Chapter 19

Viruses

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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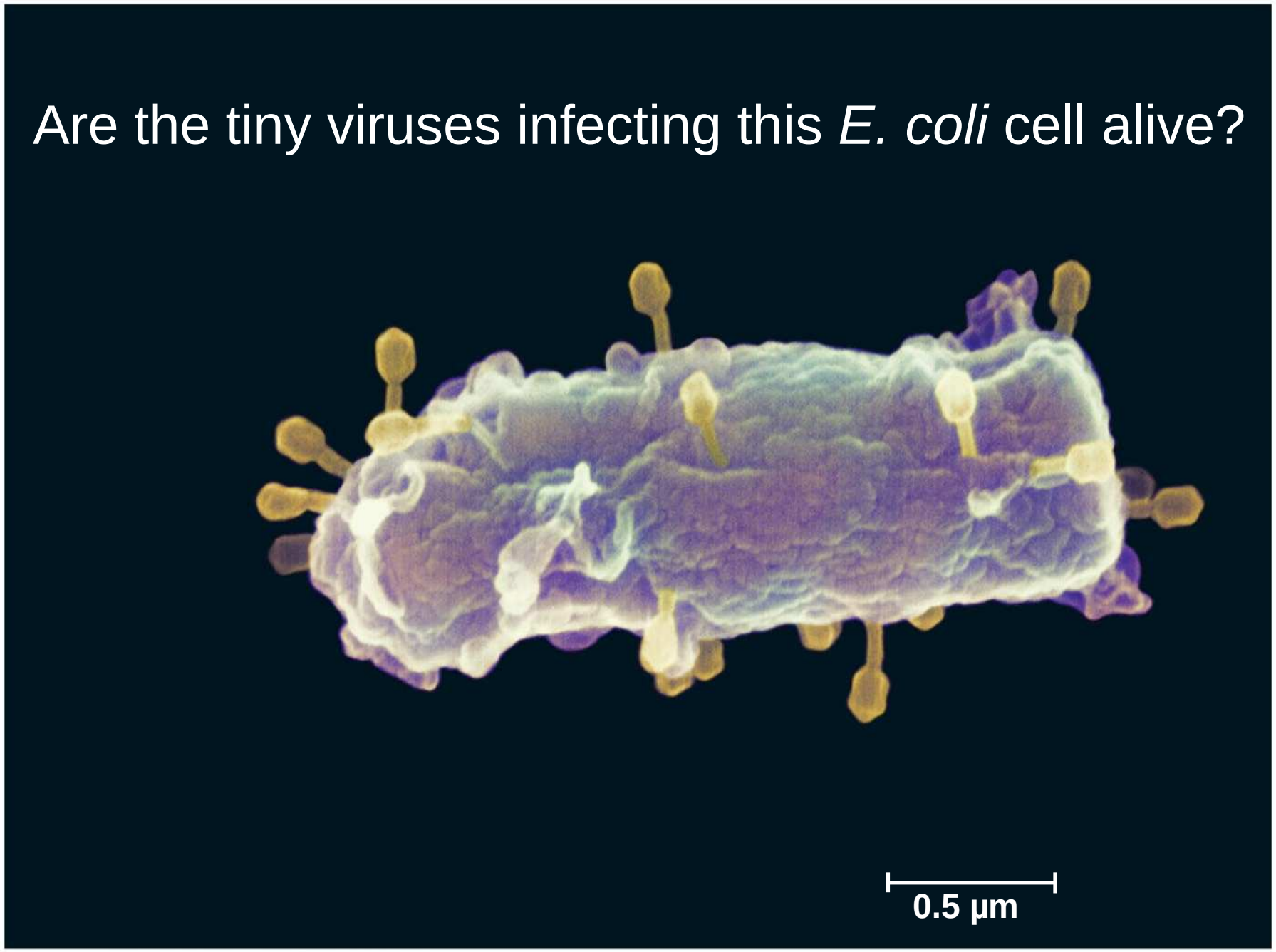
Overview: A Borrowed Life

- Viruses called bacteriophages can infect and set in motion a genetic takeover of bacteria, such as *Escherichia coli*
- Viruses lead "a kind of borrowed life" between life-forms and chemicals
- The origins of molecular biology lie in early studies of viruses that infect bacteria

Fig. 19-1



Concept 19.1: A virus consists of a nucleic acid surrounded by a protein coat

- Viruses were detected indirectly long before they were actually seen

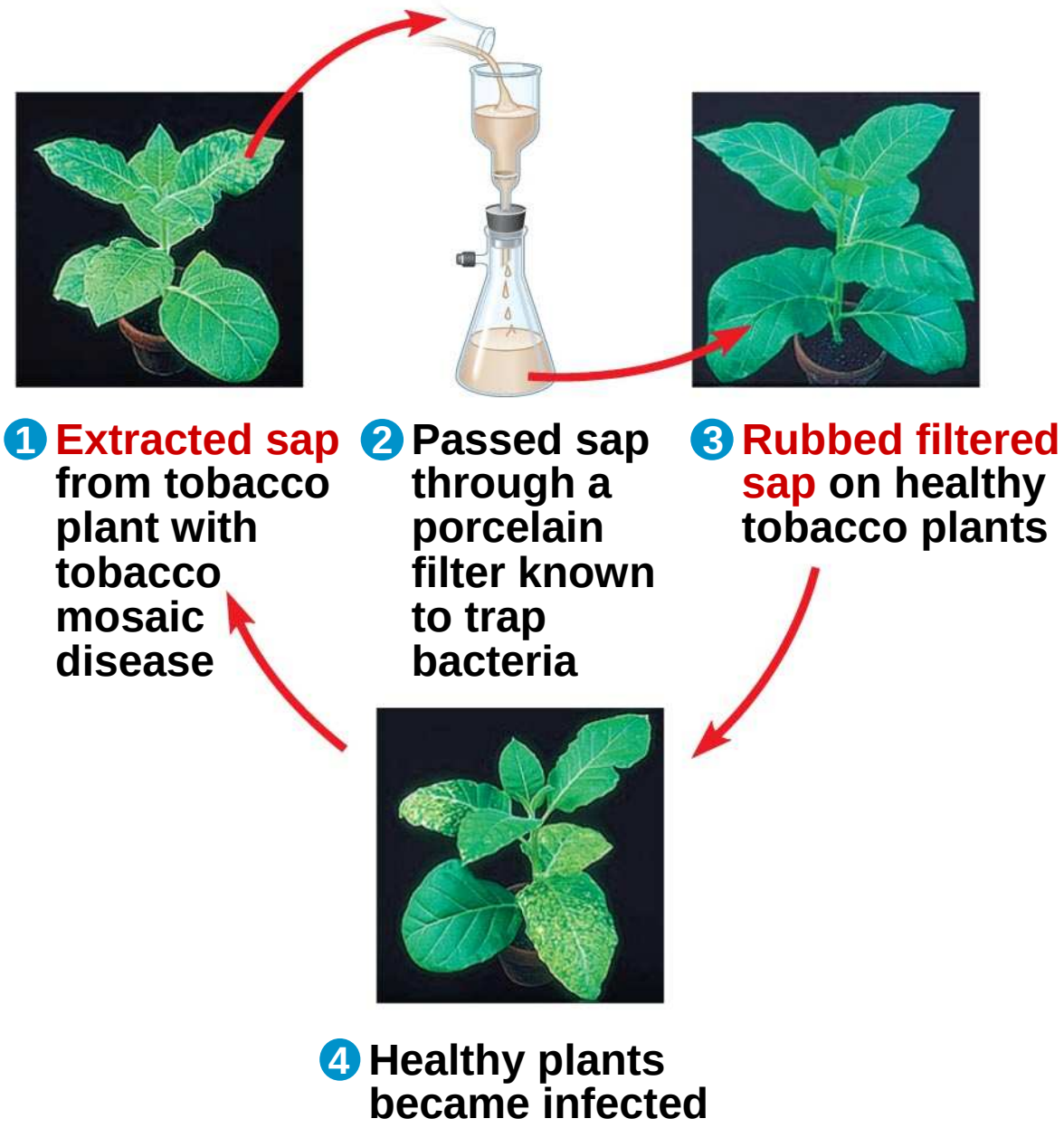
The Discovery of Viruses: *Scientific Inquiry*

- Tobacco mosaic disease stunts growth of tobacco plants and gives their leaves a mosaic (馬賽克的;鑲嵌的) coloration
- In the late 1800s, researchers hypothesized that a particle smaller than bacteria caused the disease
- In 1935, Wendell Stanley confirmed this hypothesis by crystallizing the infectious particle, now known as tobacco mosaic virus (TMV)

Fig. 19-2

RESULTS

What causes tobacco mosaic disease?



Structure of Viruses

- **Viruses are not cells**
- Viruses are very small infectious particles consisting of (1) **nucleic acid** enclosed in a (2) **protein coat** and, in some cases, a **membranous envelope**

Viral Genomes

- Viral genomes may consist of either
  - Double- or single-stranded DNA, or
    - dsDNA or ssDNA
  - Double- or single-stranded RNA
    - dsRNA or ssRNA
- Depending on its type of nucleic acid, a virus is called a DNA virus or an RNA virus

Capsids and Envelopes

- A **capsid** is the protein shell that encloses the viral genome
- Capsids are built from protein subunits called *capsomeres*
- A capsid can have various structures

Fig. 19-3

Viral structure (overview,next page…)

