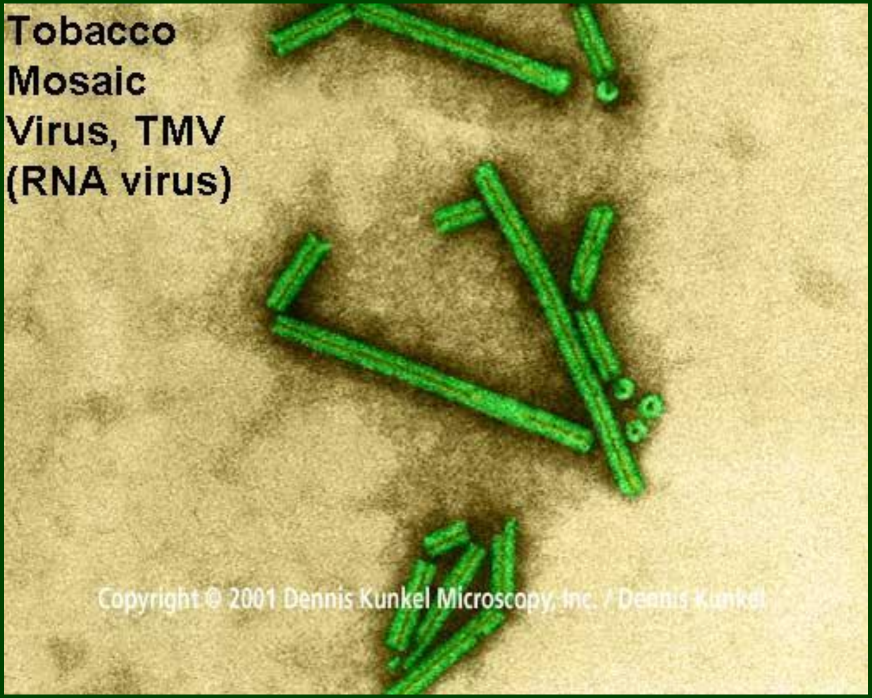
Plant Viruses

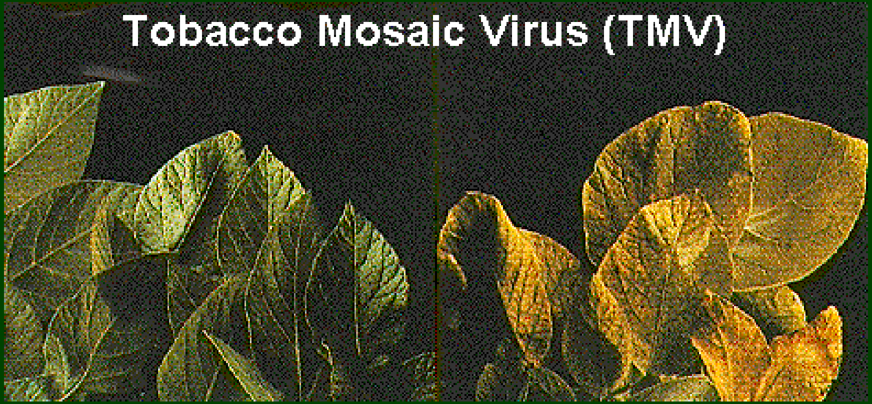


Bean Mosaic Virus

Potato Blight Virus

Plant Viruses





Tulips infected by Tulip Mosaic Virus.

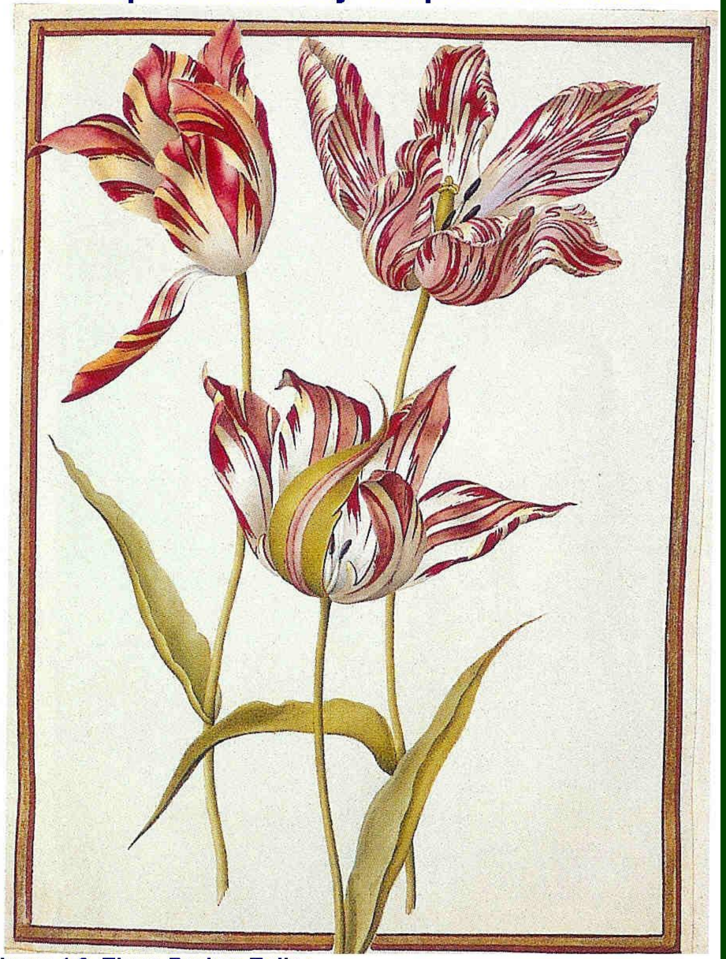
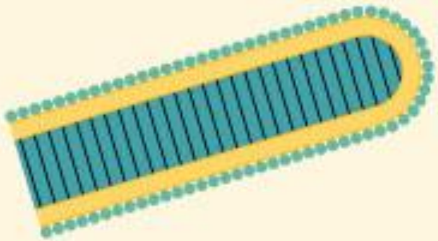


