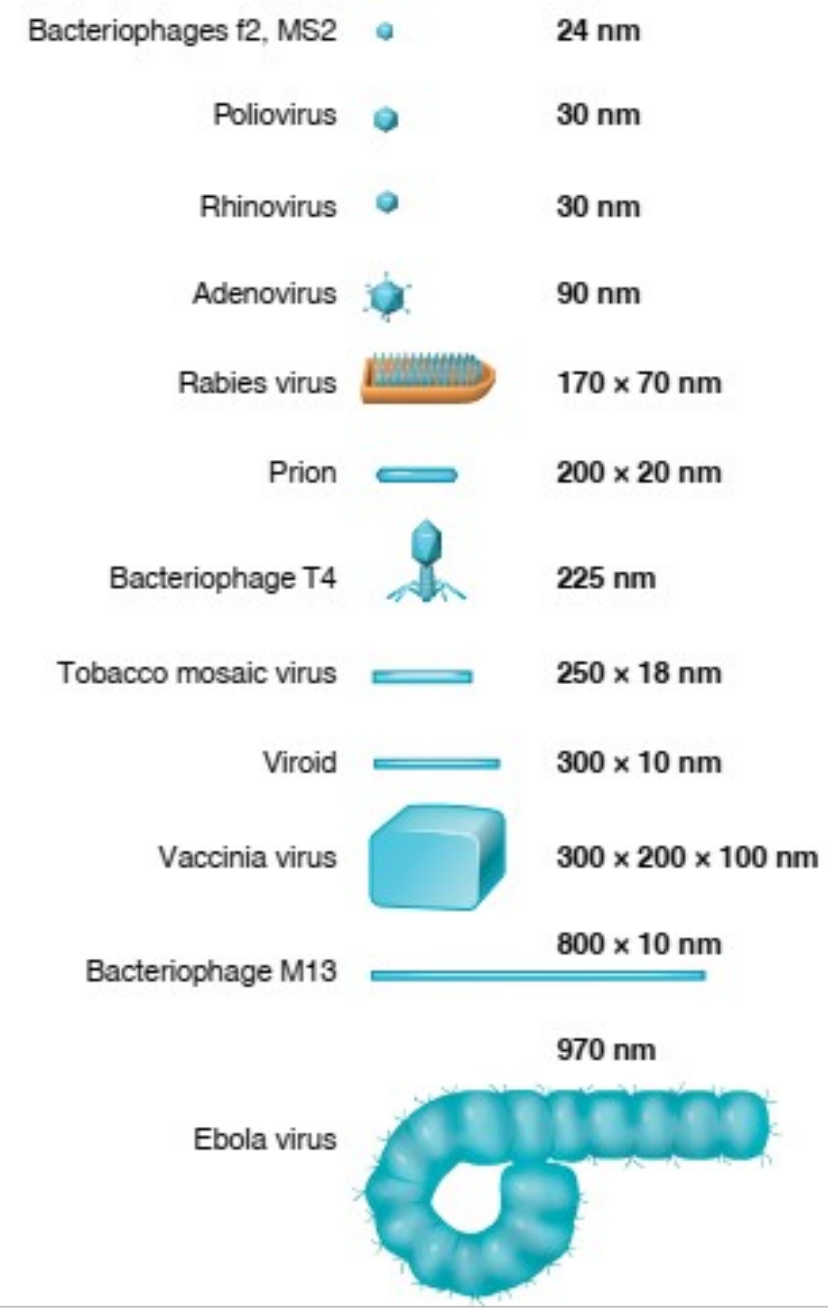
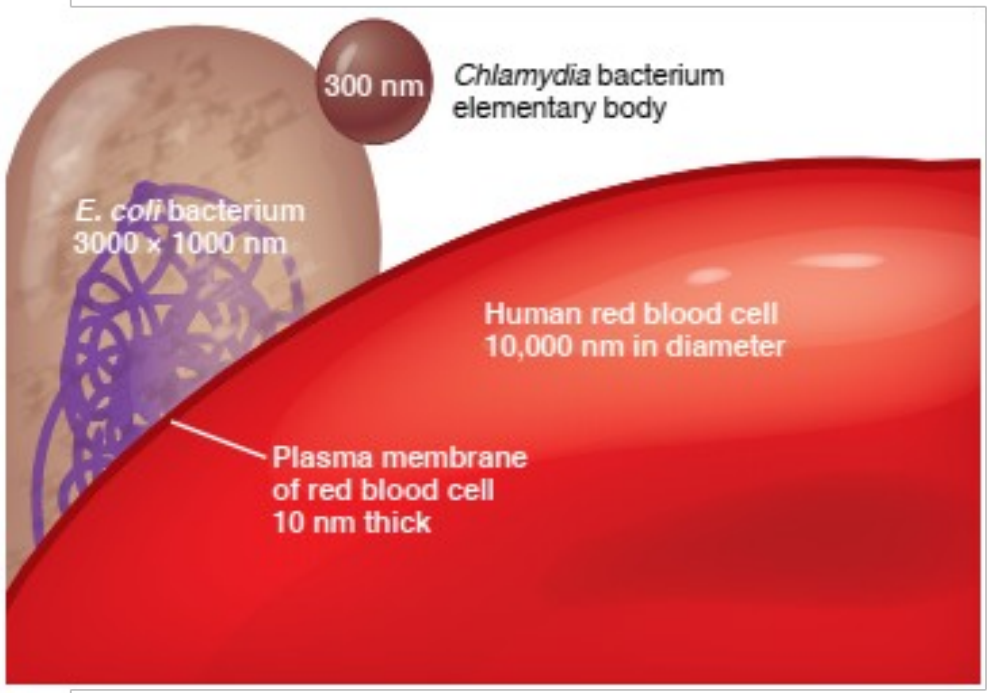
VIRUSES

- Morphology
- Classification
- Structures and functions
- Multiplication

Morphology


Bacteriophages f2, MS2
24 nm
Poliovirus
30 nm
Rhinovirus
30 nm
Adenovirus
90 nm
Rabies virus
170 × 70 nm
Prion
200 × 20 nm
Bacteriophage T4
225 nm
Tobacco mosaic virus
250 × 18 nm
Viroid
300 × 10 nm
Vaccinia virus
300 × 200 × 100 nm
Bacteriophage M13
800 × 10 nm
Ebola virus
970 nm


300 nm
Chlamydia bacterium
elementary body
E. coli bacterium
3000 × 1000 nm
Human red blood cell
10,000 nm in diameter
Plasma membrane
of red blood cell
10 nm thick

A VIRION is a complete, fully developed, infectious viral particle composed of **nucleic acid** and surrounded by a **protein** coat that protects it from the environment and is a vehicle of transmission from one host cell to another.

Classification

- Disease symptoms
- Infected hosts
- Viral morphology
- Genetic material types
- Genetic material replication mechanisms

Classification

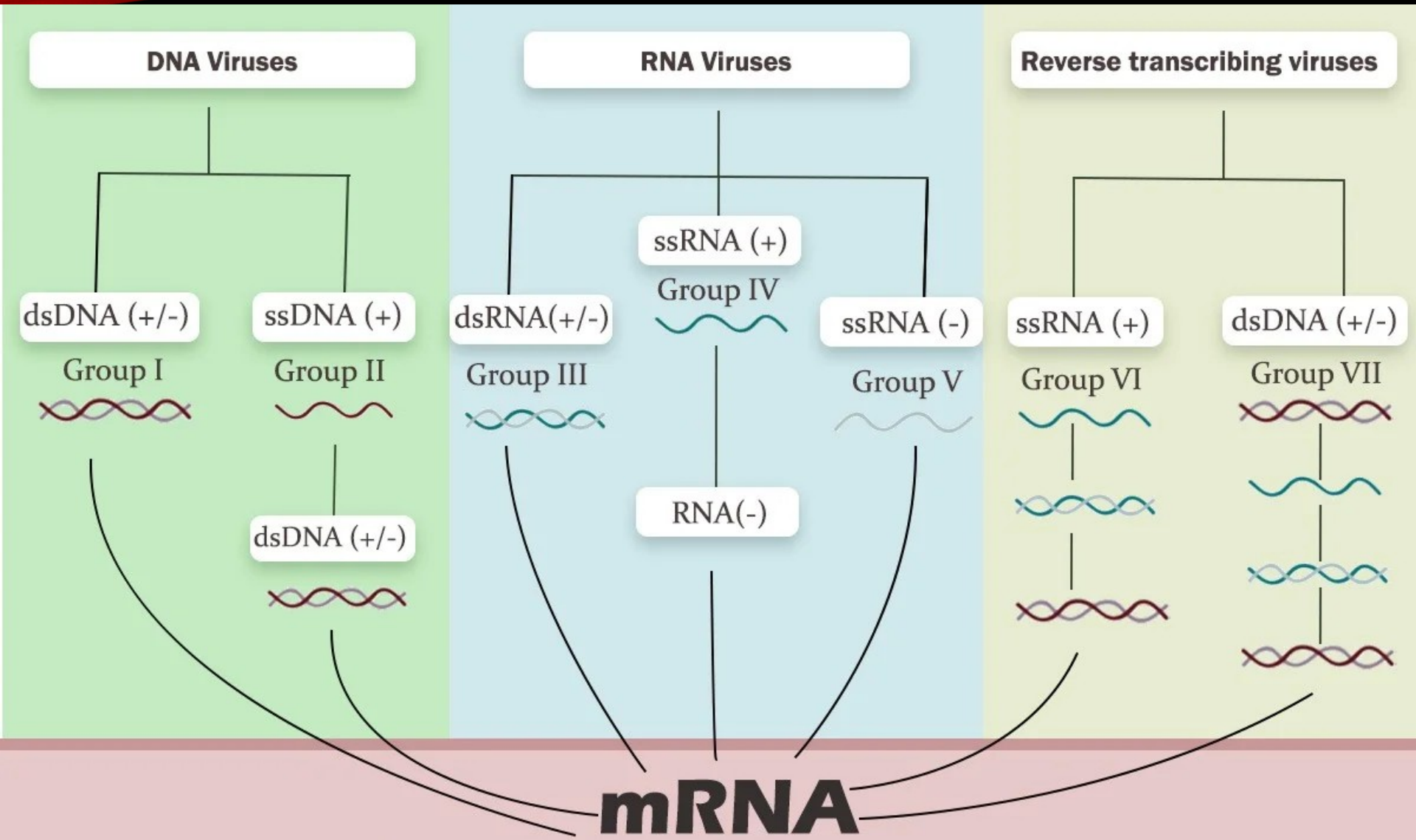
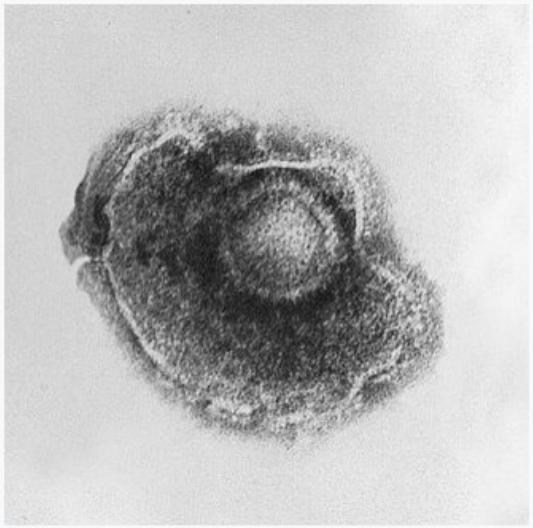


