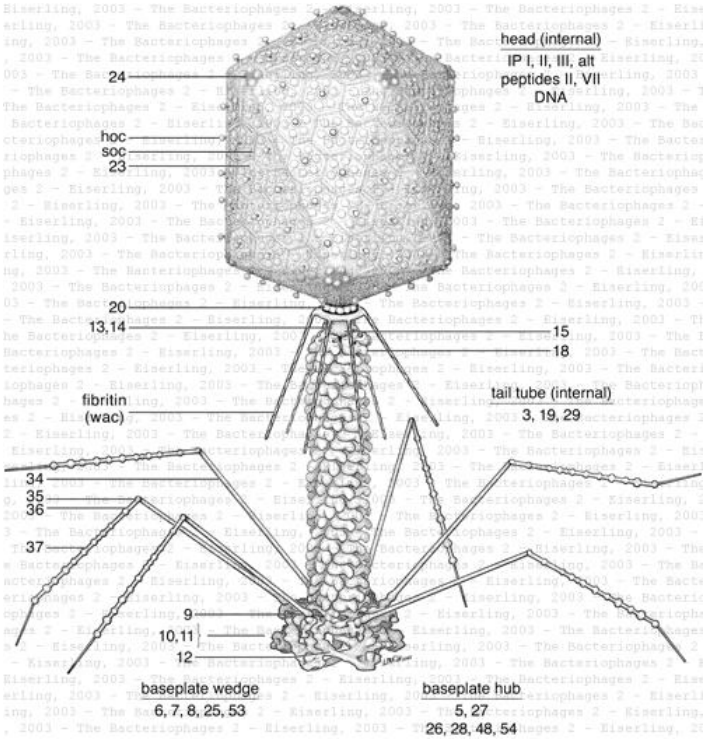
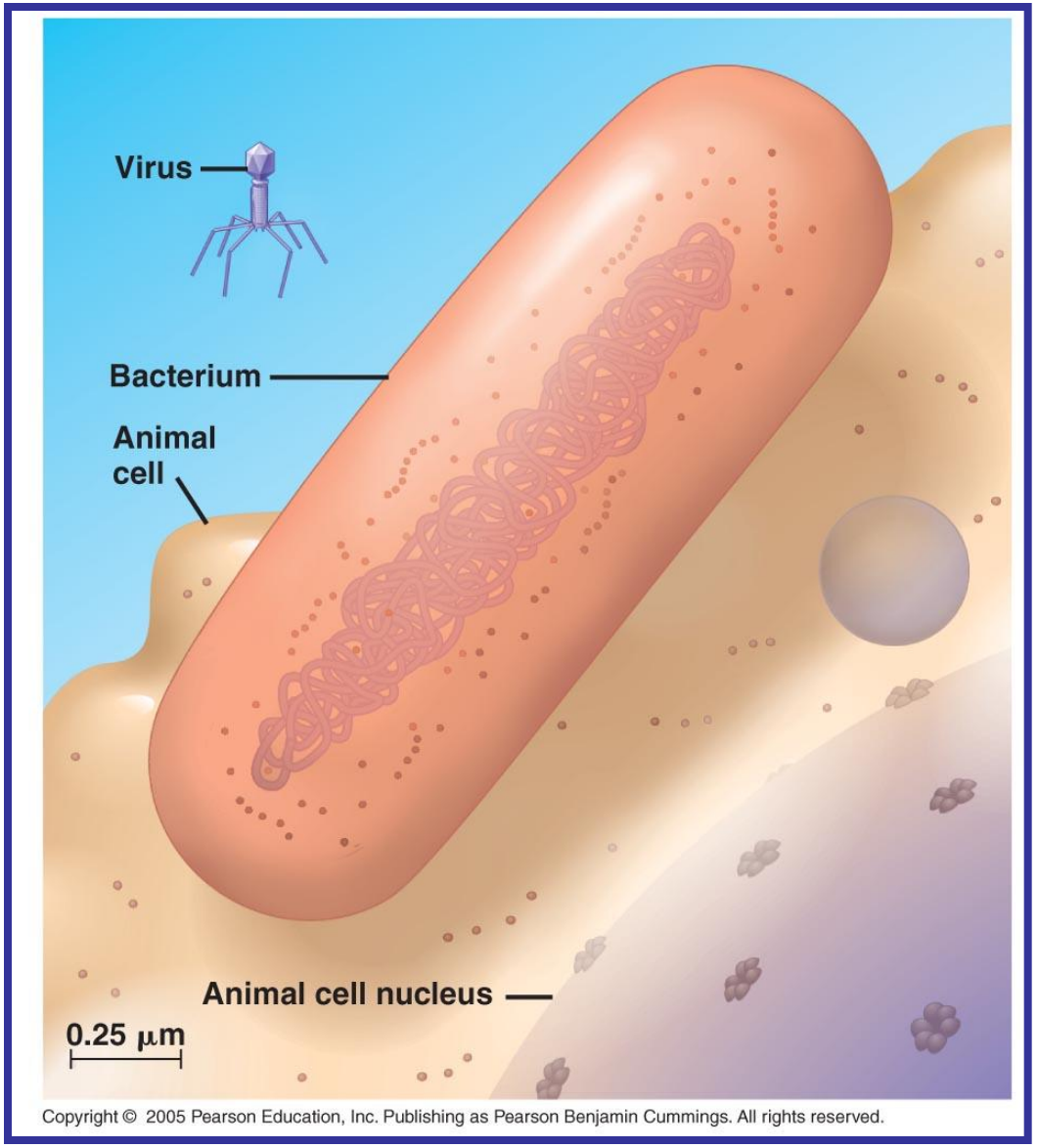
Chapter 19: The Genetics of Viruses and Bacteria