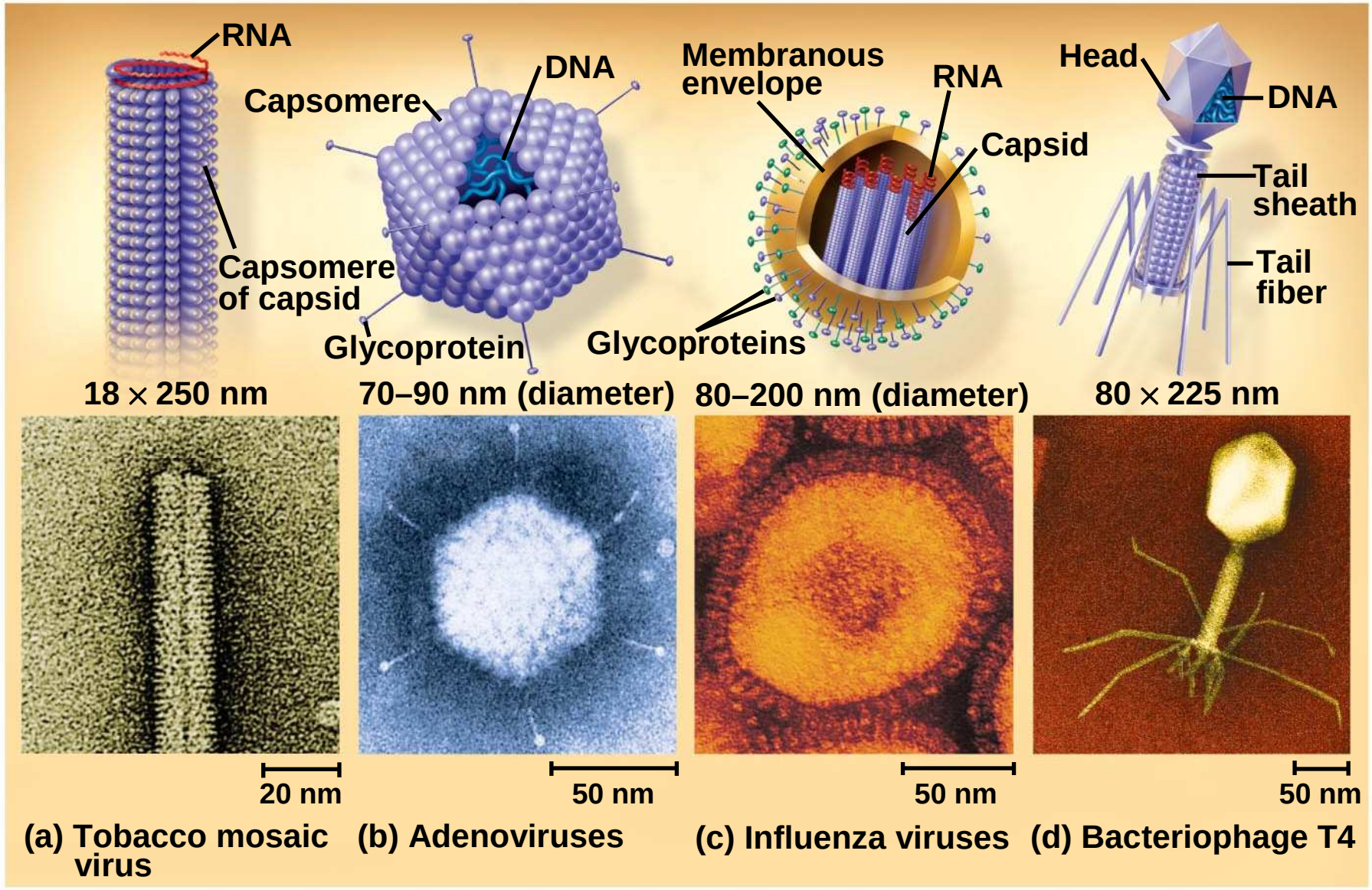
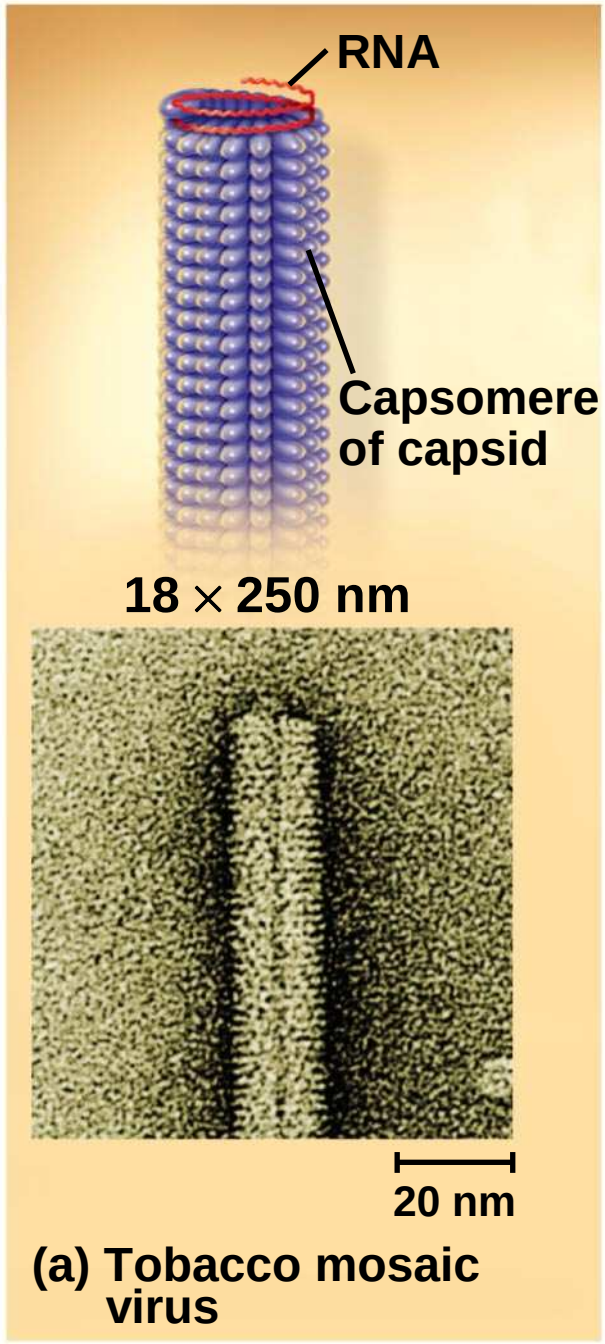


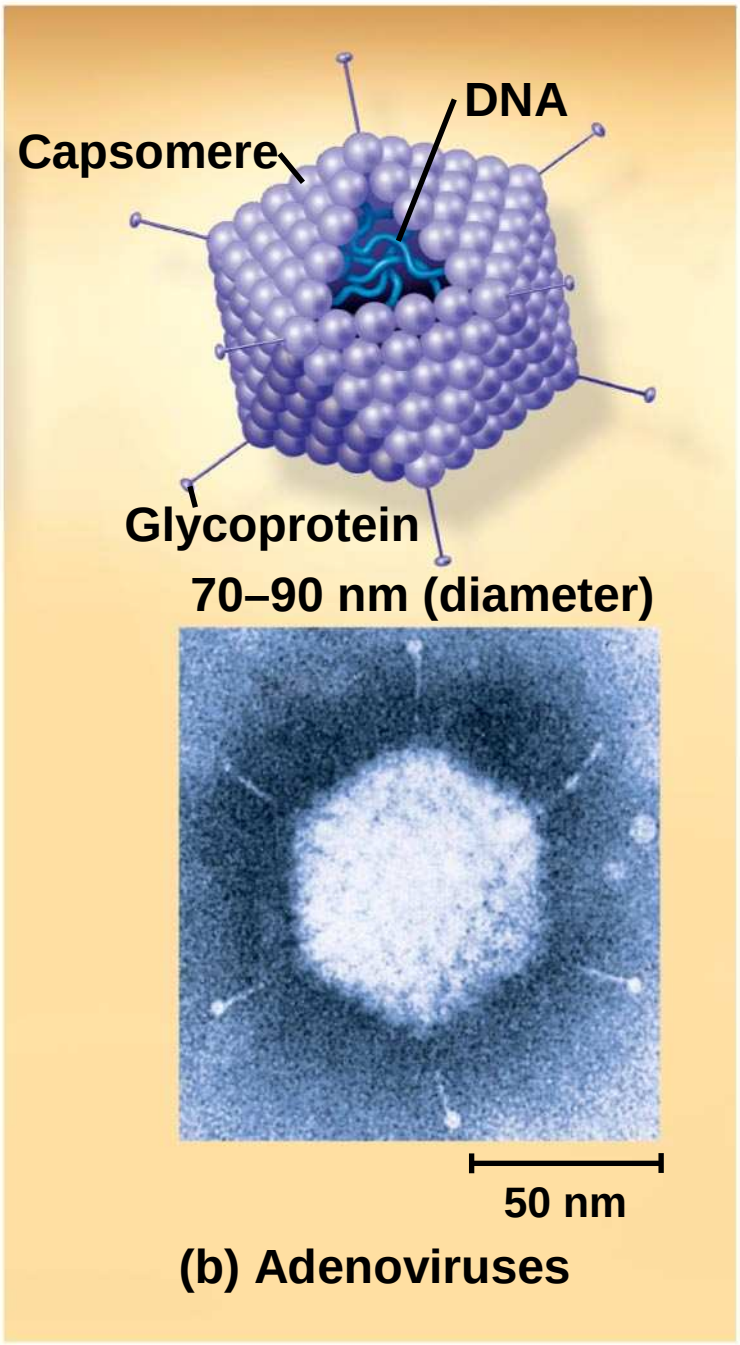
Fig. 19-3a

Viral structure

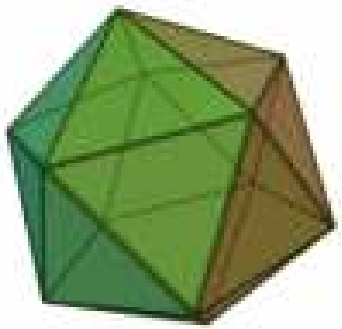


Tobacco mosaic virus has a helical capsid (殼體) with the overall shape of a rigid rod

Fig. 19-3b

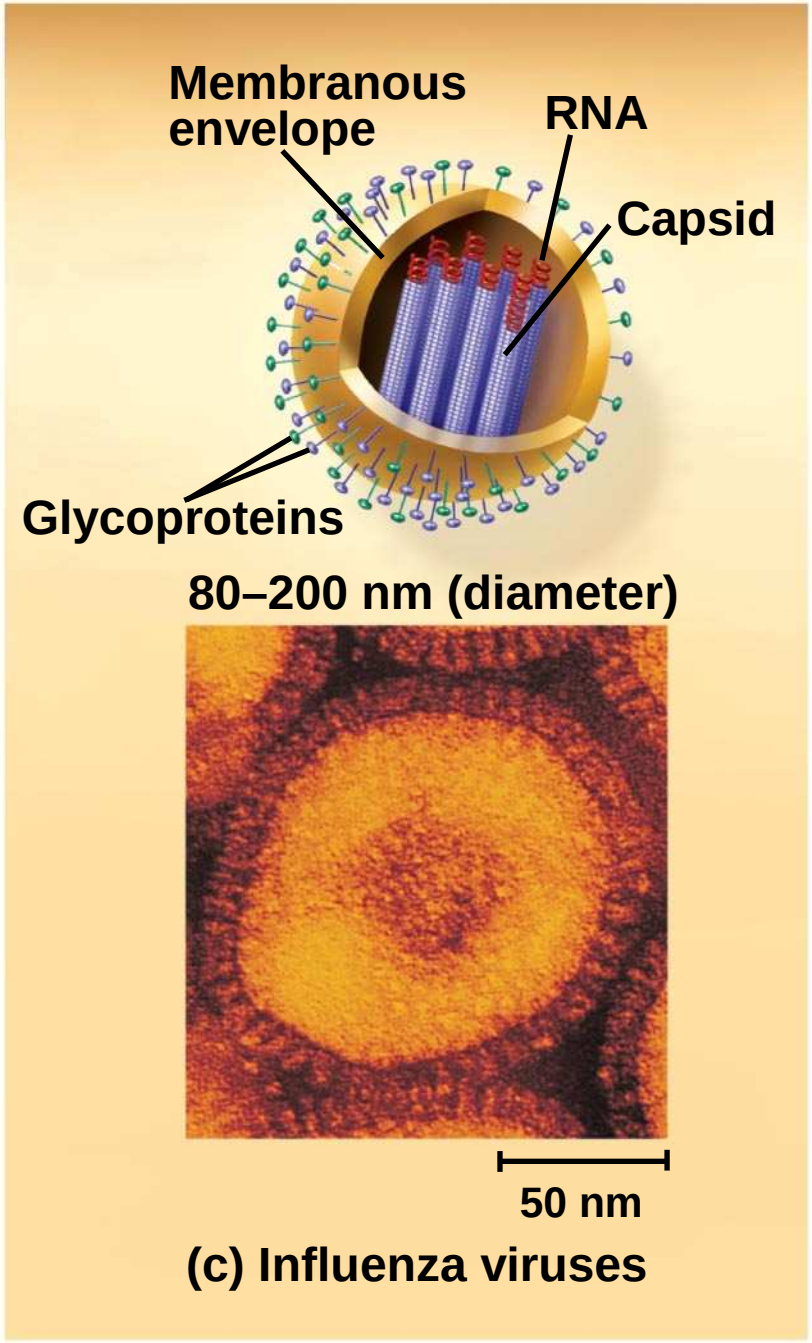


Viral structure



Adenoviruses has an icosahedral (二十面體) capsid with a glycoprotein spike at each vertex

