

# Chapter 19

## Viruses

PowerPoint® Lecture Presentations for

# Biology

*Eighth Edition*

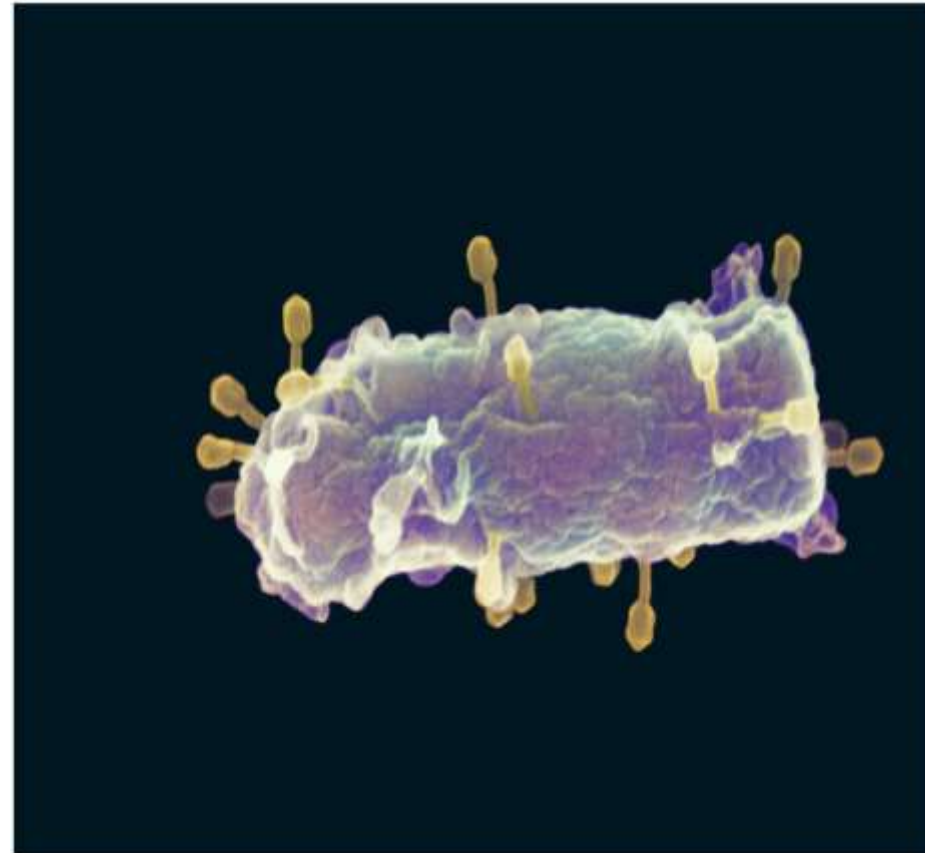
Neil Campbell and Jane Reece

Lectures by Chris Romero, updated by Erin Barley with contributions from Joan Sharp

# 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

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 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)

## RESULTS

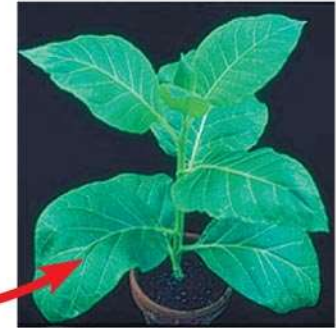
What causes tobacco mosaic disease?