Image credit: Microbiologynote.com

Classification

- The suffix ***-virus*** is used for **genus** names;
- **Family** names end in ***-viridar;***
- **Order** names end in ***-ales***.
- A viral **species** is a group of viruses sharing the same genetic information and ecological niche (host range)
- Viral species are designated by descriptive common names, with subspecies (if any) designated by a number

Human alphaherpesvirus 3



Electron micrograph of a *Human alphaherpesvirus 3* virion

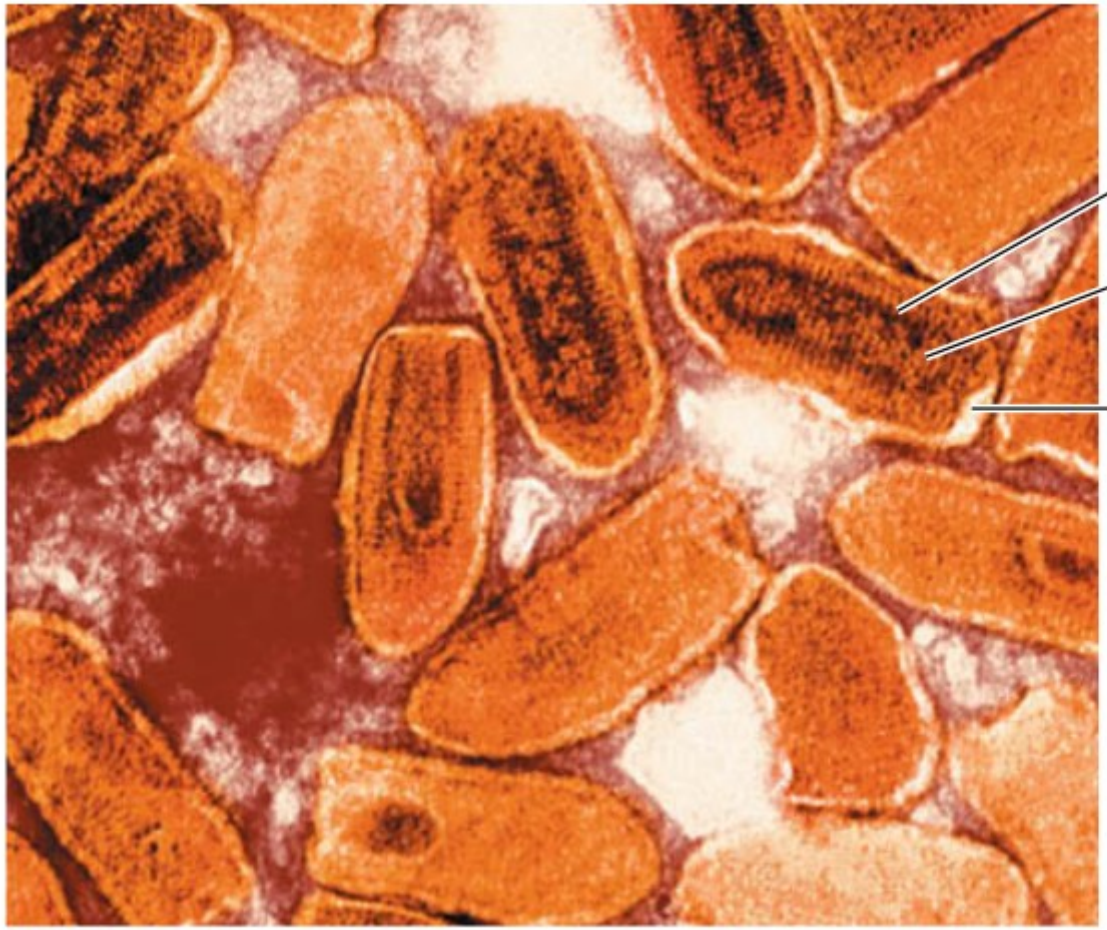
Virus classification

(unranked):	Virus
Realm:	*Duplodnaviria*
Kingdom:	*Heunggongvirae*
Phylum:	*Peploviricota*
Class:	*Herviviricetes*
Order:	*Herpesvirales*
Family:	*Orthoherpesviridae*
Genus:	*Varicellovirus*
Species:	***Human alphaherpesvirus 3***

Herpesviridae: herpesviruses

- ✓ HHV-1 & HHV-2, genus *Simplexvirus*, causing cold sores;
- ✓ HHV-3, genus *Varicellovirus*, causing chickenpox;
- ✓ HHV-4, genus *Lymphocryptovirus*, causing infectious mononucleosis;
- ✓ HHV-5, genus *Cytomegalovirus*, causing CMV inclusion disease;
- ✓ HHV-6, genus *Roseolovirus*, causing roseola;
- ✓ HHV-7, genus *Roseolovirus*, infecting most infants, causing measleslike rashes;
- ✓ HHV-8, genus *Rhadinovirus*, causing Kaposi's sarcoma, primarily in AIDS patients.

Virus Family
Parvoviridae
Herpesviridae Papovaviridae Poxviridae
Hepadnaviridae
Picornaviridae Togaviridae
Rhabdoviridae
Reoviridae
Retroviridae



(a) A rhabdovirus

Structures

Nucleic acid

- ✓ DNA or RNA
- ✓ Single- or double-stranded
- ✓ Linear or circular
- ✓ Consists of one or more chromosomes

Structures

Capsid & Envelope

Capsid is the protein coat that envelops the viral genome

- capsid shape can be

  - ✓ rod-shaped
  - ✓ polyhedral
  - ✓ complex

- capsid is made up of protein subunits called **capsomeres**
- Capsomere can be made up of one or more proteins. The arrangement of capsomers is specific to each virus.

Structures

Capsid & Envelope

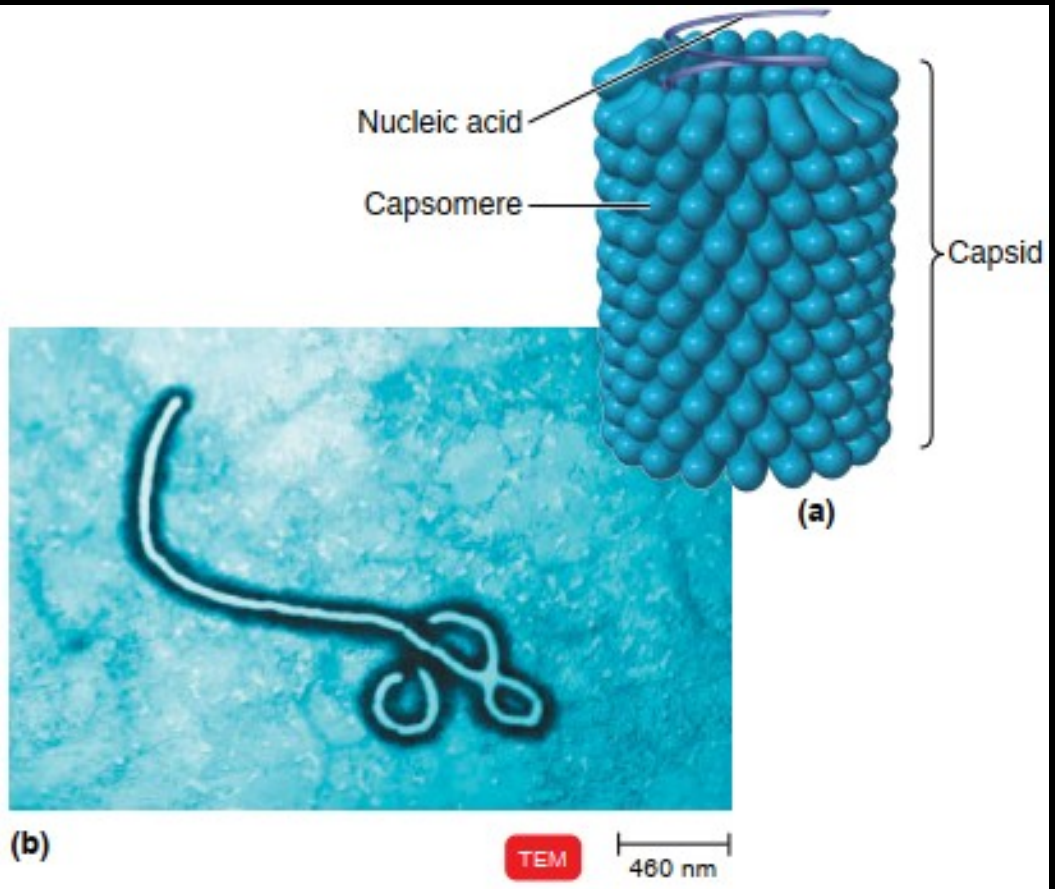


Figure 13.4 Morphology of a helical virus. **(a)** A diagram of a portion of a helical virus. A row of capsomeres has been removed to reveal the nucleic acid. **(b)** A micrograph of Ebola virus, a filovirus, showing a helical rodlike shape.