Fig. 19-3c



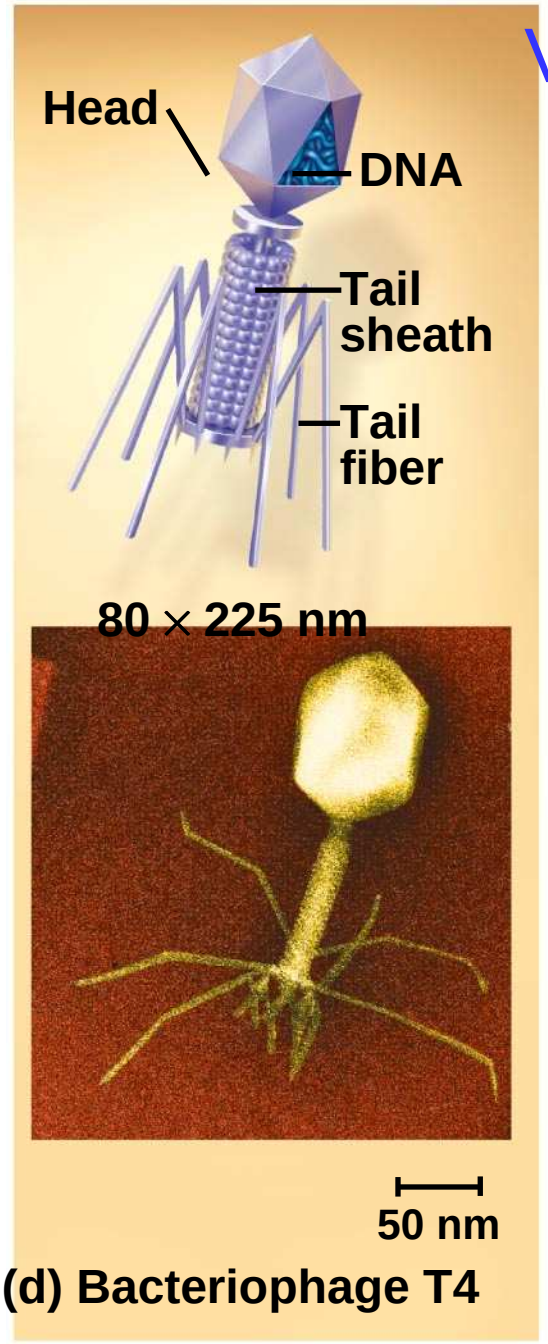
Viral structure

Influenza viruses have an outer envelope studded with glycoprotein spikes. The genome consists of eight different RNA molecules, each wrapped in a helical capsid.

Viral envelopes

- Some viruses have membranous envelopes that help them infect hosts
- These **viral envelopes** surround the capsids of influenza viruses and many other viruses found in animals
- Viral envelopes, which are derived from the host cell's membrane, contain a combination of viral and host cell molecules

Fig. 19-3d



Viral structure

Bacteriophage T4, like other “T-even” phages, has a complex capsid consisting of an icosahedral head an a tail apparatus

Bacteriophages

- **Bacteriophages**, also called **phages**, are viruses that infect bacteria
  - They have the most complex capsids found among viruses
  - Phages have an elongated capsid head that encloses their DNA
  - A protein tail piece attaches the phage to the host and injects the phage DNA inside

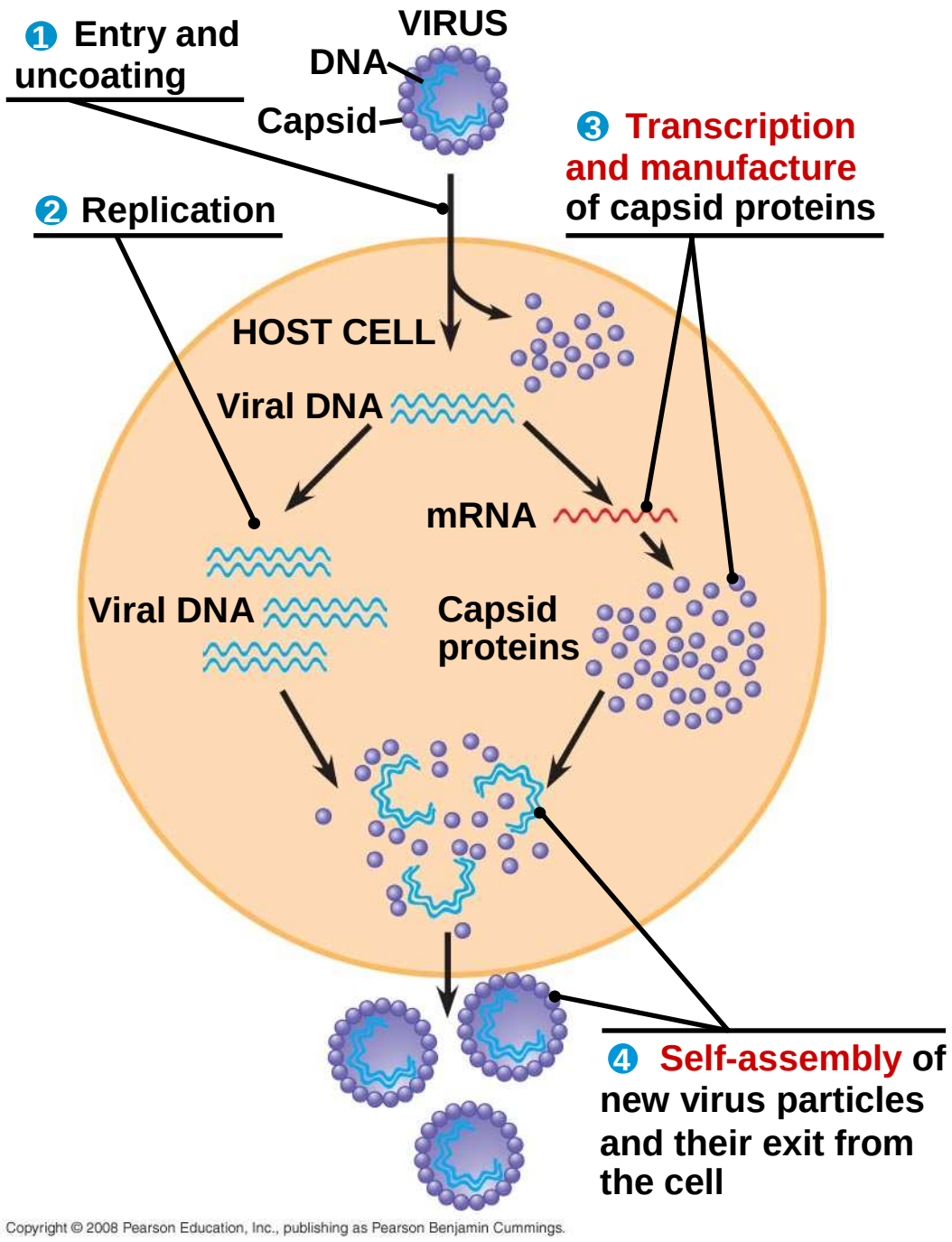
Concept 19.2: Viruses reproduce only in host cells

- Viruses are **obligate intracellular parasites**, which means they can reproduce only within a host cell
- Each virus has a **host range**, a limited number of host cells that it can infect

General Features of Viral Reproductive Cycles

- Once a viral genome has entered a cell, the cell begins to manufacture viral proteins
- The virus makes use of host enzymes, ribosomes, tRNAs, amino acids, ATP, and other molecules
- Viral nucleic acid molecules and capsomeres spontaneously self-assemble into new viruses

Fig. 19-4



Reproductive Cycles of Phages

- Phages are the best understood of all viruses
- Phages have two reproductive mechanisms: the lytic cycle and the lysogenic cycle

The Lytic Cycle

- The **lytic cycle** is a phage reproductive cycle that culminates in the death of the host cell
- The lytic cycle produces new phages and digests the host's cell wall, releasing the progeny viruses
- A phage that reproduces only by the lytic cycle is called a **virulent phage** [**vir**-yuh-luh nt]
- Bacteria have defenses against phages, including **restriction enzymes** that recognize and cut up certain phage DNA