**1** Extracted sap from tobacco plant with tobacco mosaic disease



**2** Passed sap through a porcelain filter known to trap bacteria



**3** Rubbed filtered sap on healthy tobacco plants



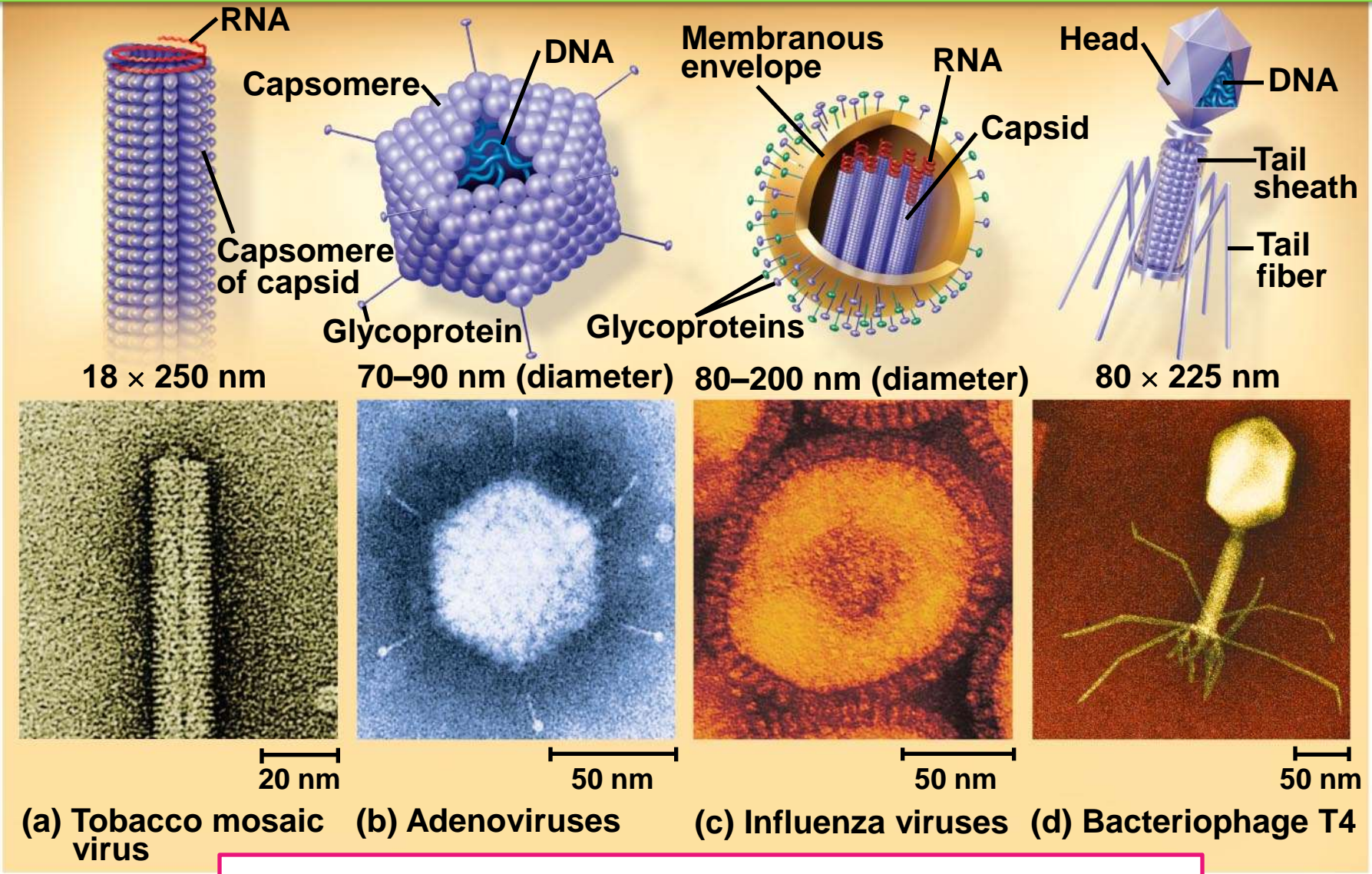
**4** Healthy plants became infected

# Structure of Viruses

- Viruses are not cells
- Viruses are very small infectious particles **consisting of nucleic acid enclosed in a protein coat**
- Viral genomes may consist of either **DNA** or **RNA**
- Depending on its type of nucleic acid, a virus is called a **DNA virus** or an **RNA virus**



# A capsid is the protein shell that encloses the viral genome



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A capsid can have various structures

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- 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**

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- **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**



# Viruses reproduce only in host cells

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- Viruses are therefore **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