What is Microbiology?

- Microbiology is the science that studies microorganisms = living things that are too small to be seen with the naked eye
- Microorganisms cannot be distinguished phylogenetically from “Macro-organisms”
  - Includes fungi, protists, and bacteria
- A microbiologist usually first isolates a specific microorganism from a population and then cultures it

Relative Microbe Sizes





What are the different types of DNA?

- Eukaryotic DNA – linear
- Prokaryotic DNA – circular
- Mitochondrial DNA
- Plasmid – small circular DNA in bacteria
- Viral DNA

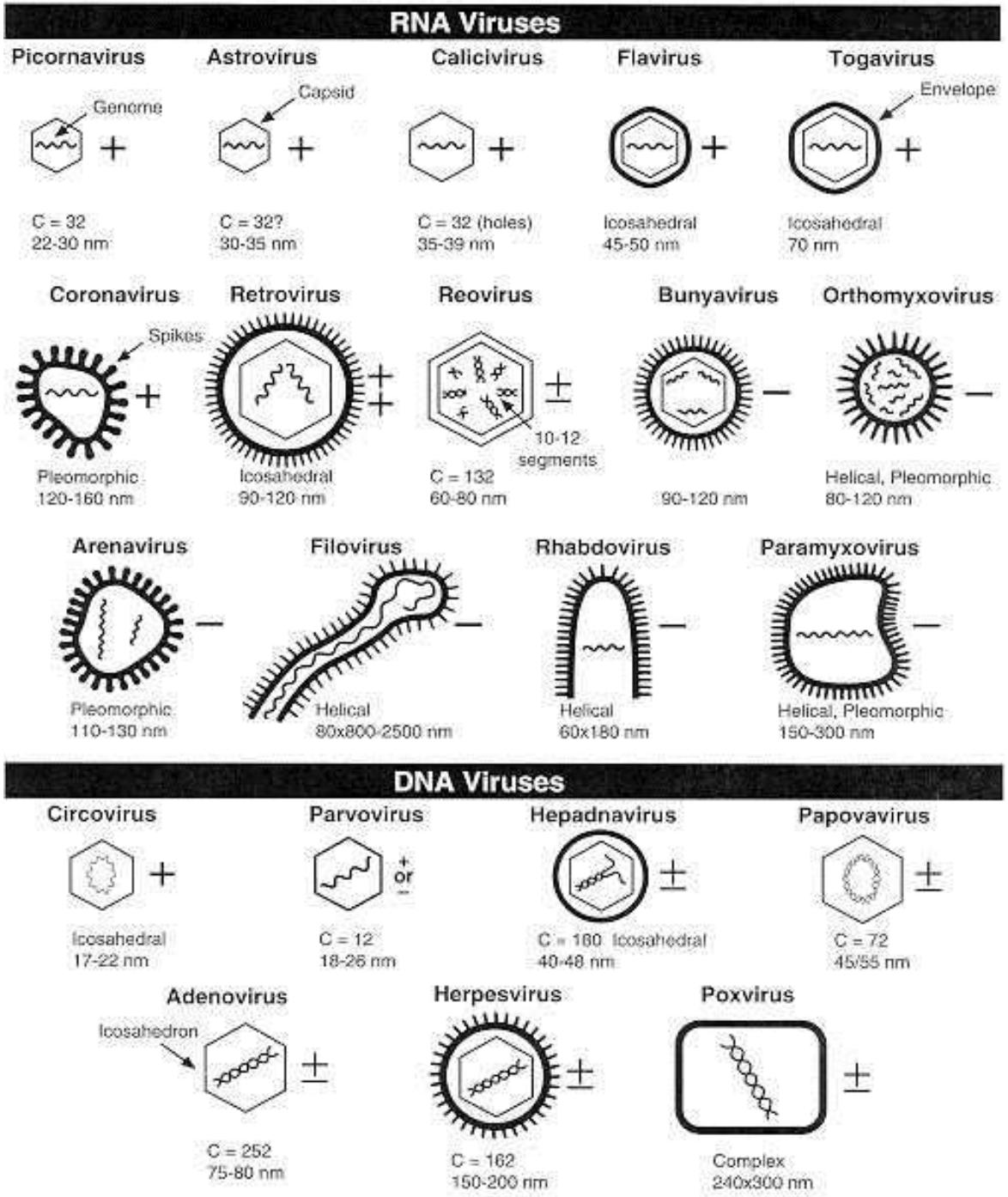
What is a Virus?

- Viruses are infectious agents of a small size and simple composition that can multiply in living cells of animals, plants and bacteria
  - Obligate parasites that are metabolically inert when they are outside their hosts (rely on the host for its reproduction)

- Motto: Get In, Take Over, Get Out!!

Structure of Viruses

- Viral Genome = nucleic acid (DNA or RNA, single or double stranded)
  - 4 genes to several thousand in their genomes