PLAY Animation: Phage T4 Lytic Cycle

Fig. 19-5-1

The lytic cycle of phage T4, a virulent phage

1 **Attachment**

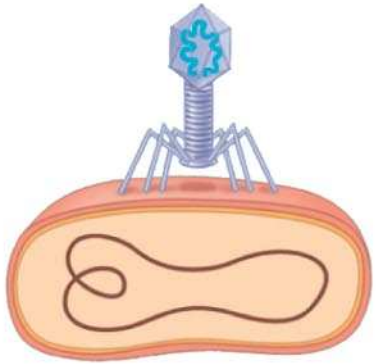


Fig. 19-5-2

The lytic cycle of phage T4, a virulent phage

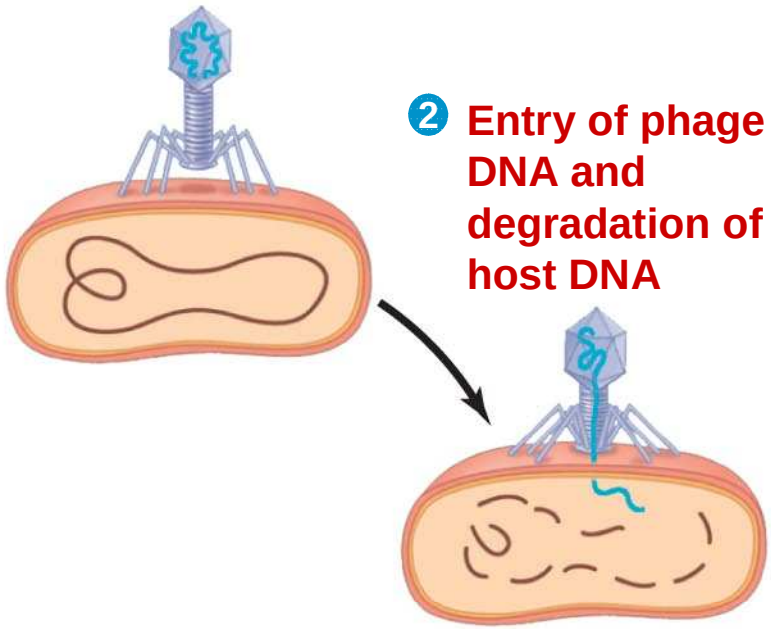


Fig. 19-5-3

The lytic cycle of phage T4, a virulent phage

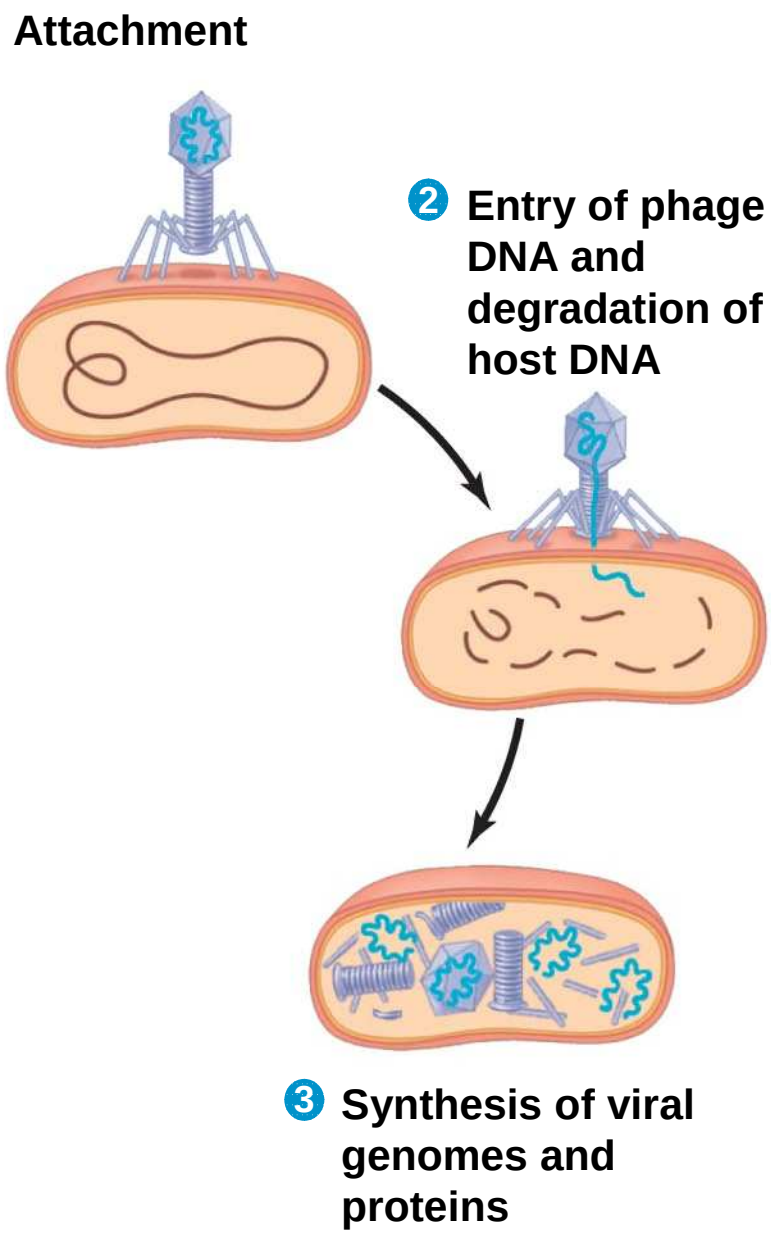


Fig. 19-5-4

The lytic cycle of phage T4, a virulent phage

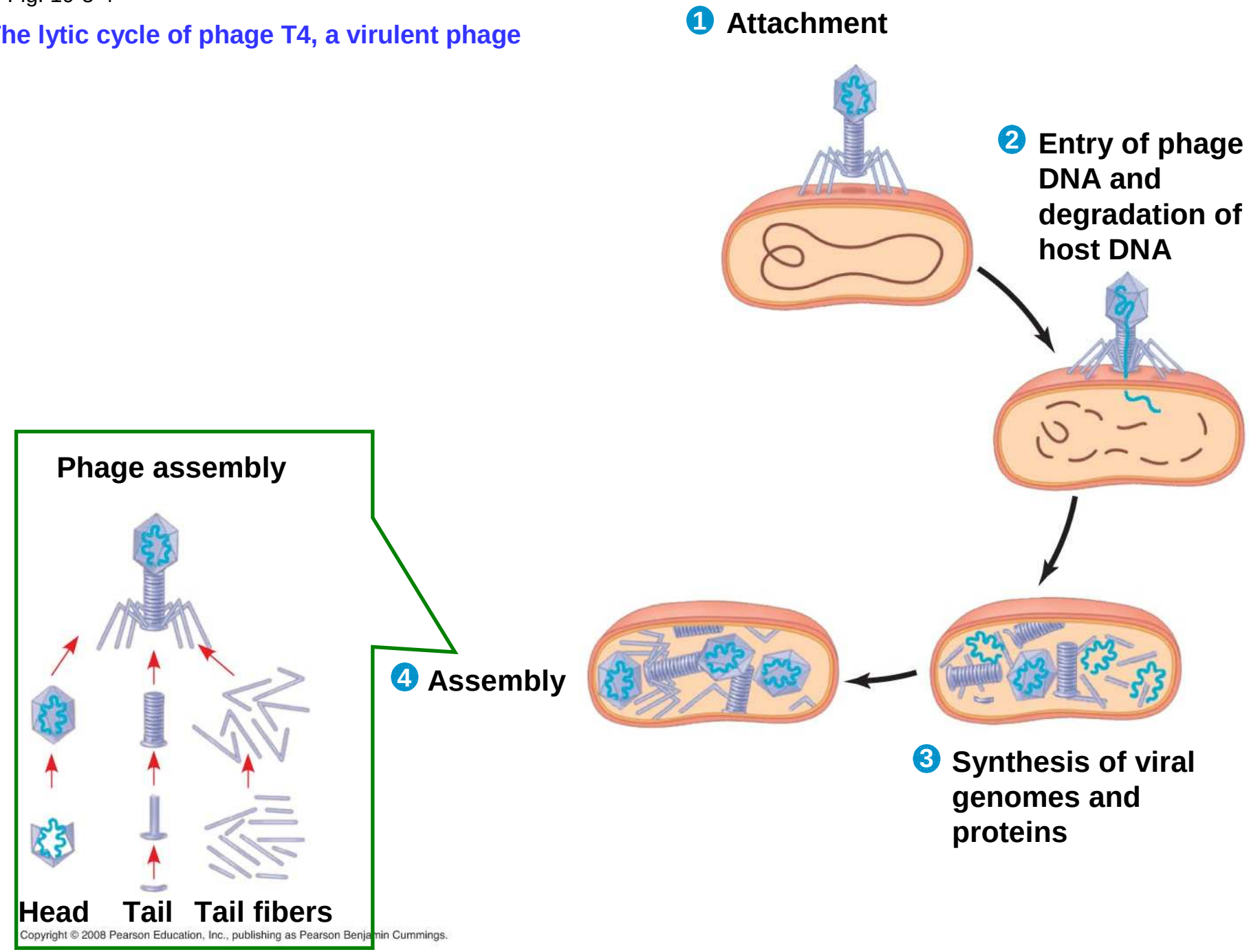
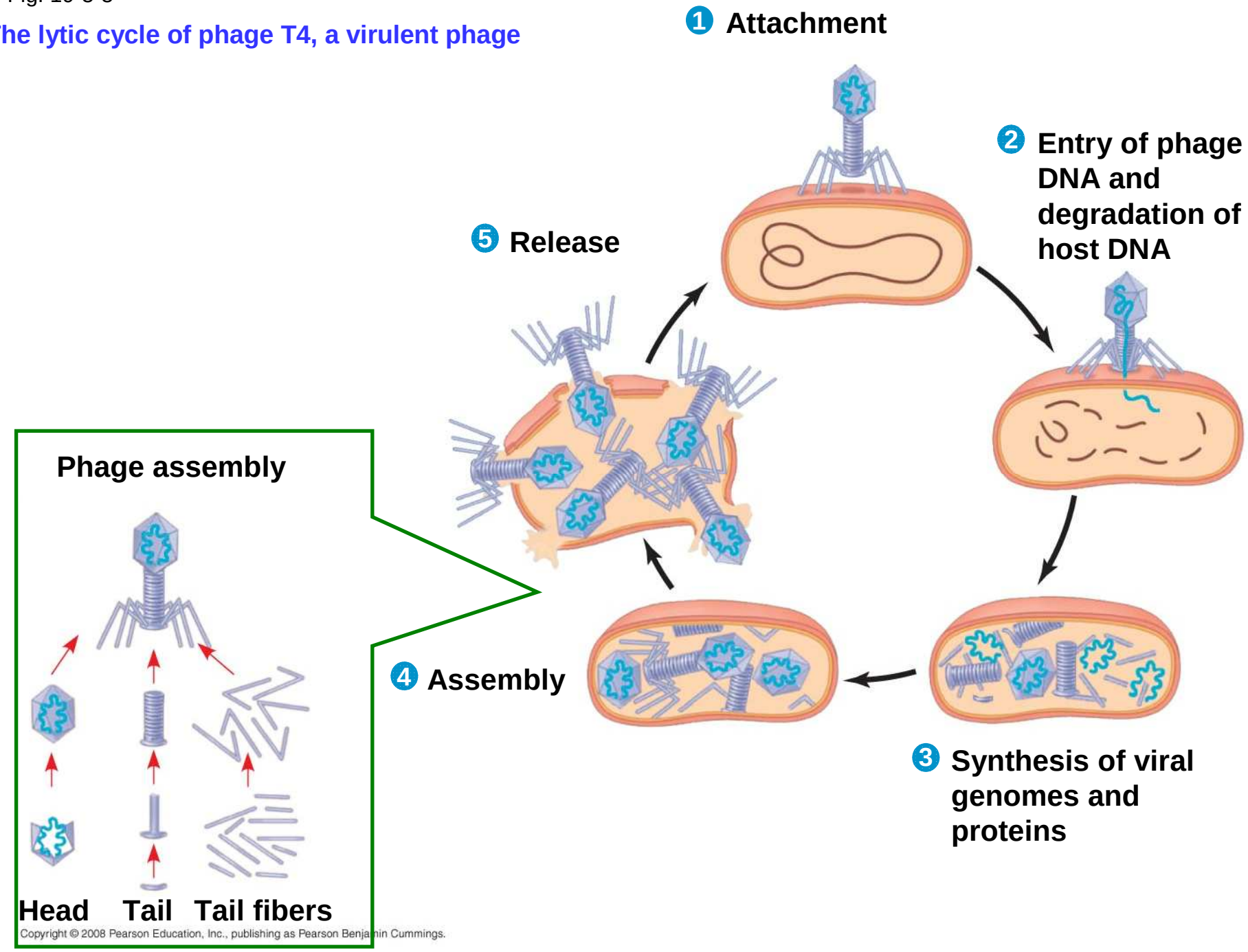