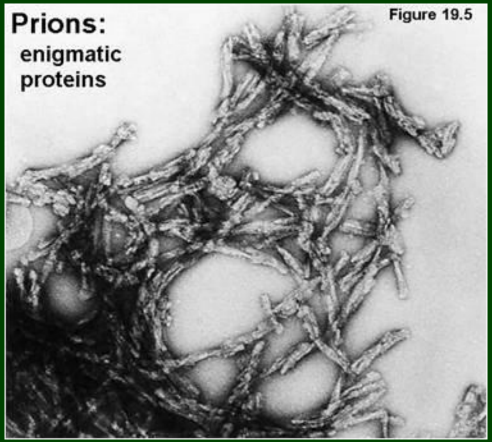
Figure 1.2 Three Broken Tulips.
A painting by Nicolas Robert (1624-1685). Stripping patterns (color breaking) in tulips were caused by the tulip mosaic virus.
Ref. Principles of Virology; S.J. Flint et al. 2000. ASM Press. USA.

TABLE 13.6 Classification of Some Major Plant Viruses

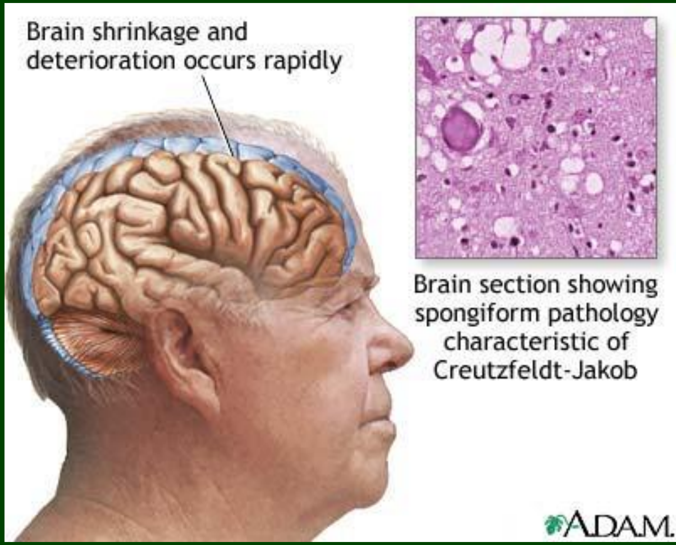
Characteristic	Viral Family	Viral Genus or Unclassified Members	Morphology	Method of Transmission
Double-stranded DNA, nonenveloped	Papovaviridae	Cauliflower mosaic virus		Aphids
Single-stranded RNA, + strand, nonenveloped	Picornaviridae	Bean mosaic virus		Pollen
	Tetraviridae	*Tobamovirus*		Wounds
Single-stranded RNA, strand, enveloped –	Rhabdoviridae	Potato yellow dwarf virus		Leafhoppers and aphids
Double-stranded RNA, nonenveloped	Reovirus	Wound tumor virus		Leafhoppers