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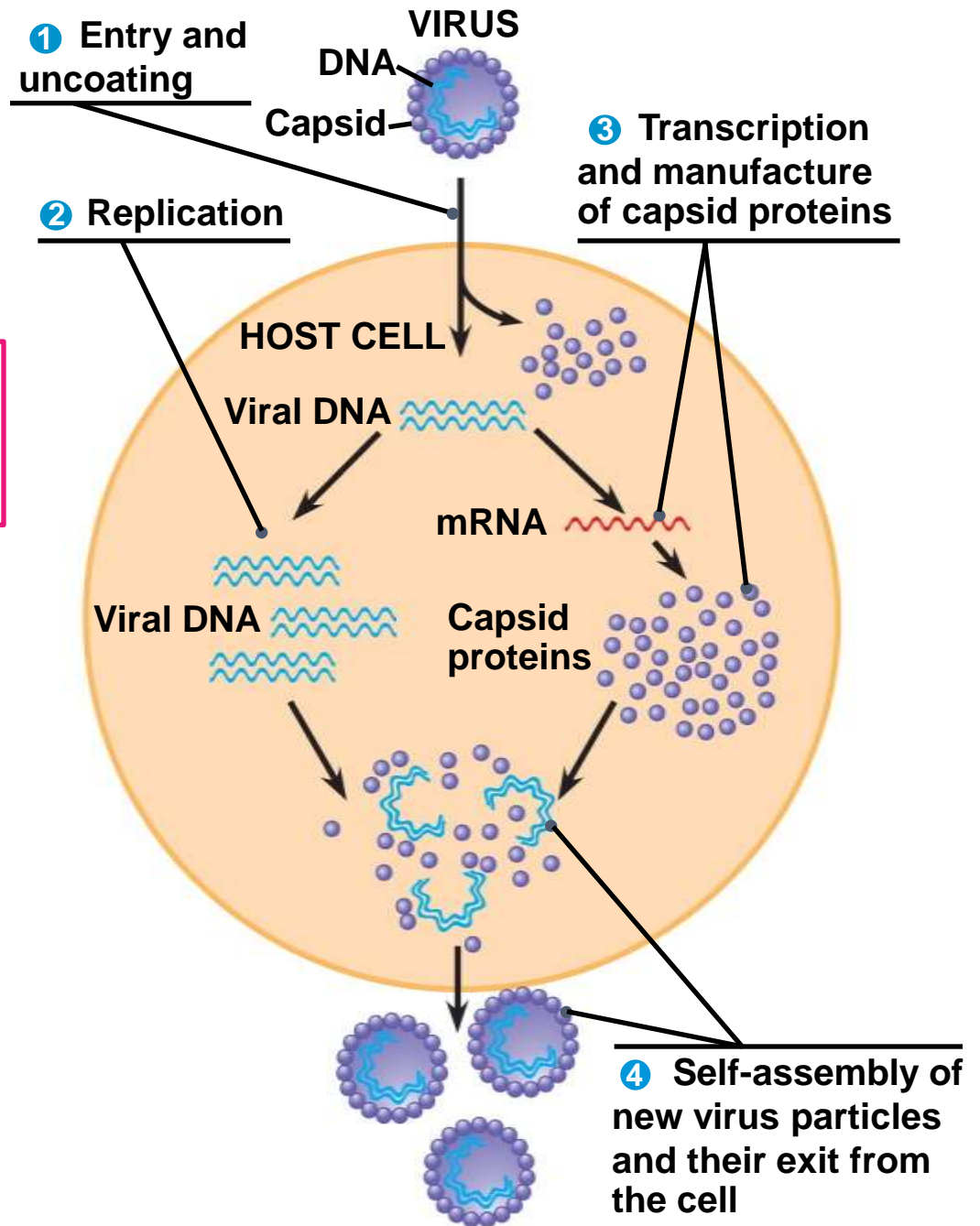
- Once a viral genome has **entered** a cell, the **cell begins to manufacture viral proteins**
- The virus makes use of host enzymes, ribosomes, tRNAs, amino acids, ATP, and other molecules

**PLAY**

Animation: Simplified Viral Reproductive Cycle

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A simplified viral reproductive cycle



# *The Lytic Cycle*

- Phages have **two reproductive mechanisms**: the **lytic cycle** and the **lysogenic 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**
- Bacteria have defenses against phages, including **restriction enzymes** that recognize and cut up certain phage DNA