Fig. 19-5-5

The lytic cycle of phage T4, a virulent phage



The Lysogenic Cycle

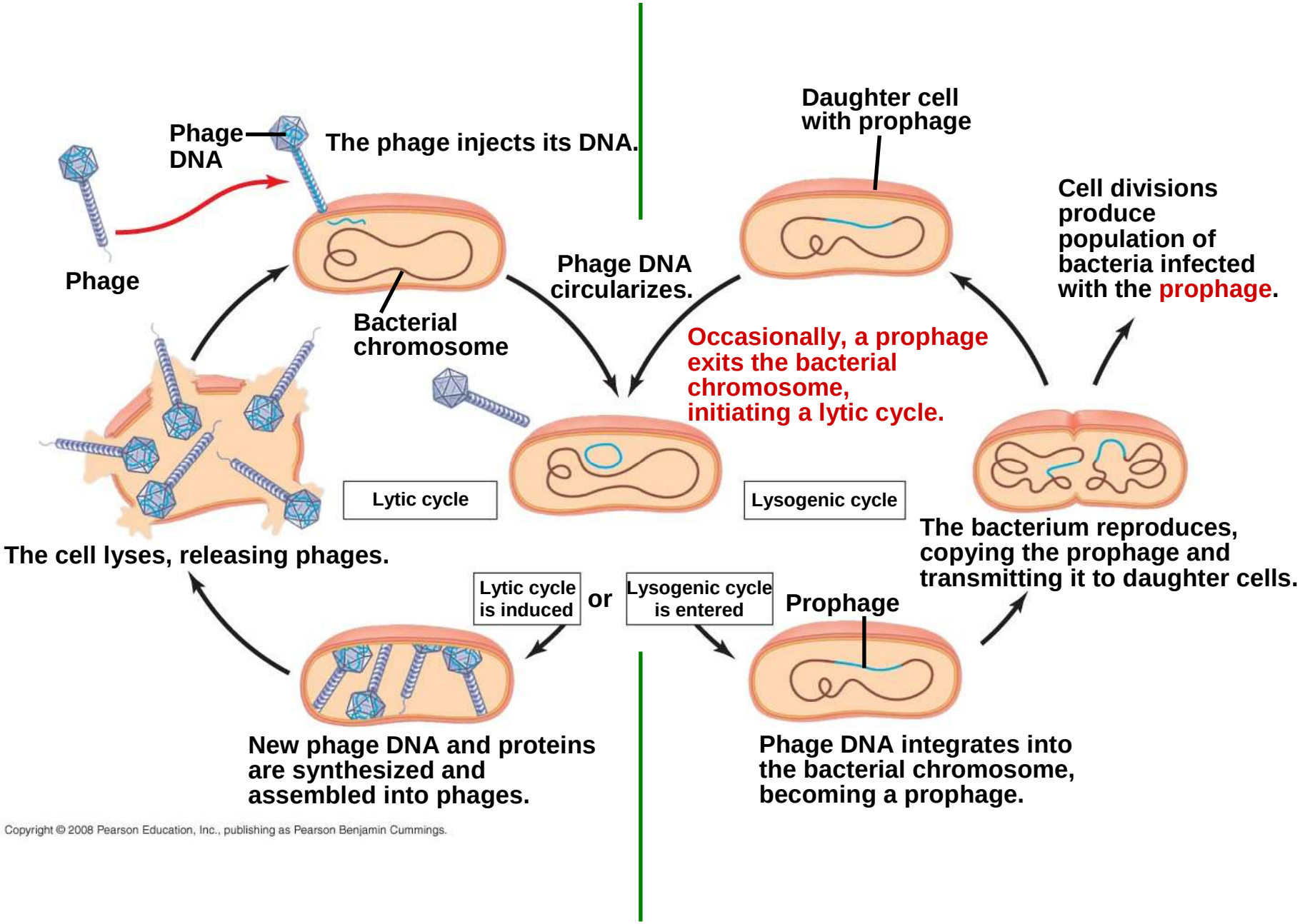
- The **lysogenic cycle** replicates the phage genome without destroying the host
- The viral DNA molecule is incorporated into the host cell's chromosome
- This integrated viral DNA is known as a **prophage**
- Every time the host divides, it copies the phage DNA and passes the copies to daughter cells

PLAY **Animation: Phage Lambda Lysogenic and Lytic Cycles**

- An environmental signal can trigger the virus genome to exit the bacterial chromosome and switch to the lytic mode
- Phages that use both the lytic and lysogenic cycles are called **temperate phages**（溫和、有節制的嗜菌體）

Fig. 19-6

The lytic and lysogenic cycles of phage λ, a temperate phage



Reproductive Cycles of Animal Viruses

- There are two key variables used to classify viruses that infect animals:
  - DNA or RNA?
  - Single-stranded or double-stranded?
  - (and, Reverse transcription or not?)

Table 19-1

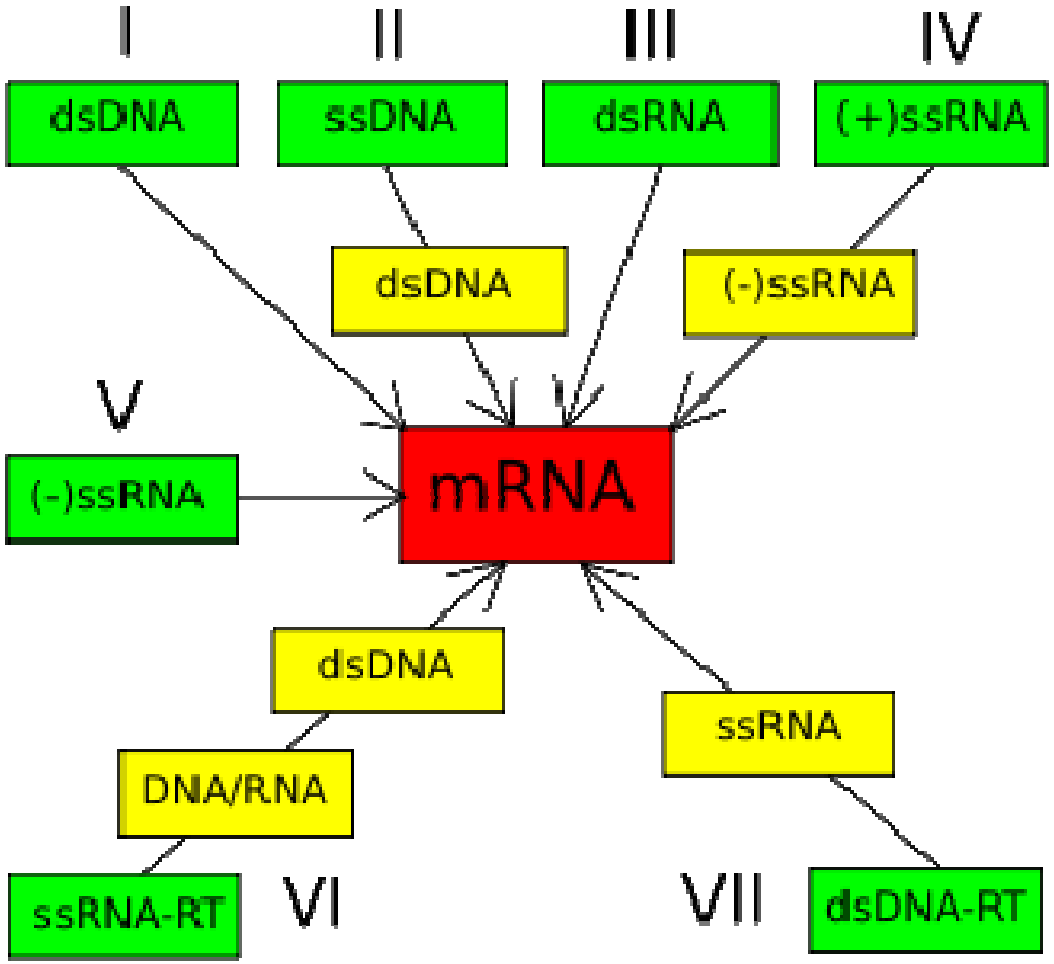
Table 19.1 Classes of Animal Viruses

Class/ Family	Envelope	Examples/ Disease
I. Double-stranded DNA (dsDNA)		
Adenovirus	No	Respiratory diseases; tumors
Papovavirus	No	Papillomavirus (warts, cervical cancer); polyomavirus (tumors)
Herpesvirus	Yes	Herpes simplex I and II (cold sores, genital sores); varicella zoster (shingles, chicken pox); Epstein-Barr virus (mononucleosis, Burkitt's lymphoma)
Poxvirus	Yes	Smallpox virus; cowpox virus
II. Single-stranded DNA (ssDNA)		
Parvovirus	No	B19 parvovirus (mild rash)
III. Double-stranded RNA (dsRNA)		
Reovirus	No	Rotavirus (diarrhea); Colorado tick fever virus
IV. Single-stranded RNA (ssRNA); serves as mRNA		
Picornavirus	No	Rhinovirus (common cold); poliovirus, hepatitis A virus, and other enteric (intestinal) viruses
Coronavirus	Yes	Severe acute respiratory syndrome (SARS)
Flavivirus	Yes	Yellow fever virus; West Nile virus; hepatitis C virus
Togavirus	Yes	Rubella virus; equine encephalitis viruses
V. ssRNA; template for mRNA synthesis		
Filovirus	Yes	Ebola virus (hemorrhagic fever)
Orthomyxovirus	Yes	Influenza virus
Paramyxovirus	Yes	Measles virus; mumps virus
Rhabdovirus	Yes	Rabies virus
VI. ssRNA; template for DNA synthesis		
Retrovirus	Yes	HIV, human immunodeficiency virus (AIDS); RNA tumor viruses (leukemia)

Classes of Animal Viruses

Baltimore Classification (巴爾的摩分類法)

- Different route to synthesize viral mRNA



http://zh.wikipedia.org/w/index.php?title=%E7%97%85%E6%AF%92&variant=zh-tw

Table 19-1a

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腺
乳突
疹
痘
細小
呼腸弧

Memorize!