Q What is the chemical composition of a capsomere?

Structures
Capsid & Envelope

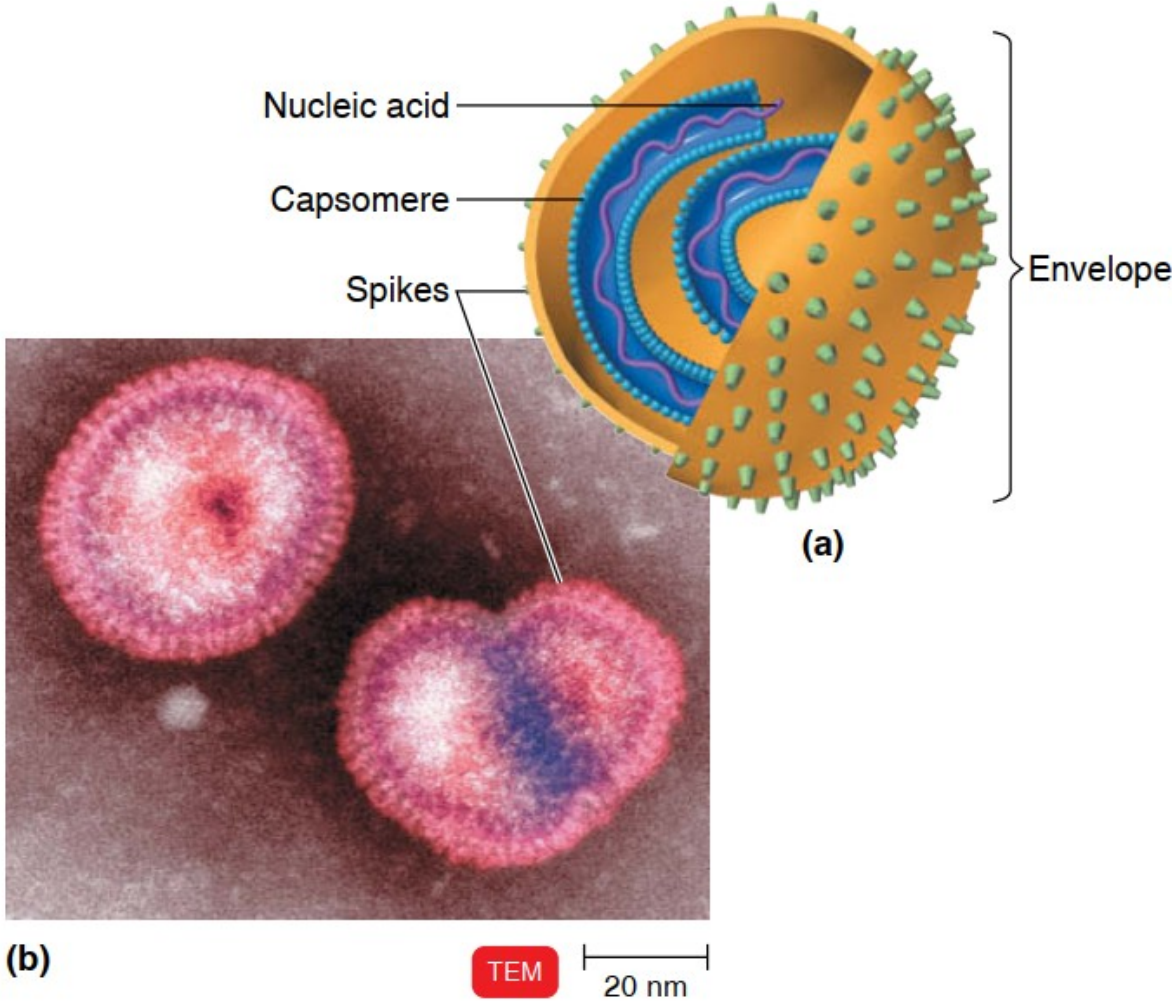
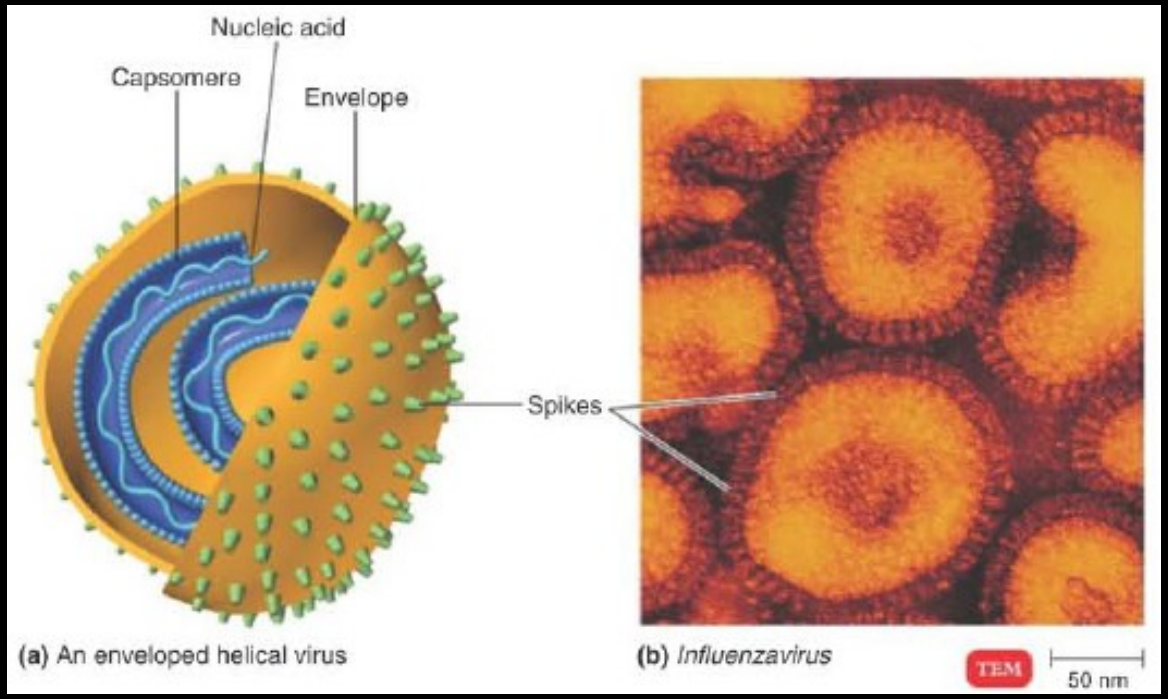


Figure 13.3 Morphology of an enveloped helical virus. **(a)** A diagram of an enveloped helical virus. **(b)** A micrograph of *Influenzavirus* A2. Notice the halo of spikes projecting from the outer surface of each envelope (see Chapter 24).

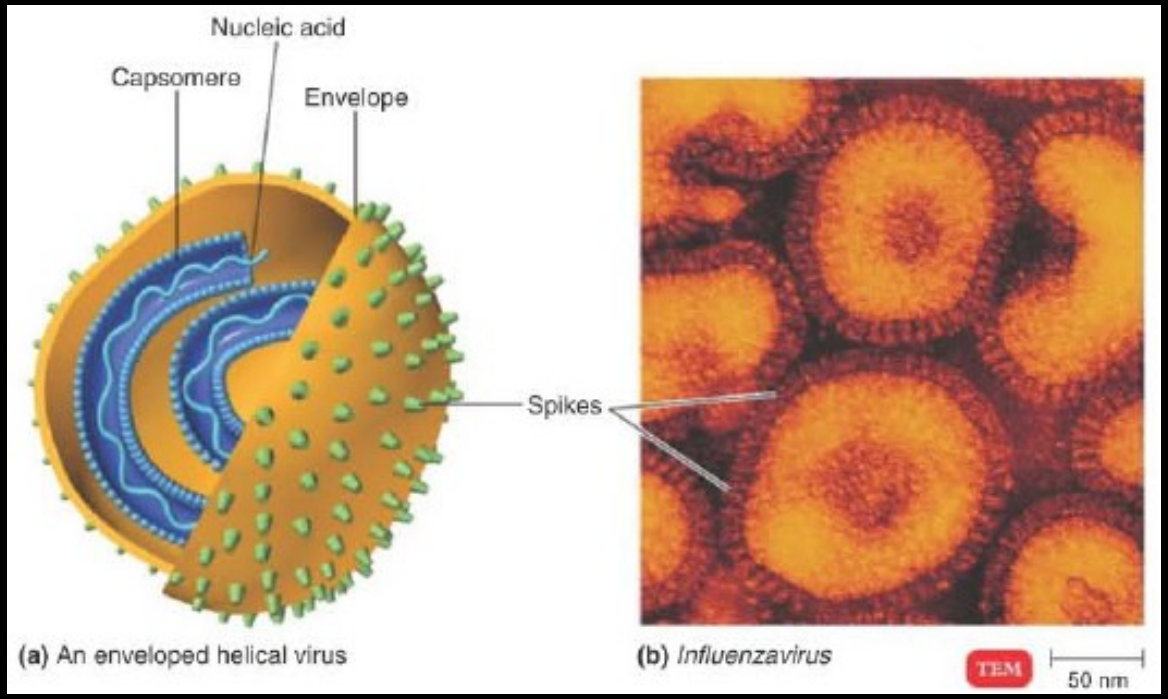
- **Envelope** covers capsid, commonly composed of **lipids**, **proteins** and **carbohydrates**.