**PLAY**

Animation: Phage T4 Lytic Cycle

12

# The **lytic cycle** of phage T4, a virulent phage

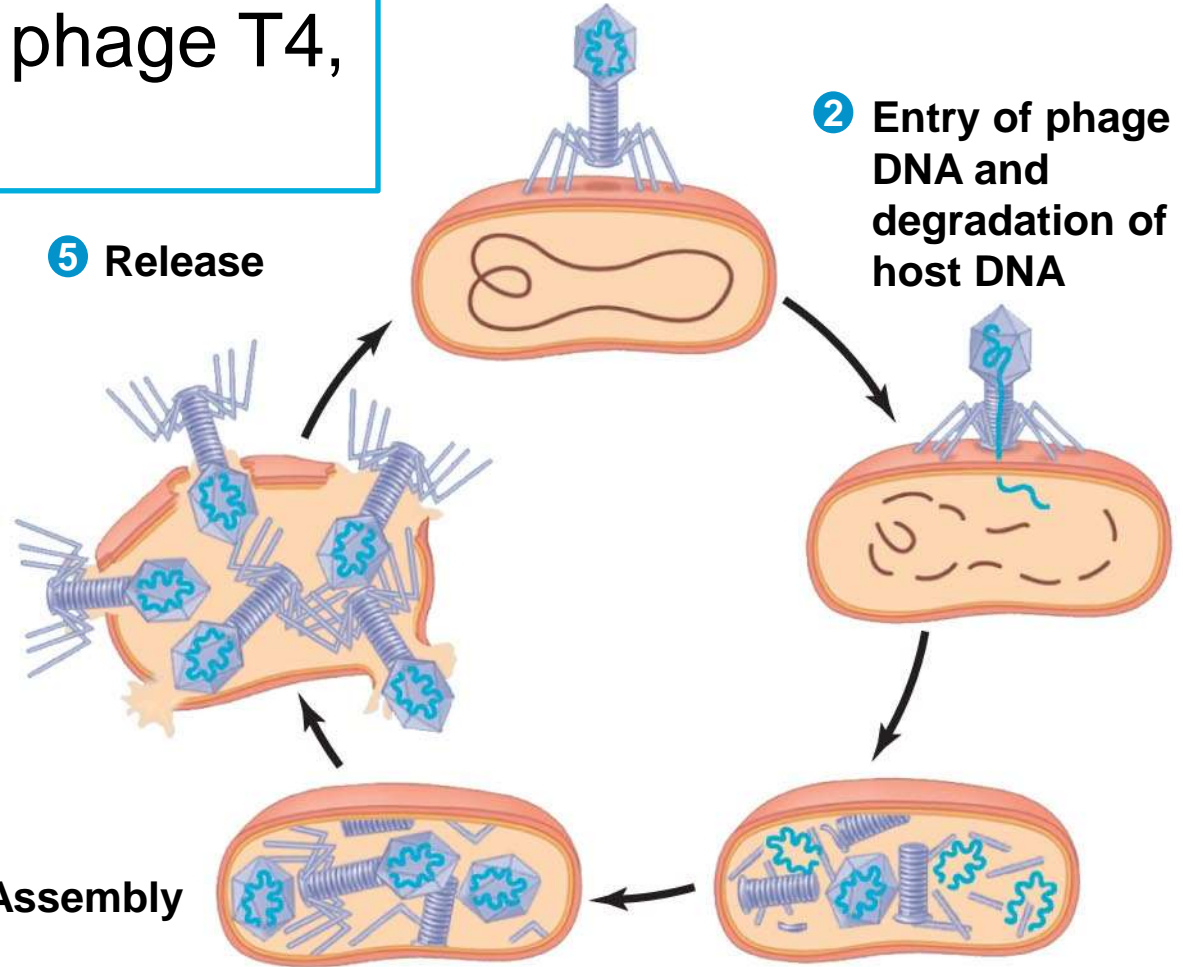
## 1 Attachment

## 2 Entry of phage DNA and degradation of host DNA

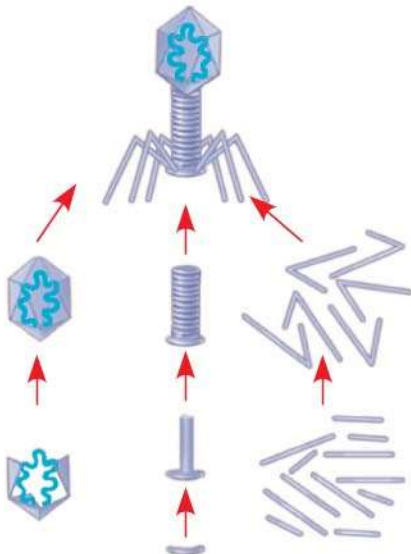
## 5 Release

## 4 Assembly

## 3 Synthesis of viral genomes and proteins



## Phage assembly



Head Tail Tail fibers

# The Lysogenic Cycle

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- 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