皰疹

輪狀病毒

Table 19-1b

Table 19.1 Classes of Animal Viruses

Class/ Family	Envelope	Examples/ Disease
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Rhabdovirus	Yes	Rabies virus
VI. ssRNA; template for DNA synthesis		
Retrovirus	Yes	HIV, human immunodeficiency virus (AIDS); RNA tumor viruses (leukemia)

微小核糖核酸

冠狀

黃

披蓋

絲狀

正黏液

副黏液

彈狀

反轉錄

Dengue

(Rubella 德國麻疹）

（麻疹; 腮腺炎)

課本漏掉的第七類病毒

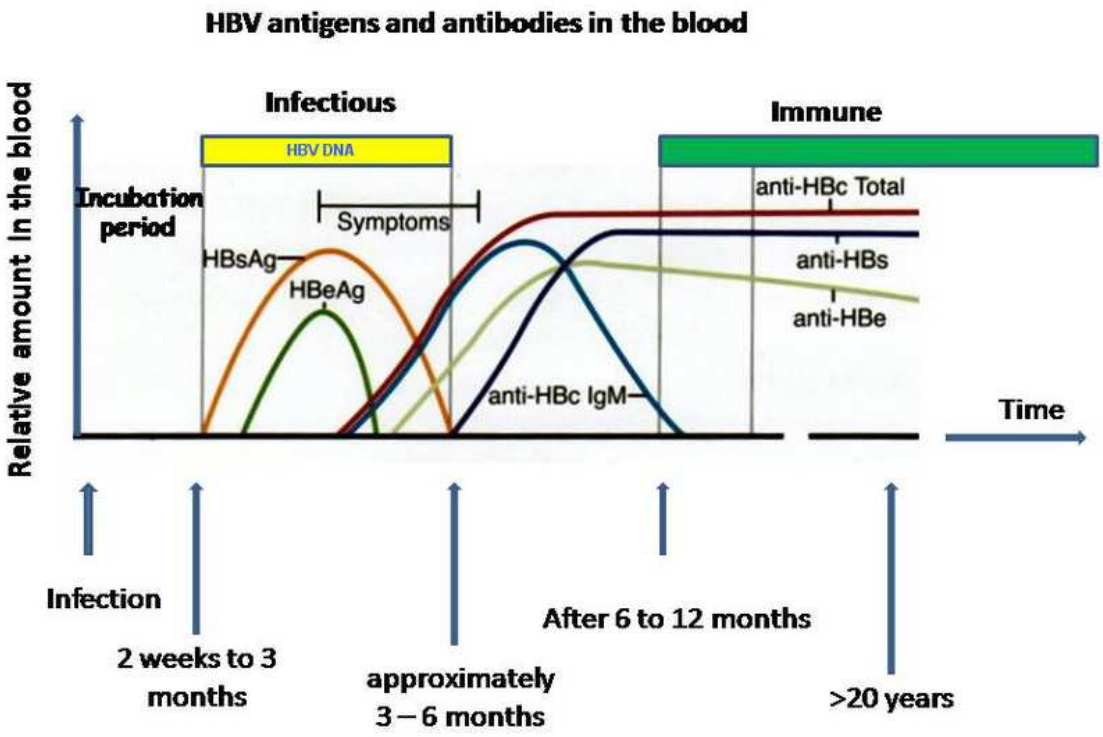
VII. dsDNA-RT

正肝 Orthohepadnavirus

禽肝 Avihepadnavirus

Yes on envelope

Example
- Hepatitis B virus

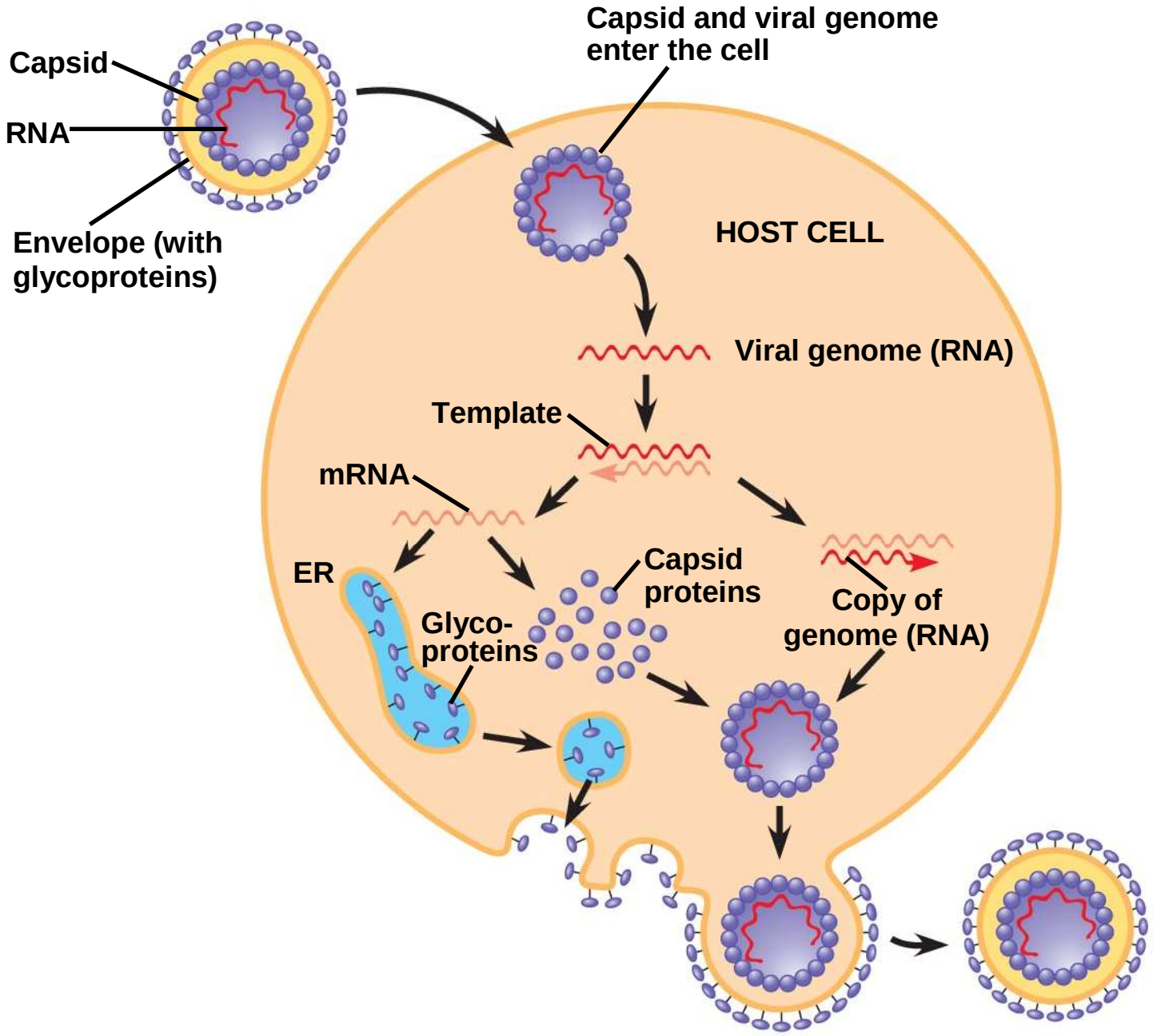


Viral Envelopes

- Many viruses that infect animals have a membranous envelope
- Viral glycoproteins on the envelope bind to specific receptor molecules on the surface of a host cell
- Some viral envelopes are formed from the host cell's plasma membrane as the viral capsids exit

- Other viral membranes form from the host's nuclear envelope and are then replaced by an envelope made from Golgi apparatus membrane