Structures
Capsid & Envelope



- Envelope may be of **host cell origin** or **viral encoded**.

Structures
Capsid & Envelope



- Depending on virus species, envelope can be covered by protein-carbohydrate complexes called **spikes.**

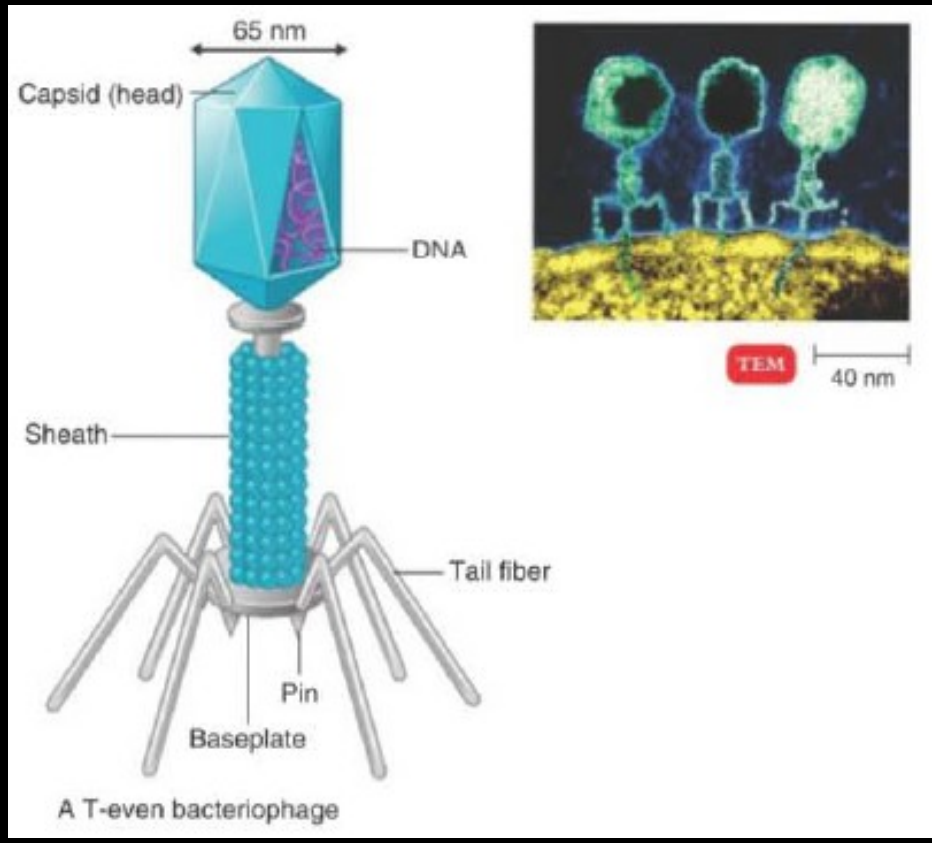
Structures
Capsid & Envelope

=> **Functions:**

- ✓ Help the virus contact and attack the cell
- ✓ Protect the viral nucleic acid inside the cell

Structures
Capsid & Envelope

- *Complex viruses*:
  - ✓ *Bacteriophages* (phages): attack the bacterial cells.
    - Type 1 (T1)
    - Type 2 (T2)
    - …
    - Type 7 (T7)



Multiplication

Viruses can just only multiply inside the host cell.

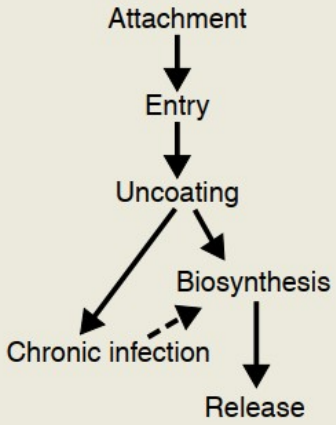
- ✓ Viruses do not have ribosomes → they cannot multiply outside the host cell.
- ✓ Viruses recognize the host cell using the **"lock & key" mechanism**, that is, the matching between viral surface proteins and specific receptor molecules on the host cells.

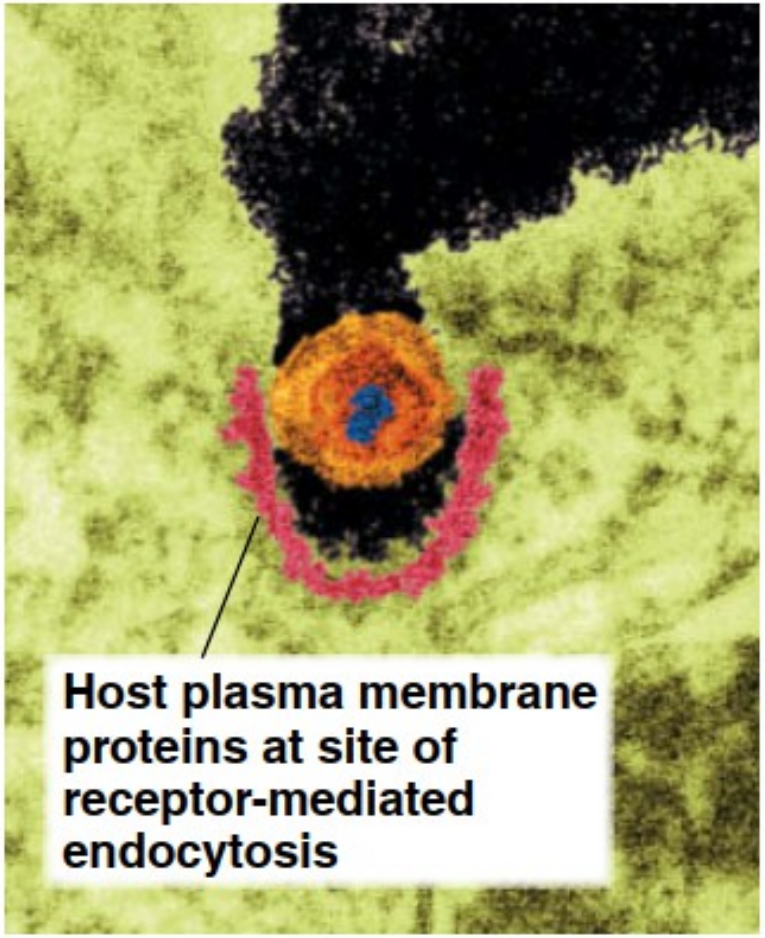
Multiplication

General characteristics of viral multiplication cycles

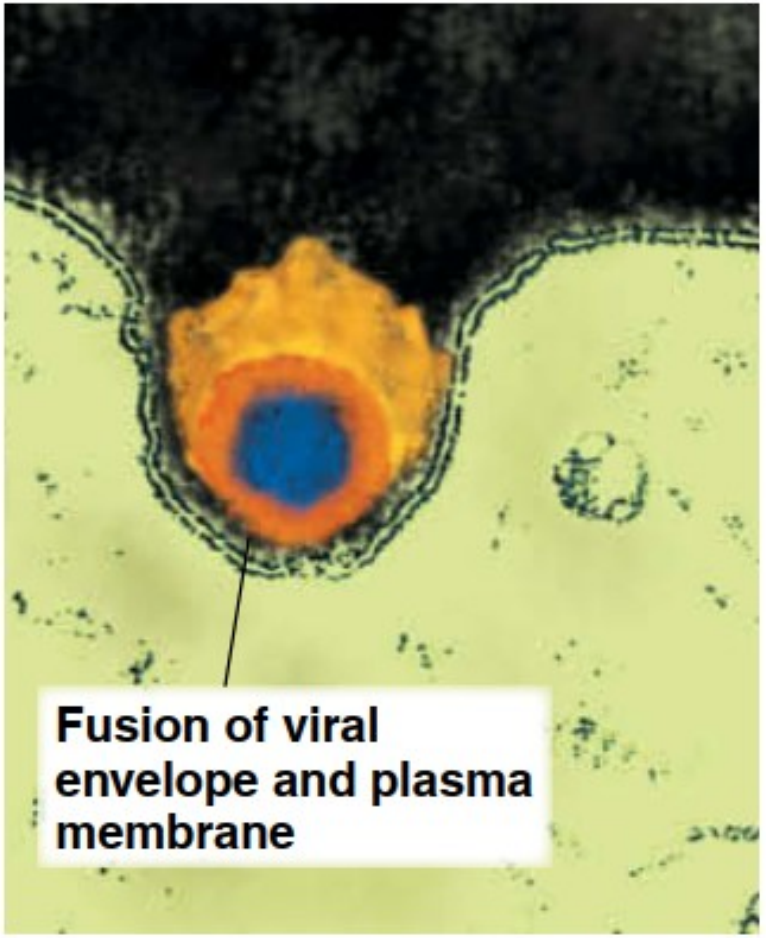
- The **mechanism of attack** depends on the virus type and the host cell type:
  - ✓ T-even phages use their elaborate tail apparatus to **puncture** bacterial cell walls.
  - ✓ Some viruses enter host cells by **endocytosis**.
  - ✓ Enveloped viruses enter host cells by fusion with the host plasma membrane.