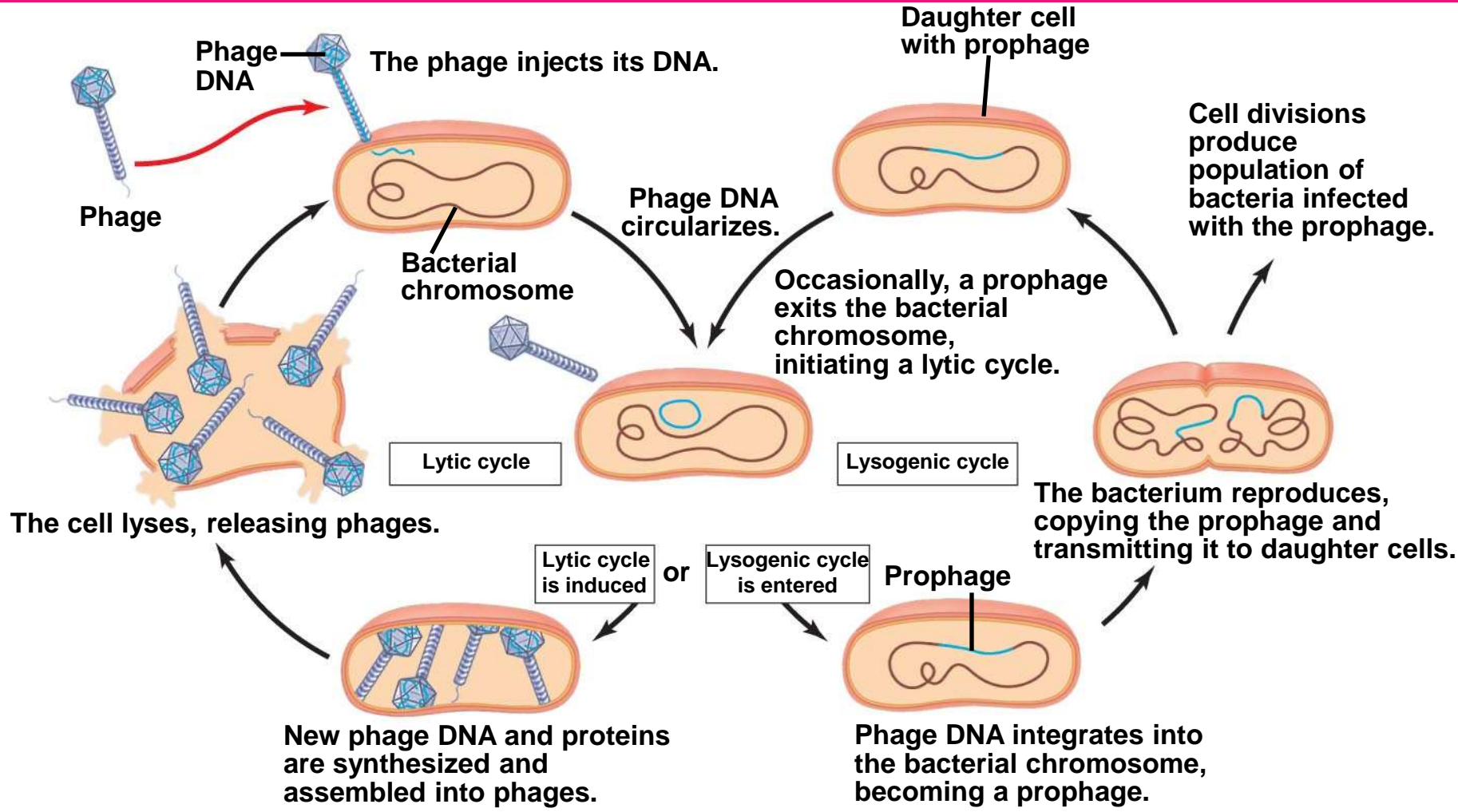
**PLAY**

Animation: Phage Lambda Lysogenic and Lytic Cycles

14



# Phages that use both the lytic and lysogenic cycles are called **temperate phages**



# The lytic and lysogenic cycles of phage $\lambda$ , 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?

Table 19.1 Classes of Animal Viruses		
Class/ Family	Envelope	Examples/ Disease
<b>I. Double-stranded DNA (dsDNA)</b>		
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
<b>II. Single-stranded DNA (ssDNA)</b>		
Parvovirus	No	B19 parvovirus (mild rash)
<b>III. Double-stranded RNA (dsRNA)</b>		