Fig. 19-7

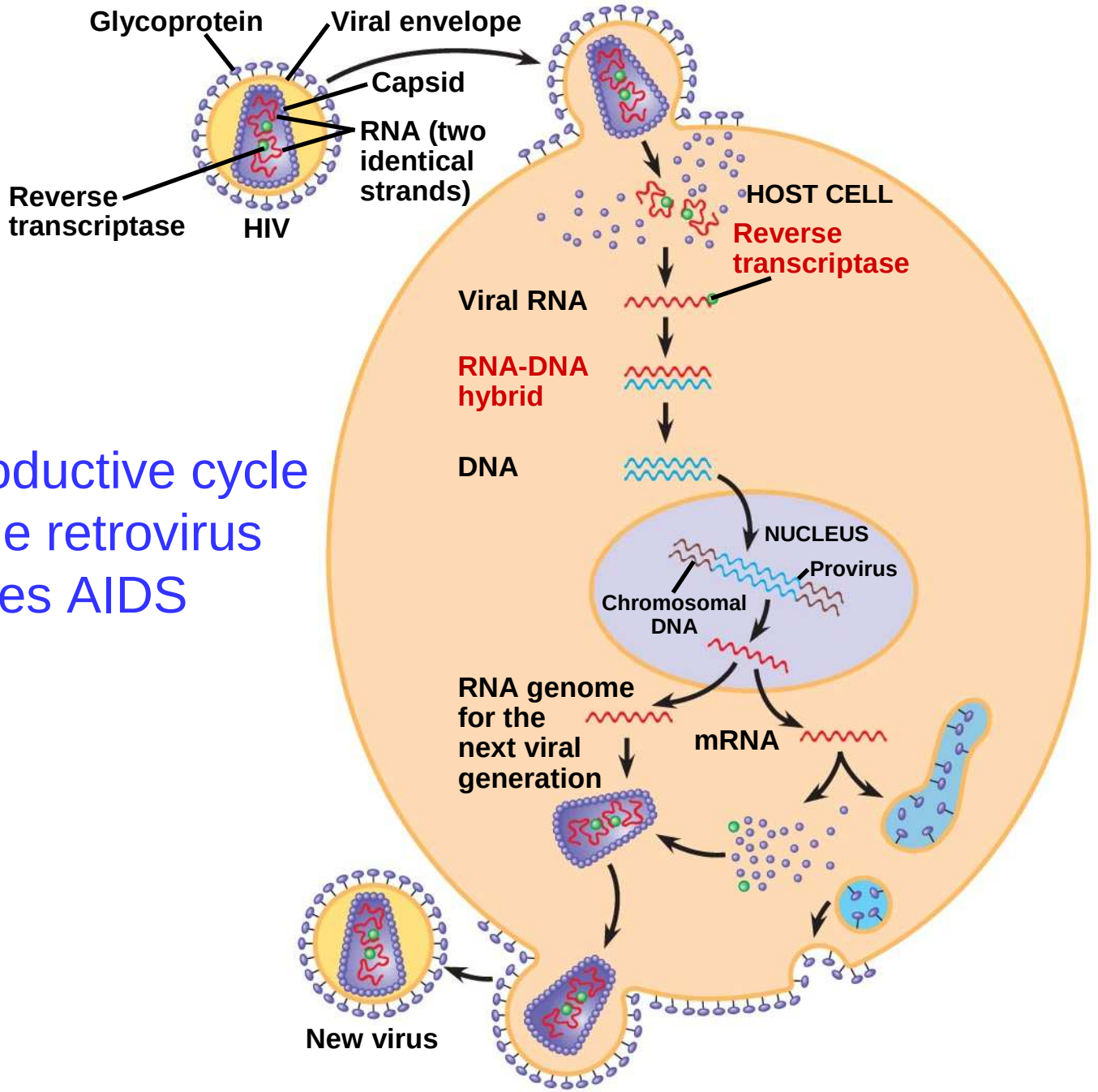


The reproductive cycle of an enveloped RNA virus

RNA as Viral Genetic Material

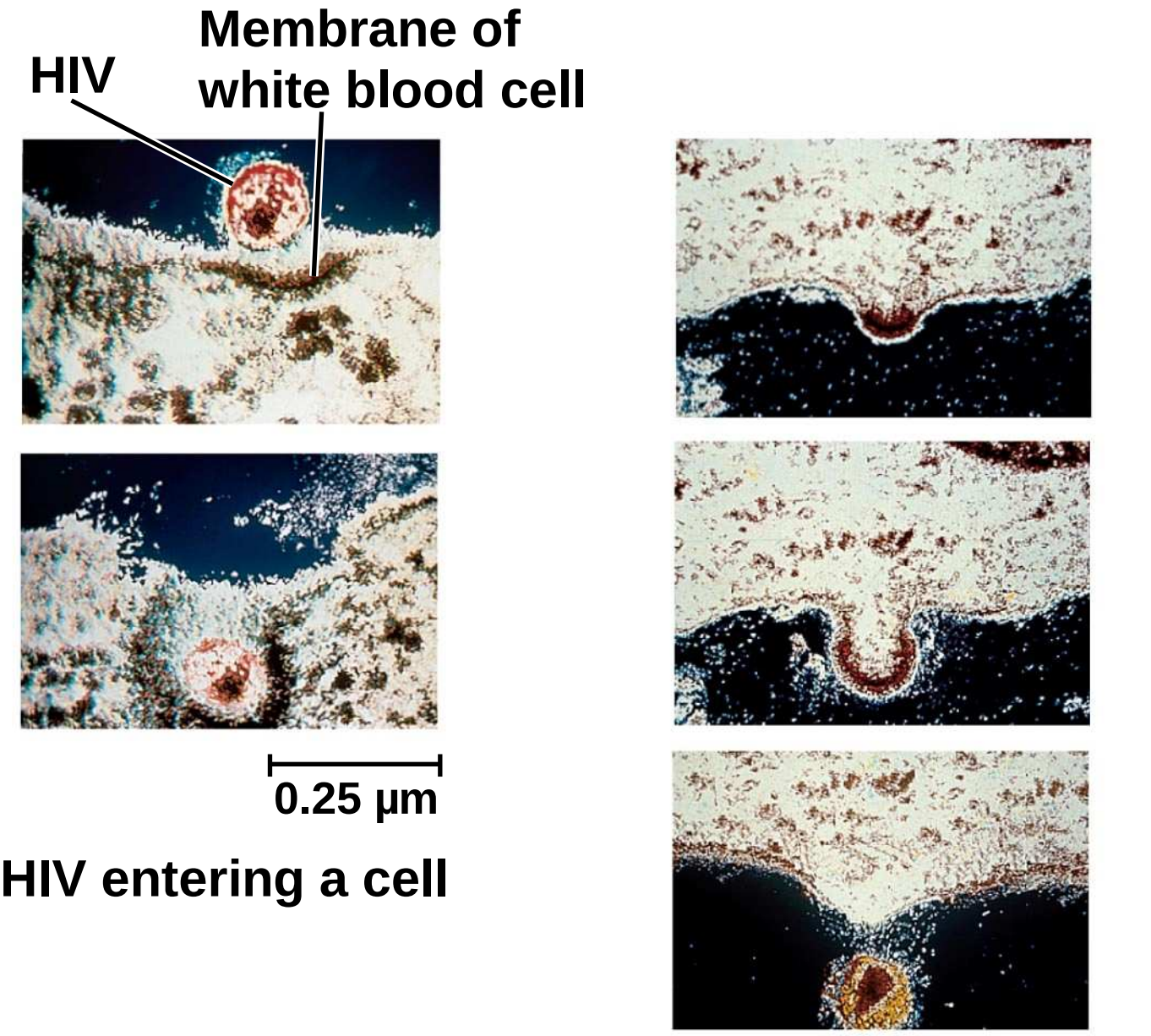
- The broadest variety of RNA genomes is found in viruses that infect animals
- **Retroviruses** use **reverse transcriptase** to copy their RNA genome into DNA
- **HIV (human immunodeficiency virus)** is the retrovirus that causes **AIDS (Acquired ImmunoDeficiency Syndrome)**

Fig. 19-8a



The reproductive cycle of HIV, the retrovirus that causes AIDS

Fig. 19-8b



Provirus

- The viral DNA that is *integrated into the host genome* is called a **provirus**
- Unlike a prophage, a provirus remains a permanent resident of the host cell
- The host's RNA polymerase transcribes the proviral DNA into RNA molecules
- The RNA molecules function both as mRNA for synthesis of viral proteins and as genomes for new virus particles released from the cell

Evolution of Viruses

- Viruses do not fit our definition of living organisms
- Since viruses can reproduce only within cells, they probably evolved as bits of cellular nucleic acid
- Candidates for the source of viral genomes are plasmids, circular DNA in bacteria and yeasts, and transposons, small mobile DNA segments
- Plasmids, transposons, and viruses are all mobile genetic elements

Mimivirus

- Mimivirus, a double-stranded DNA virus, is the largest virus yet discovered
- There is controversy about whether this virus evolved before or after cells

Concept 19.3: Viruses, viroids, and prions are formidable pathogens in animals and plants

- Diseases caused by viral infections affect humans, agricultural crops, and livestock worldwide

Viral Diseases in Animals

- Viruses may damage or kill cells by causing the release of hydrolytic enzymes from lysosomes
- Some viruses cause infected cells to produce toxins that lead to disease symptoms
- Others have toxic envelope proteins

Vaccines

- **Vaccines** are harmless derivatives of pathogenic microbes that stimulate the immune system to mount defenses against the actual pathogen
- Vaccines can prevent certain viral illnesses
- Viral infections cannot be treated by antibiotics
- Antiviral drugs can help to treat, though not cure, viral infections

Emerging Viruses （新生,新興的病毒）

- Emerging viruses are those that appear suddenly or suddenly come to the attention of scientists
- Severe acute respiratory syndrome (SARS) recently appeared in China
- Outbreaks of “new” viral diseases in humans are usually caused by existing viruses that expand their **host territory**

- New viral diseases can emerge when viruses spread from animals to humans (i.e. SARS, Avian flu)
  - Viral strains that jump species can exchange genetic information with other viruses to which humans have no immunity

Epidemics vs. Pandemics

- Flu **epidemics** are caused by new strains of influenza virus to which people have little immunity
- Viral diseases in a small isolated population can emerge and become global (i.e. HIV)
- These strains can cause **pandemics**, global epidemics
- The “avian flu” is a virus that recently appeared in humans and originated in wild birds

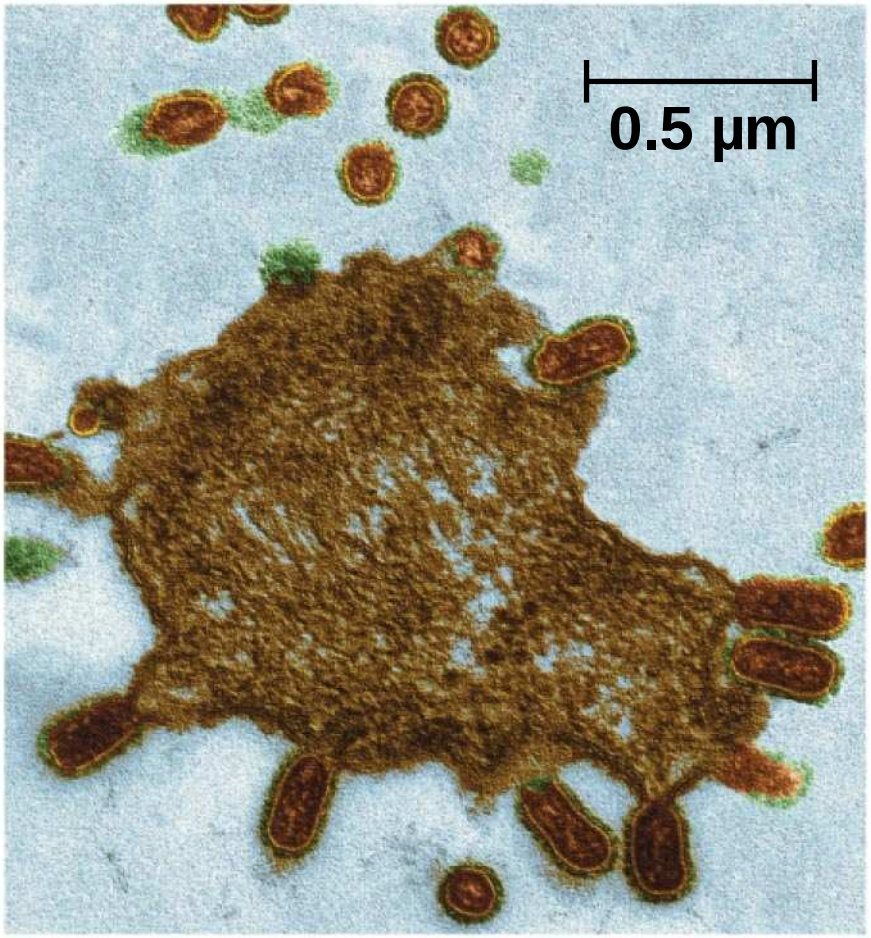
Fig. 19-9a

The 1918 flu pandemic

Spanish Flu pandemic of 1918-1919 killed ~40 million people, including many WWI soldiers.
Evidence points to birds as the source.