TABLE 13.3 Bacteriophage and Animal Viral Multiplication Compared

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



(a) Entry of pig retrovirus by receptor-mediated endocytosis



(b) Entry of herpesvirus by fusion

Figure 13.14 The entry of viruses into host cells. After attachment, viruses enter host cells by **(a)** receptor-mediated endocytosis or **(b)** fusion of the viral envelope and cell membrane.

Multiplication

General characteristics of viral multiplication cycles

- When inside the host cell, viral proteins can operate the host, reprogram the cell to **replicate viral nucleic acids** and produce viral proteins:

  - ✓ Host cells provide nucleotides to create viral nucleic acid, as well as enzymes, ribosomes, tRNAs, amino acids, ATP and other necessary components to make viral proteins.

  - ✓ DNA viruses use host DNA polymerase to synthesize the viral genomes based on the viral DNA templates.

  - ✓ RNA viruses use viral polymerase to replicate their genomes based on their RNA templates.

General characteristics of viral multiplication cycles

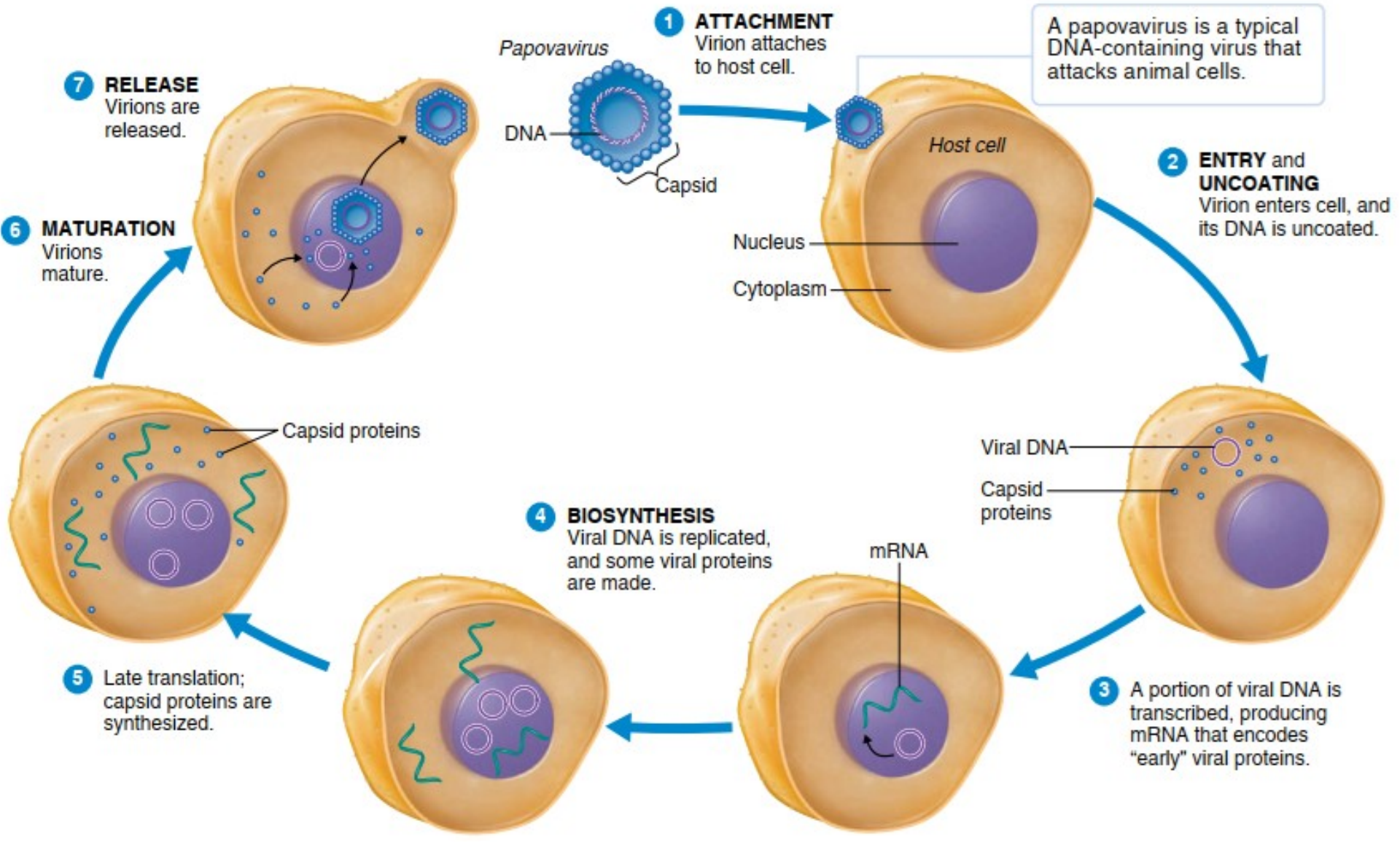
- After the nucleic acids and capsomeres are produced, they immediately assemble to form new viruses.

TABLE 13.4 The Biosynthesis of DNA and RNA Viruses Compared

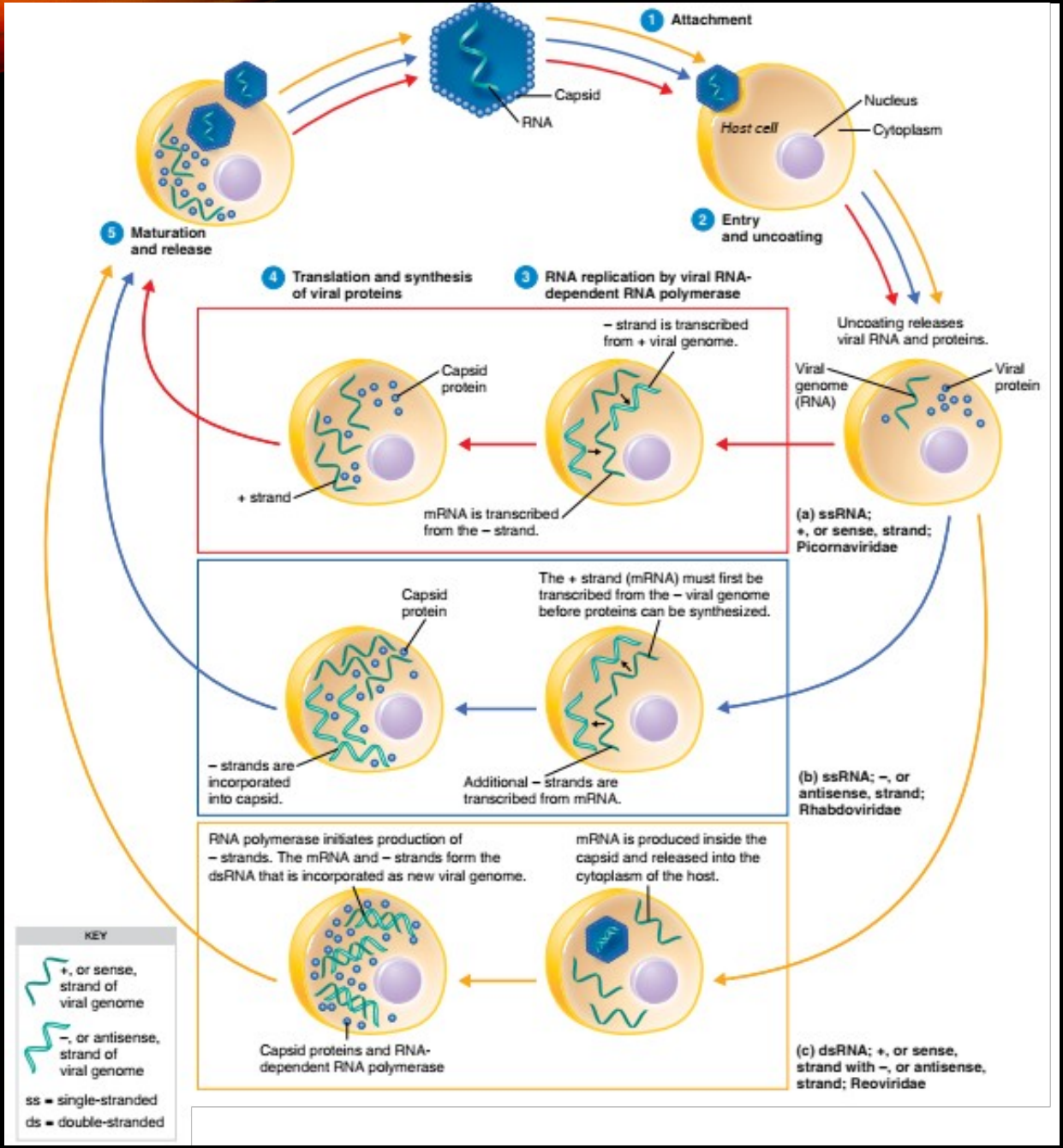
Viral Nucleic Acid	Virus Family	Special Features of Biosynthesis
DNA, single-stranded	Parvoviridae	Cellular enzyme transcribes viral DNA in nucleus.
DNA, double-stranded	Herpesviridae Papovaviridae Poxviridae	Cellular enzyme transcribes viral DNA in nucleus. Cellular enzyme transcribes viral DNA in nucleus. Viral enzyme transcribes viral DNA in cytoplasm.
DNA, reverse transcriptase	Hepadnaviridae	Cellular enzyme transcribes viral DNA in nucleus; reverse transcriptase copies mRNA to make viral DNA.
RNA, + strand	Picornaviridae Togaviridae	Viral RNA functions as a template for synthesis of RNA polymerase, which copies − strand RNA to make mRNA in cytoplasm.
RNA, − strand	Rhabdoviridae	Viral enzyme copies viral RNA to make mRNA in cytoplasm.
RNA, double-stranded	Reoviridae	Viral enzyme copies − strand RNA to make mRNA in virion, in cytoplasm.
RNA, reverse transcriptase	Retroviridae	Viral enzyme copies viral RNA to make DNA in cytoplasm; DNA moves to nucleus.