Prions

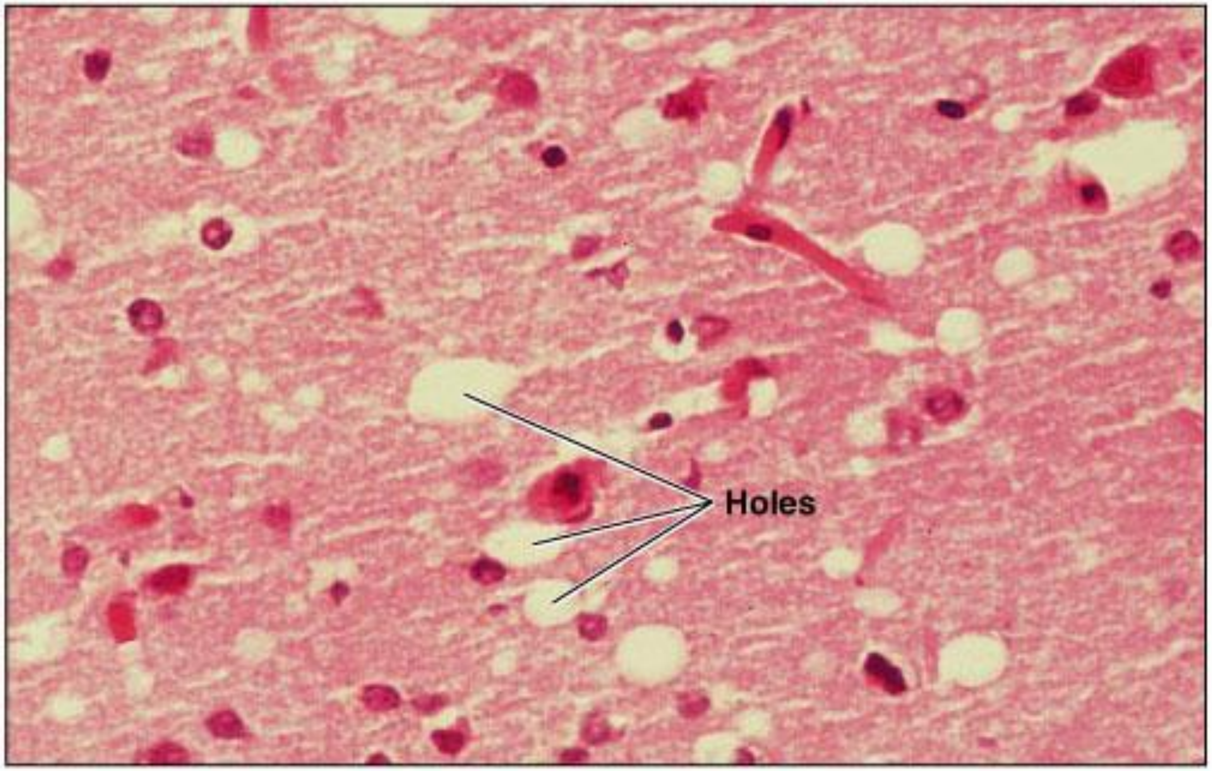
- **Prion:** Infectious agent consisting of a self-replicating *mutated protein* without detectable nucleic acid; an **"infectious proteinaceous particle".**
- Inherited and transmissible by food ingestion, transplant, and surgical instruments.
- The incubation period of prions is at least 10 years before symptoms develop, and they are not destroyed by heat through cooking.
- Cause degenerative brain diseases called **spongiform encephalopathies**:
  - ✓ **Scrapie:** in sheep and goat
  - ✓ **Mad cow disease:** bovine spongiform encephalopathy
  - ✓ **Creutzfeldt-Jakob disease:** in humans; leading to dementia and death.



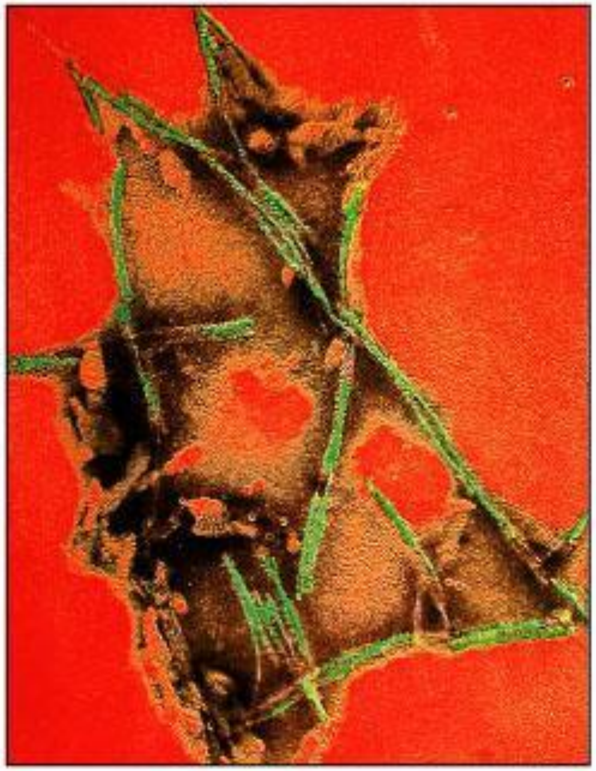
Prions: enigmatic proteins. Brain tissue from a hamster infected with *scrapie*, containing fibrous clusters of prion proteins.