Reovirus	No	Rotavirus (diarrhea); Colorado tick fever virus
<b>IV. Single-stranded RNA (ssRNA); serves as mRNA</b>		
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
<b>V. ssRNA; template for mRNA synthesis</b>		
Filovirus	Yes	Ebola virus (hemorrhagic fever)
Orthomyxovirus	Yes	Influenza virus
Paramyxovirus	Yes	Measles virus; mumps virus
Rhabdovirus	Yes	Rabies virus
<b>VI. ssRNA; template for DNA synthesis</b>		
Retrovirus	Yes	HIV, human immunodeficiency virus (AIDS); RNA tumor viruses (leukemia)

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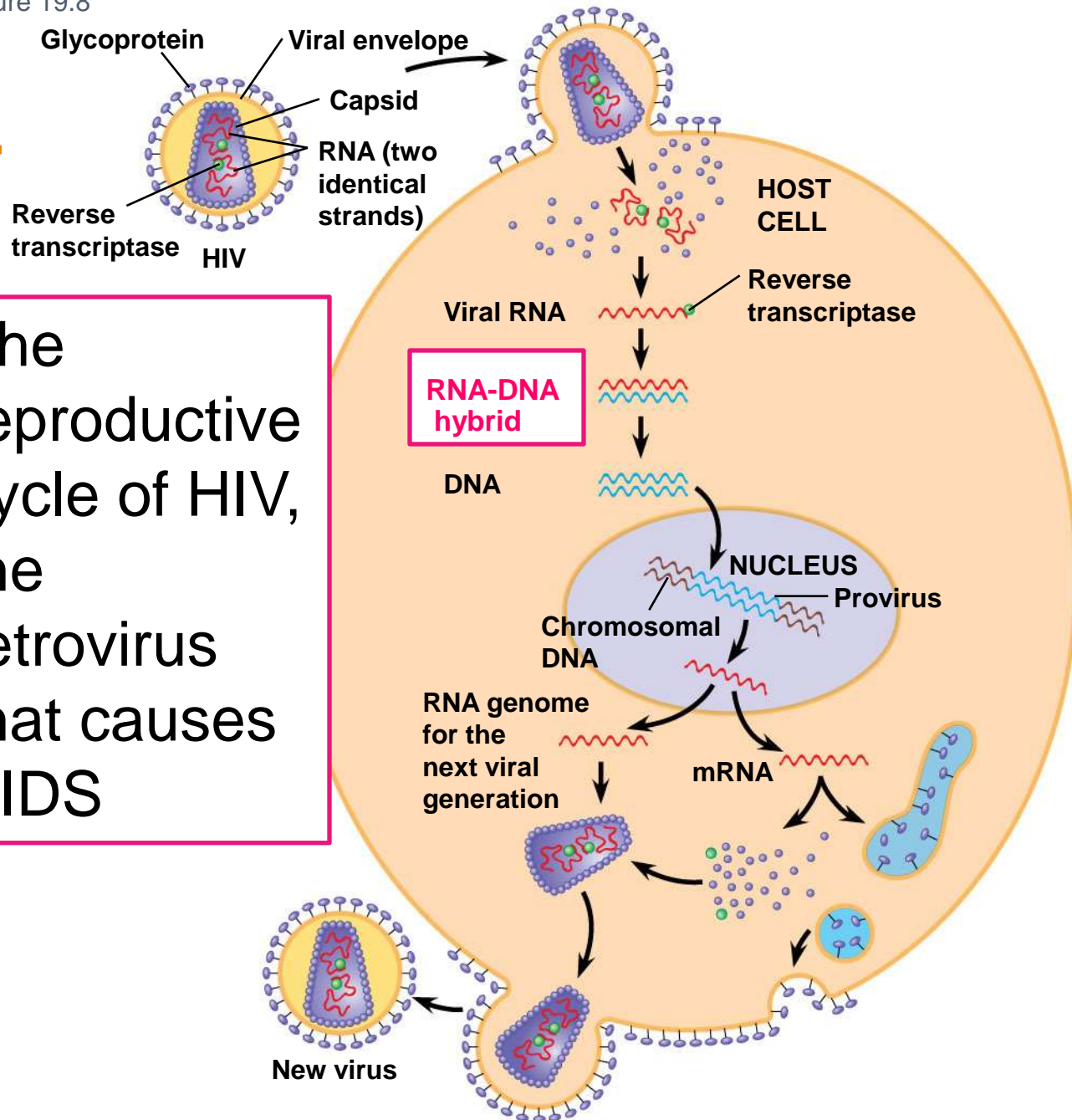
# *RNA as Viral Genetic Material*