FOUNDATION FIGURE 13.15

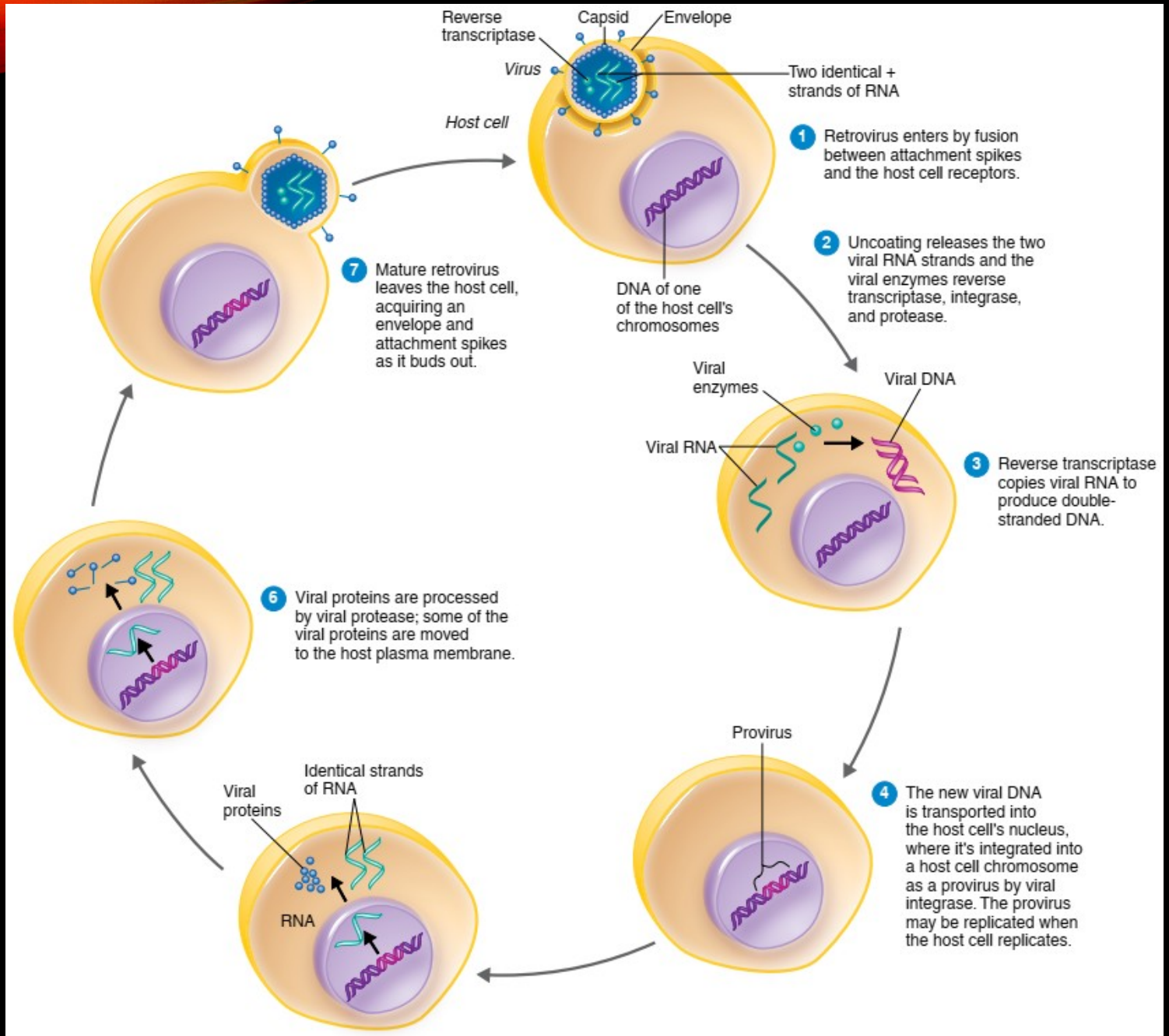
Replication of a DNA-Containing Animal Virus



Multiplication of animal RNA viruses



HIV (Human Immunodeficiency Virus)



Multiplication of bacteriophages

- ***The Lytic Cycle***

  - ✓ Phages enter the cell, multiply and destroy the host cell so that the new phage can escape.

  - ✓ Each new phage can attack another host cell, and the next few lytic cycles of new phases destroy entire host cell populations in just a few hours.

  - ✓ Phages that can only multiply through lytic cycles are known as the virulent phages.

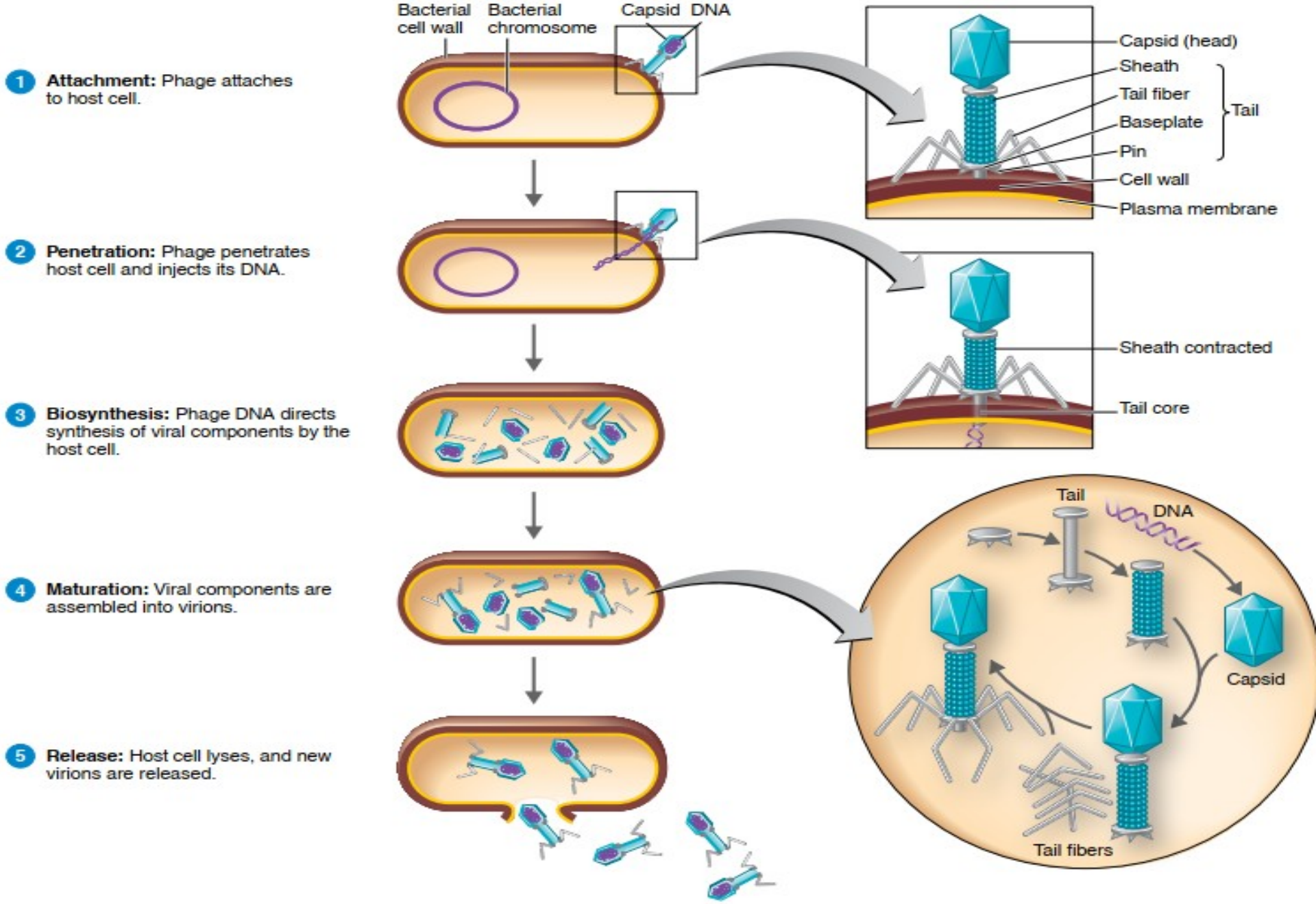


Figure 13.11 The lytic cycle of a T-even bacteriophage.

Q What is the result of the lytic cycle?

Multiplication

Multiplication of bateriophages

- ***The Lysogenic Cycle***

Phage lambda (λ)

- ✓ Temperate phage: able to multiply through both lytic and lyzogenic cycles inside a bacterial cell.
- ✓ The structure is similar to the T4 phage, but the tail has only one short tail fiber.

Multiplication

- ***The Lysogenic Cycle***

  - ✓The phage enters the cell, the phage's genome is replicated but the host cell is not destroyed.