Prions: Enigmatic Infectious Proteins



(a) Brain tissue showing spongiform lesions



(b) Characteristic fibrils of prion-caused diseases

FIGURE 22.17 - Spongiform encephalopathies, caused by prions.

- ☺ According to the leading hypothesis, a **prion** is a misfolded form of a protein normally present in brain cells. When a prion gets into a cell containing the normal form of the protein, the prion converts the normal protein to the prion version.

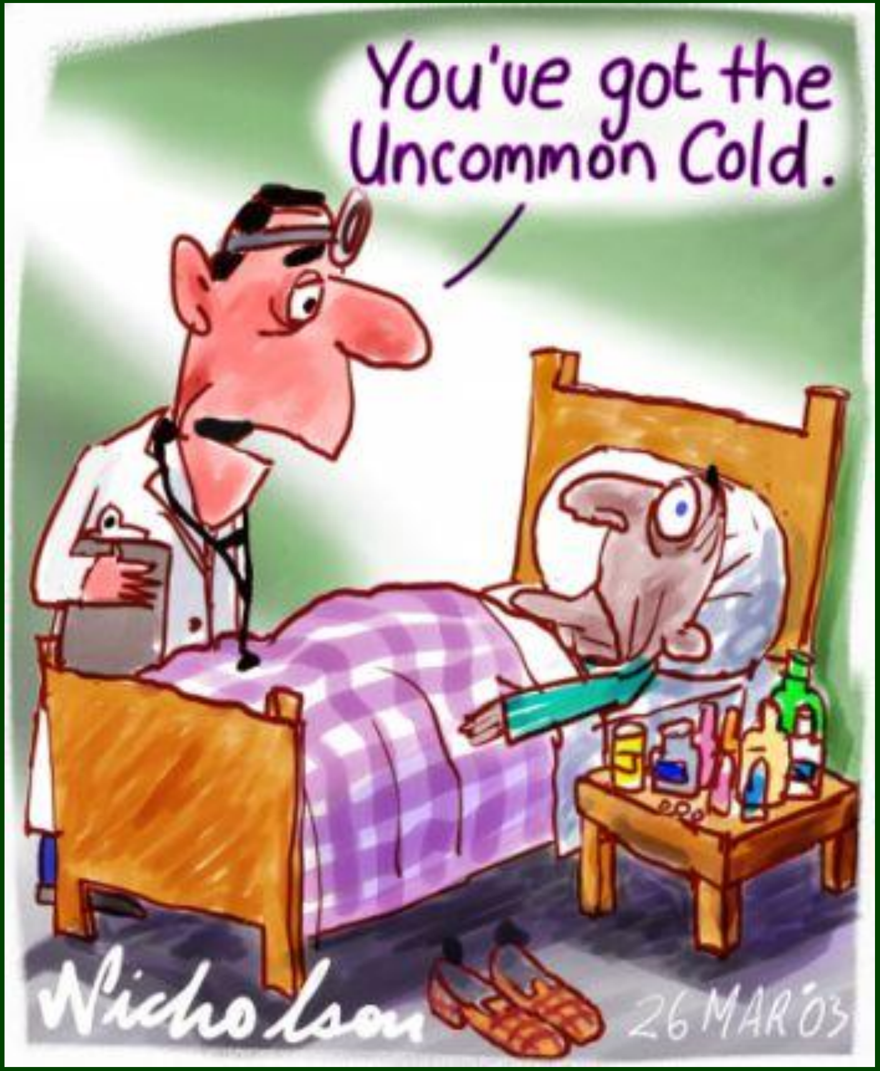
TABLE 10.7

Comparison of Viruses, Viroids, and Prions

	Virus	Viroid	Prion
Nucleic acid	+ (ssDNA, dsDNA, ssRNA, or dsRNA)	+ (ssRNA)	–
Presence of capsid or envelope	+	–	–
Presence of protein	+	–	+
Need for helper viruses	+/– (Needed by some of the smaller viruses such as the parvoviruses)		
Viewed by	Electron microscopy	Nucleotide sequence identification	Host cell damage
Affected by heat and protein denaturing agents	+	–	–
Affected by radiation of enzymes that digest DNA orRNA	+	+	–
Host	Bacteria, animals, or plants	Plants	Mammals

Table 10-7 Microbiology, 6/e


www.CartoonStock.com
VIRUS TRAVEL AGENCY
"Doorknob OK?"


You've got the Uncommon Cold.
Nicholson
26 MAR 03

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