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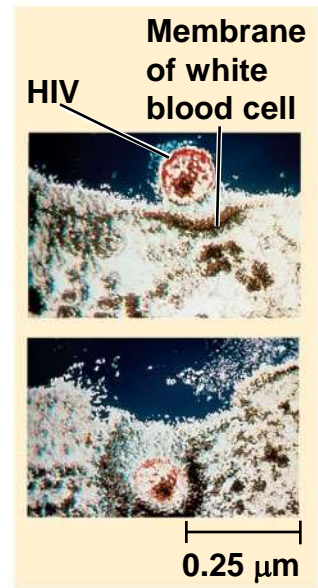
- The **broadest variety of RNA genomes is found in viruses that infect animals**
- **Retroviruses** use **reverse transcriptase** to copy their RNA genome into DNA
- **HIV (human immunodeficiency virus)** is the retrovirus that causes **AIDS (acquired immunodeficiency syndrome)**



Figure 19.8



The reproductive cycle of HIV, the retrovirus that causes AIDS



HIV entering a cell



New HIV leaving a cell

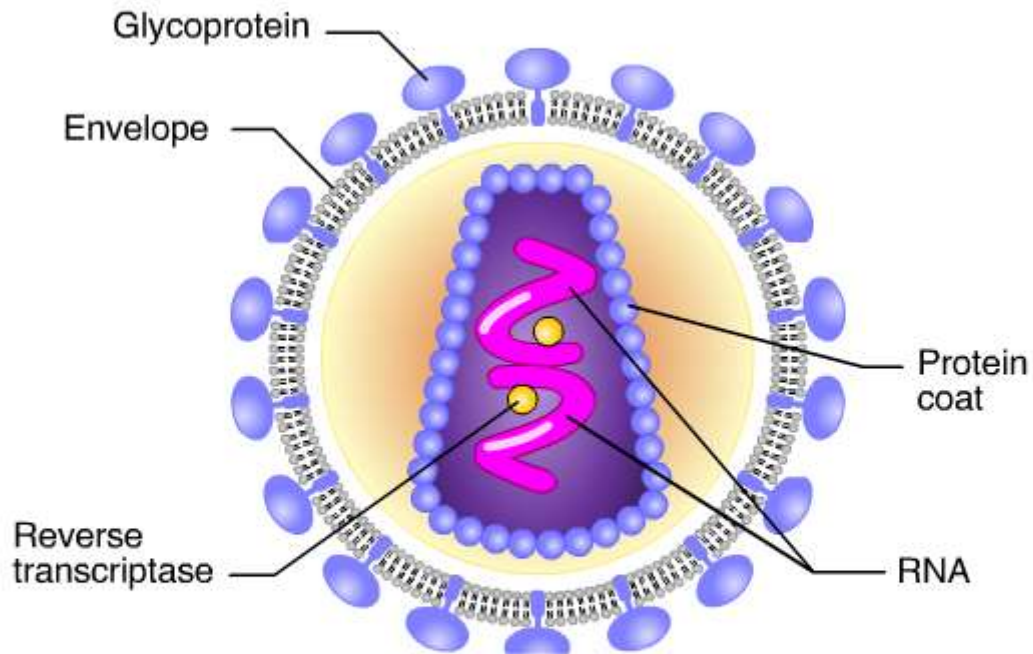
- In case of retroviruses, the viral DNA that is integrated into the host genome is called a **provirus**
- **Unlike a prophage, a provirus remains a permanent resident of the host cell**
- The host's RNA polymerase transcribes the proviral DNA into RNA molecules
- The RNA molecules function **both as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

**PLAY**

Animation: HIV Reproductive Cycle

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Animation: HIV Reproductive Cycle  
Right-click slide / select "Play"

# 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**

# Viruses, viroids, and prions are formidable pathogens in animals and plants

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- Diseases caused by viral infections affect humans, agricultural crops, and livestock worldwide
- **Smaller, less complex entities** called **viroids** and **prions** also cause disease in plants and animals, **respectively**