Multiplication

- ***The Lysogenic Cycle***

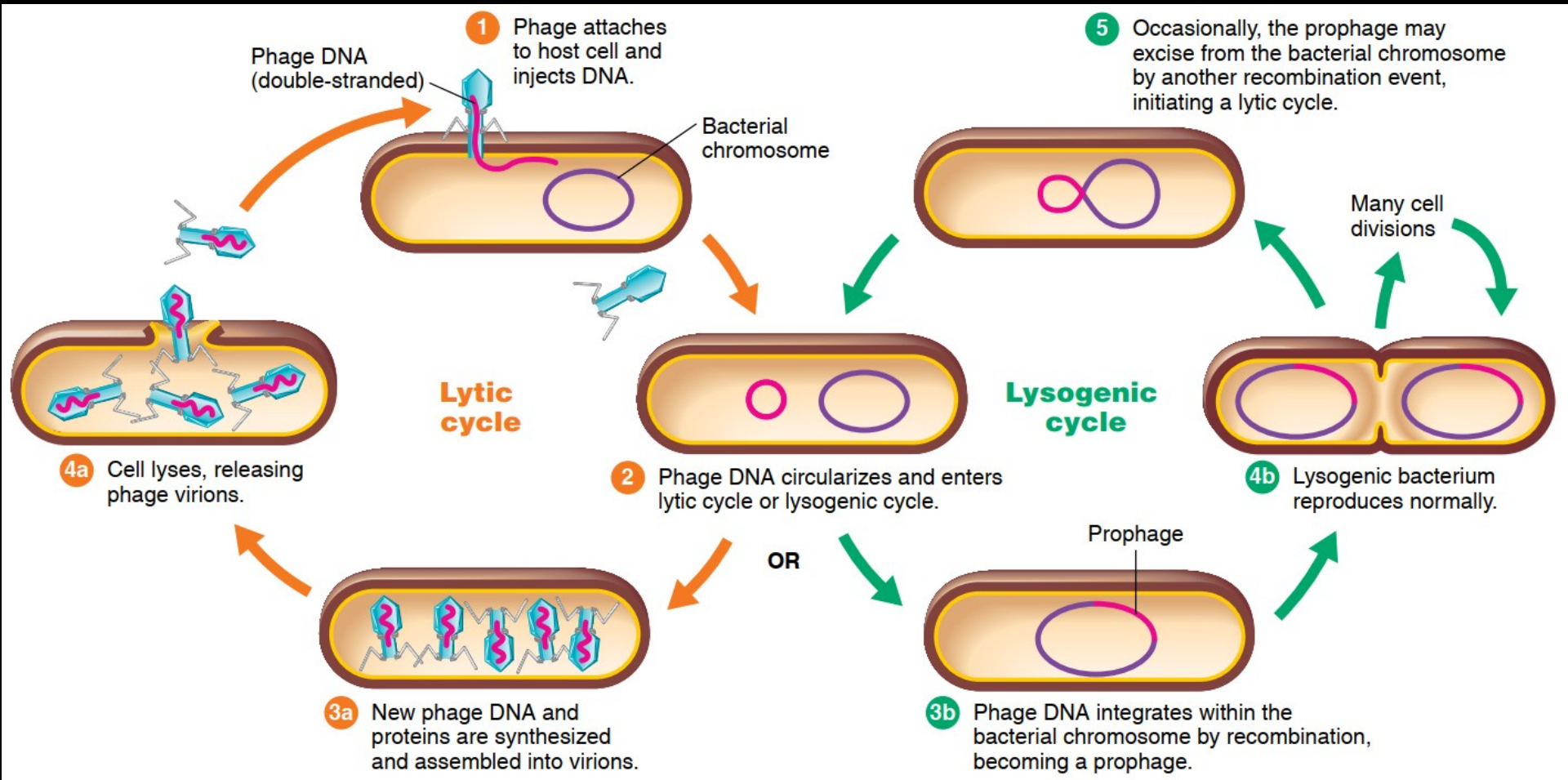


Figure 13.12 The lysogenic cycle of bacteriophage λ in *E. coli*.

VIROIDS

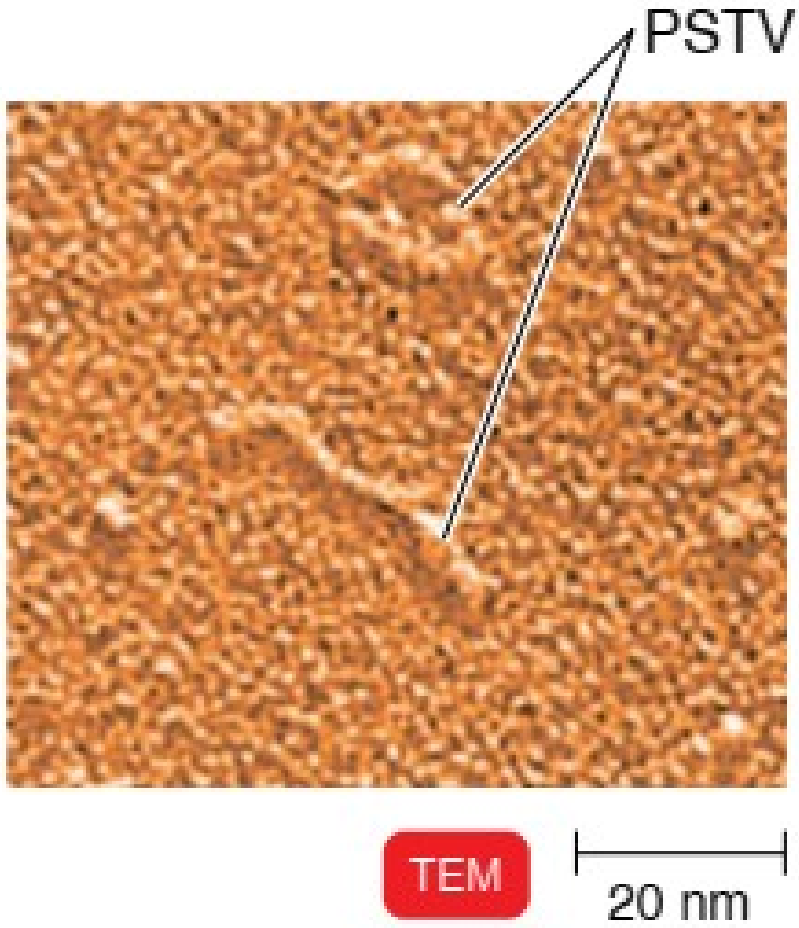


Figure 13.22 **Linear and circular potato spindle tuber viroid (PSTV).**

Q How do viroids differ from prions?

✓ Short pieces of naked RNA, only 300 to 400 nucleotides long, with no protein coat.

✓The nucleotides are often internally paired, so the molecule has a closed, folded, three-dimensional structure that presumably helps protect it from destruction by cellular enzymes.

✓ Some viroids, called virusoids, are enclosed in a protein coat. Virusoids cause disease only when the cell is infected by a virus.

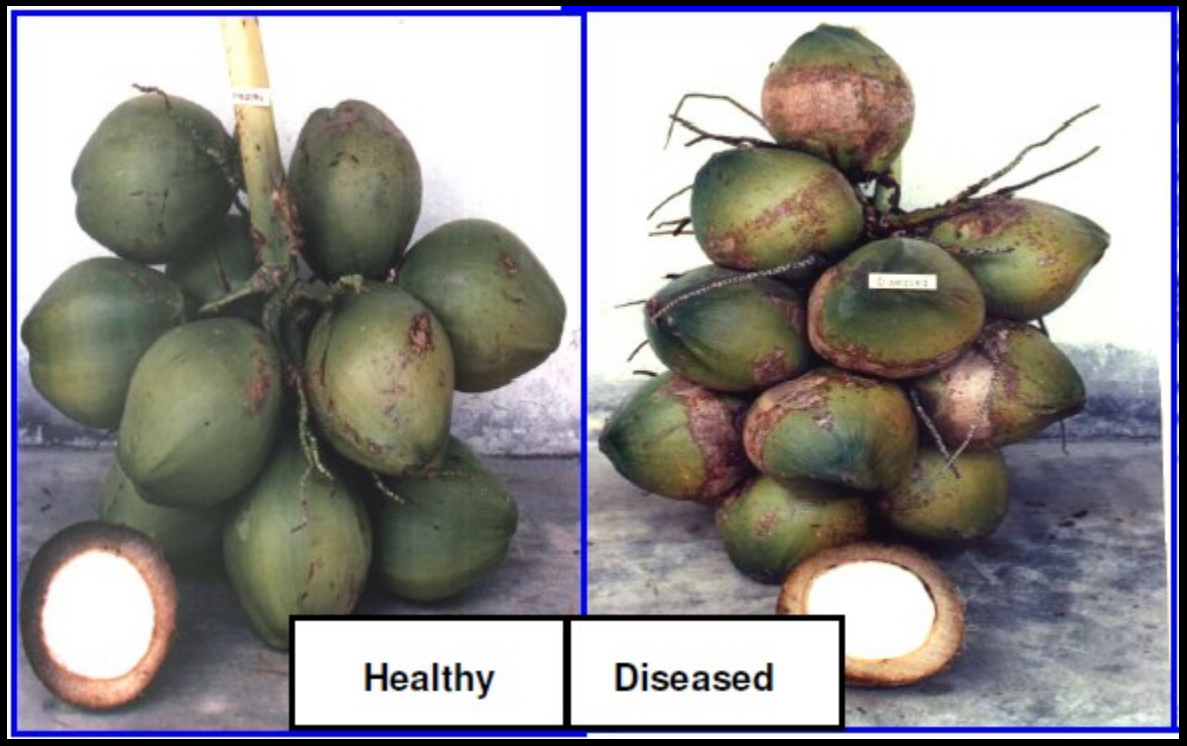
✓Viroids and virusoids are replicated continuously by host RNA polymerase in the cell nucleus or chloroplasts.

✓The viroid RNA is a ribozyme that cuts the continuous RNA into viroid segments. The RNA doesn't code for any proteins and may cause disease by gene silencing.