Fig. 19-9b

Avian Flu

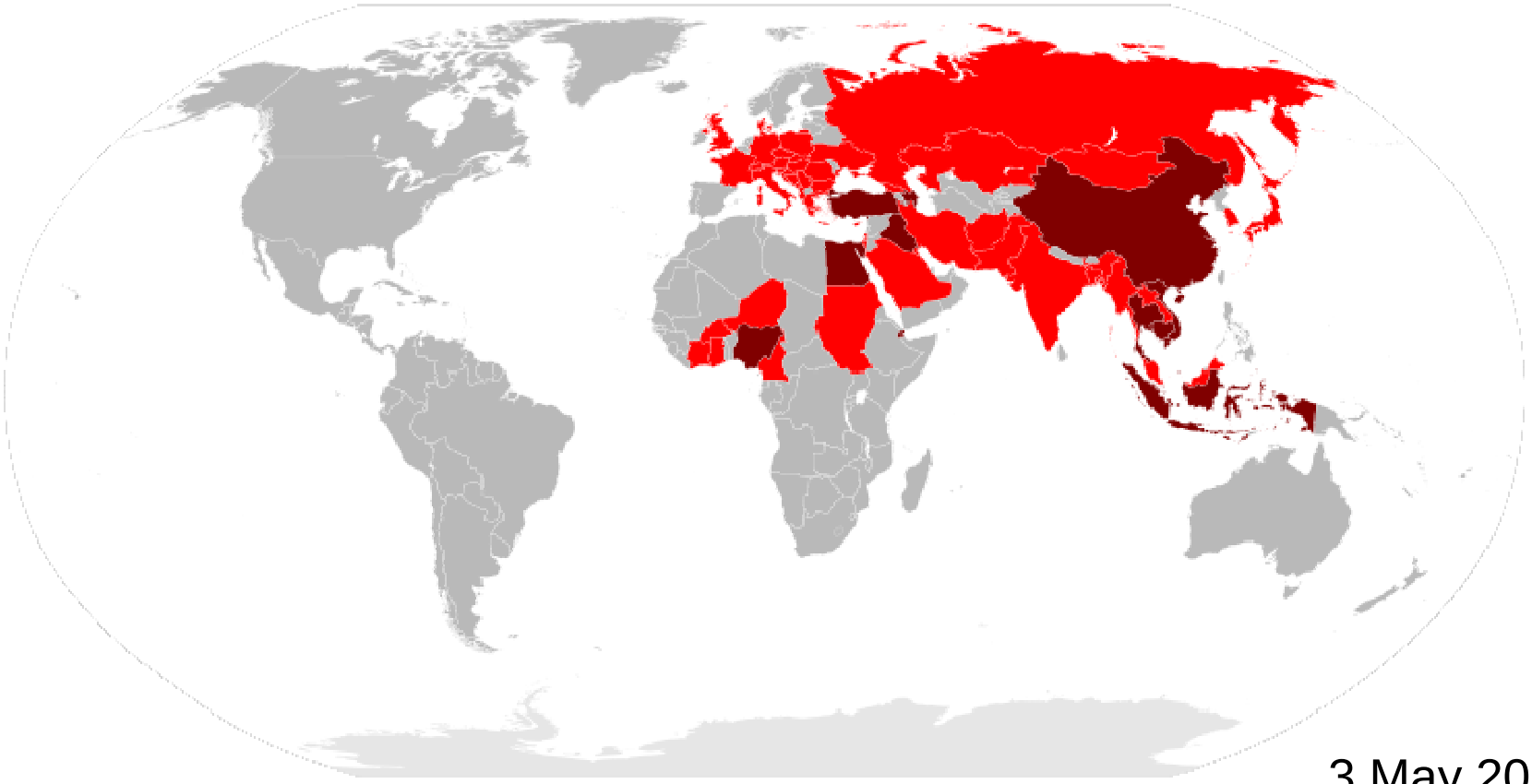


(b) Influenza A H5N1virus

(c) Vaccinating ducks

H: Hemagglutinin for attachment; 16 types
N: Neuraminidase for release; 9 types

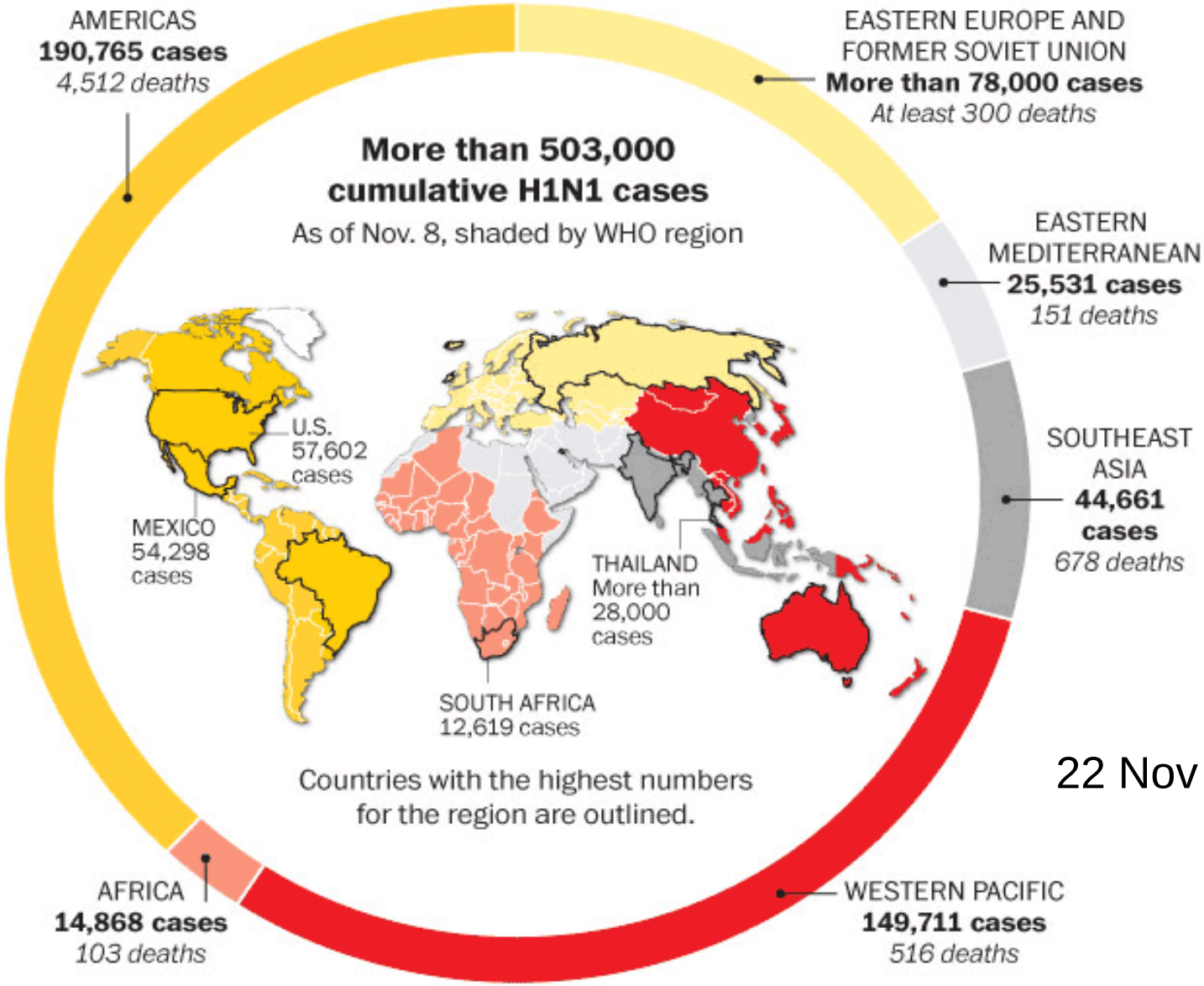
Global spread of H5N1 map



3 May 2009

→ Countries with poultry or wild birds killed by H5N1.

→ Countries with humans, poultry and wild birds killed by H5N1.


AMERICAS
190,765 cases
4,512 deaths
EASTERN EUROPE AND FORMER SOVIET UNION
More than 78,000 cases
At least 300 deaths
EASTERN MEDITERRANEAN
25,531 cases
151 deaths
SOUTHEAST ASIA
44,661 cases
678 deaths
WESTERN PACIFIC
149,711 cases
516 deaths
AFRICA
14,868 cases
103 deaths
More than 503,000 cumulative H1N1 cases
As of Nov. 8, shaded by WHO region
U.S. 57,602 cases
MEXICO 54,298 cases
THAILAND More than 28,000 cases
SOUTH AFRICA 12,619 cases
Countries with the highest numbers for the region are outlined.

22 Nov 2009

Viral Diseases in Plants

- More than 2,000 types of viral diseases of plants are known and cause spots on leaves and fruits, stunted growth, and damaged flowers or roots
- Most plant viruses have an RNA genome

Fig. 19-10

Viral infection of plants

- Plant viruses spread disease in two major modes:
  - Horizontal transmission, entering through damaged cell walls
  - Vertical transmission, inheriting the virus from a parent

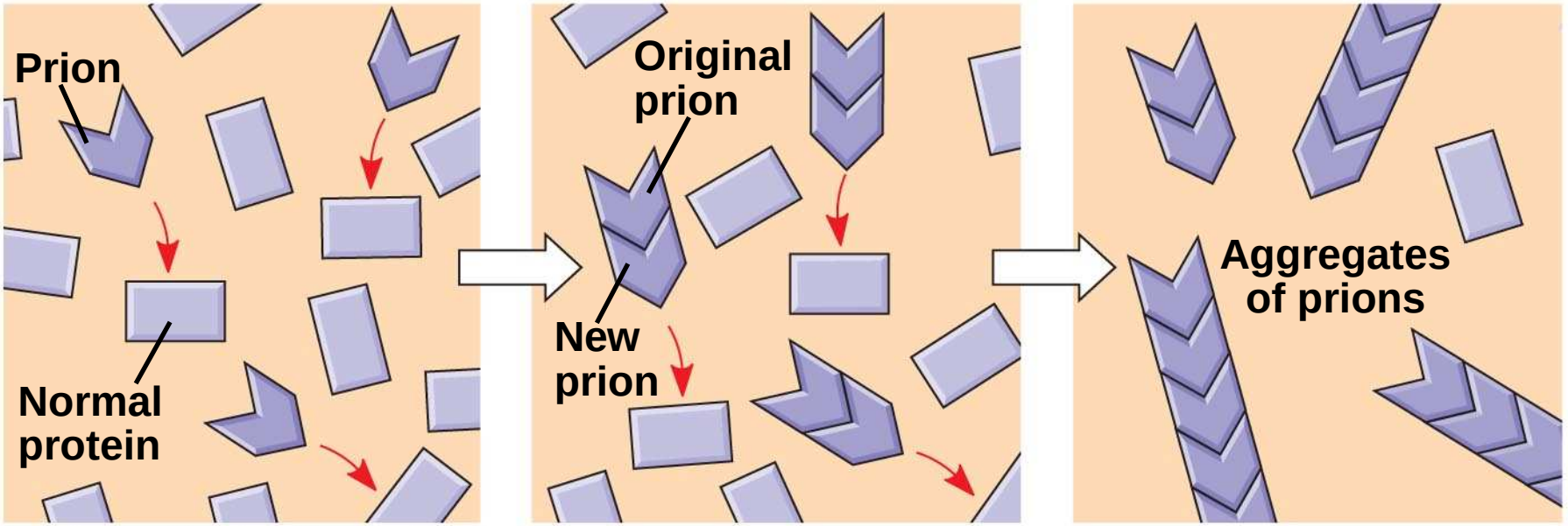
Viroids and Prions: The Simplest Infectious Agents

- Smaller, less complex entities called viroids and prions also cause disease in plants and animals, respectively

- **Viroids**（類病毒）are circular RNA molecules that infect plants and disrupt their growth
- **Prions**（傳染性蛋白質）are slow-acting, virtually indestructible infectious proteins that cause brain diseases in mammals
- Prions propagate by converting normal proteins into the prion version
- Scrapie in sheep, mad cow disease, and Creutzfeldt-Jakob disease in humans are all caused by prions

Fig. 19-11

Model for how prions propagate



You should now be able to:

- Explain how capsids and envelopes are formed
- Distinguish between the lytic and lysogenic reproductive cycles
- Explain why viruses are obligate intracellular parasites
- Describe the reproductive cycle of an HIV retrovirus
- Describe three processes that lead to the emergence of new diseases
- Describe viroids and prions