- **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

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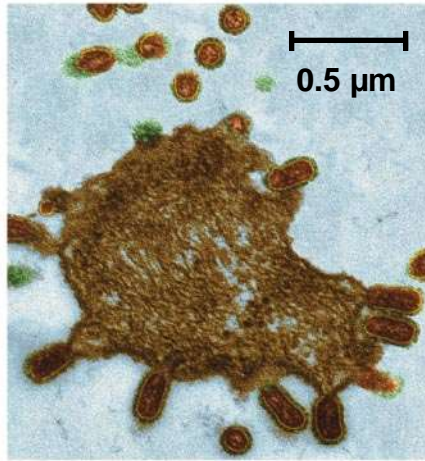
- **Emerging viruses** are those that **suddenly become apparent**
- Recently, a general outbreak (**epidemic**) of a flu-like illness appeared in Mexico and the United States, caused by an influenza virus named H1N1
- Flu epidemics are caused by new strains of influenza virus to which people have little immunity

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- 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**
  - New viral diseases can emerge when **viruses spread from animals to humans**
  - Viral strains that jump species can exchange genetic information with other viruses to which humans have no immunity





**(a) The 1918 flu pandemic**



**(b) Influenza A  
H5N1 virus**



**(c) Vaccinating ducks**

# Viral Diseases in Plants

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- 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**



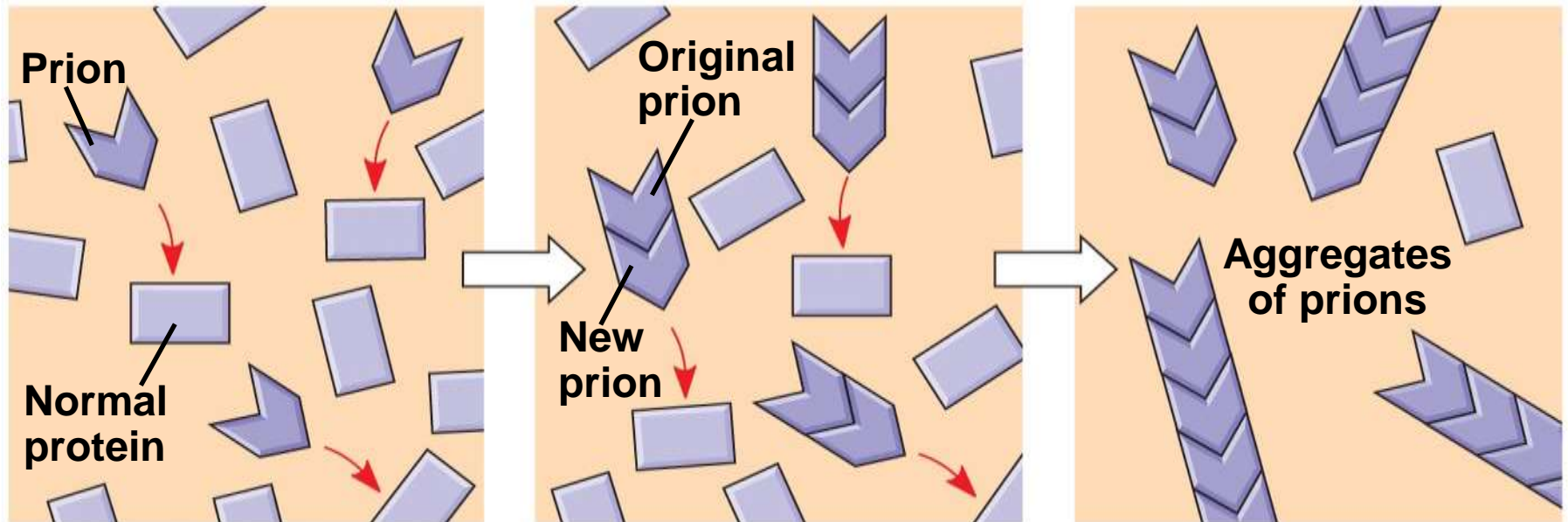


# Viroids and Prions: The Simplest Infectious Agents

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- **Viroids** are **circular RNA molecules that infect plants and disrupt their growth**
- **Prions** 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

# Model for how prions propagate





Questions ?

Questions ?

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