Cadang-cadang (Philippines)

Family: Pospiviroidae
Genus: Cocadviroid
Species: Coconut cadang-cadang viroid

Cadang-cadang

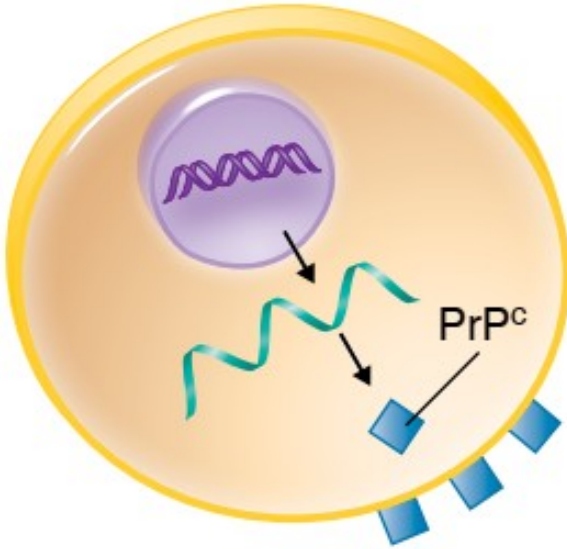


* **Family *Pospiviroidae***
    - o Genus *Pospiviroid*: potatoes
    - o Genus *Hostuviroid*: hublon
    - o Genus *Cocadviroid*: coconuts
    - o Genus *Apscaviroid*: apples
    - o Genus *Coleviroid*: perilla

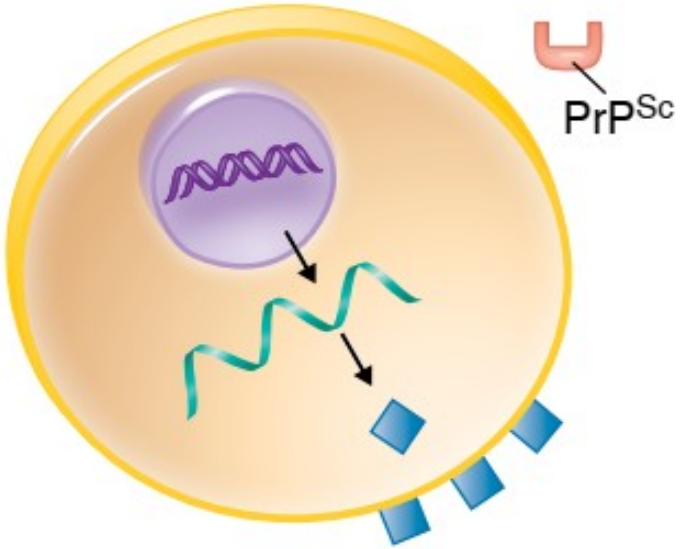
* **Family *Avsunviroidae***
    - o Genus *Avsunviroid*: avocado
    - o Genus *Pelamoviroid*: peaches

PRIONS

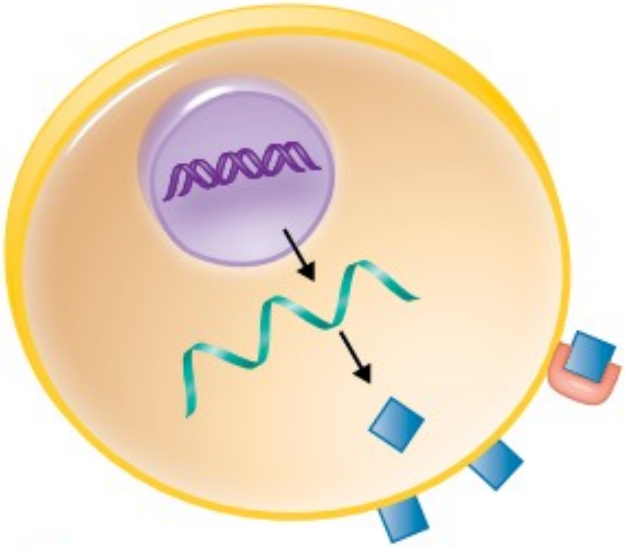
- ✓ Are proteins
- ✓ Cause some degenerative brain diseases
- ✓ Transmitted through contaminated medical equipment or ingestion of infected tissue
- ✓ Attacks very slowly, with an incubation period of at least 10 years
- ✓ Not destroyed or inactivated at normal cooking temperatures.



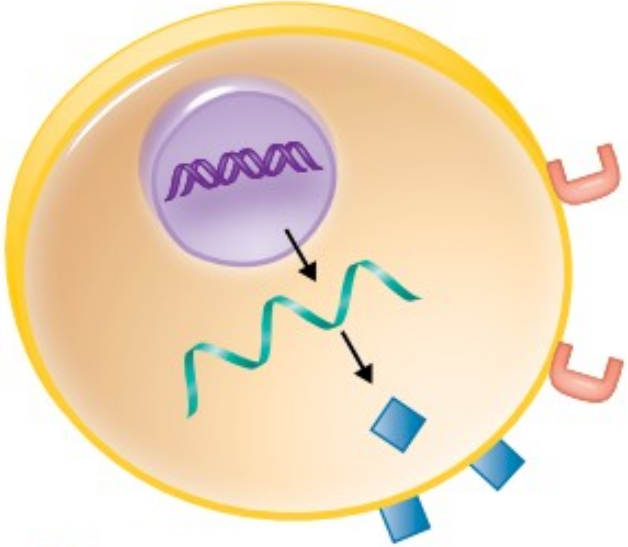
1 PrP^{C} produced by cells is secreted to the cell surface.



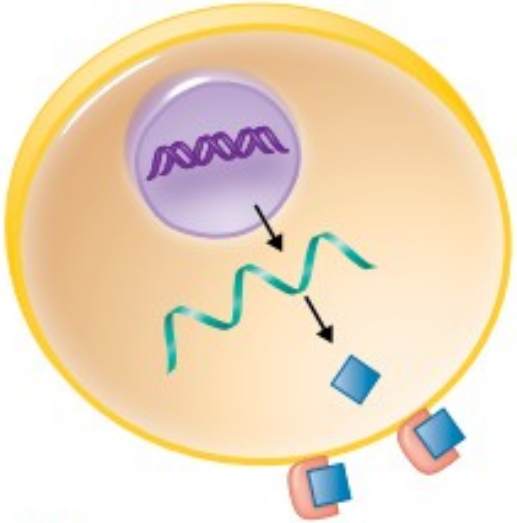
2 PrP^{Sc} may be acquired or produced by an altered PrP^{C} gene.



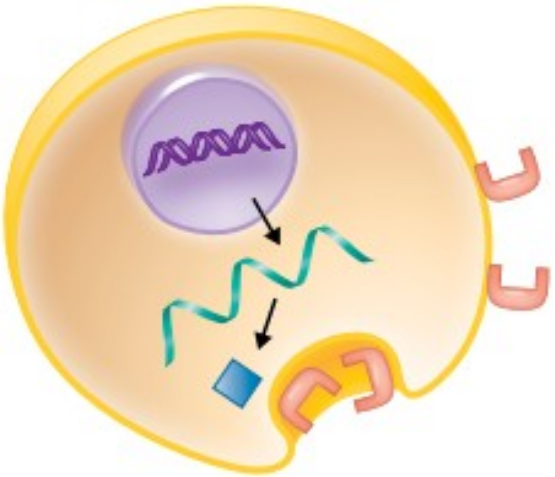
3 PrP^{Sc} reacts with PrP^{C} on the cell surface.



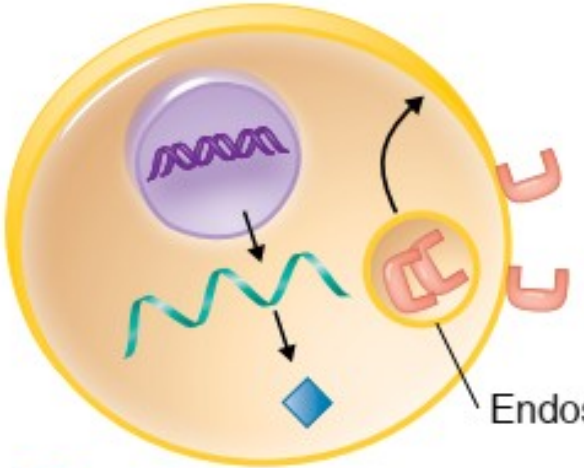
4 PrP^{Sc} converts the PrP^{C} to PrP^{Sc}.



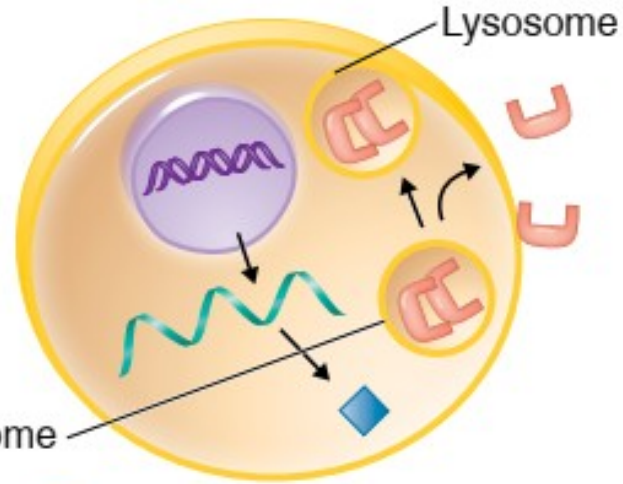
5 The new PrP^{Sc} converts more PrP^{C}.



6 The new PrP^{Sc} is taken in, possibly by receptor-mediated endocytosis.



7 PrP^{Sc} accumulates in endosomes. Some may be transferred back to the cell surface.



8 PrP^{Sc} continues to accumulate as the endosome contents are returned to the cell surface or are transferred to lysosomes. The result is cell death.