- Capsids and Envelopes
  - Capsid = protein shell
    - Most complex are found in bacteriophages
  - Envelopes = derived from host membrane and contains host's phospholipids and membrane proteins (influenza virus)
- Glycoproteins
  - Aids in attachment to host cell


RNA Viruses
Picornavirus
Genome
+
C = 32
22-30 nm
Astrovirus
Capsid
+
C = 32?
30-35 nm
Calicivirus
+
C = 32 (holes)
35-39 nm
Flavirus
+
Icosahedral
45-50 nm
Togavirus
Envelope
+
Icosahedral
70 nm
Coronavirus
Spikes
+
Pleomorphic
120-160 nm
Retrovirus
++
Icosahedral
90-120 nm
Reovirus
±
10-12
segments
C = 132
60-80 nm
Bunyavirus
−
90-120 nm
Orthomyxovirus
−
Helical, Pleomorphic
80-120 nm
Arenavirus
−
Pleomorphic
110-130 nm
Filovirus
−
Helical
80x800-2500 nm
Rhabdovirus
−
Helical
60x180 nm
Paramyxovirus
−
Helical, Pleomorphic
150-300 nm
DNA Viruses
Circovirus
+
Icosahedral
17-22 nm
Parvovirus
+
or
−
C = 12
18-26 nm
Hepadnavirus
±
C = 160 Icosahedral
40-48 nm
Papovavirus
±
C = 72
45/55 nm
Adenovirus
Icosahedron
±
C = 252
75-80 nm
Herpesvirus
±
C = 162
150-200 nm
Poxvirus
±
Complex
240x300 nm

Examples of Types of Viruses

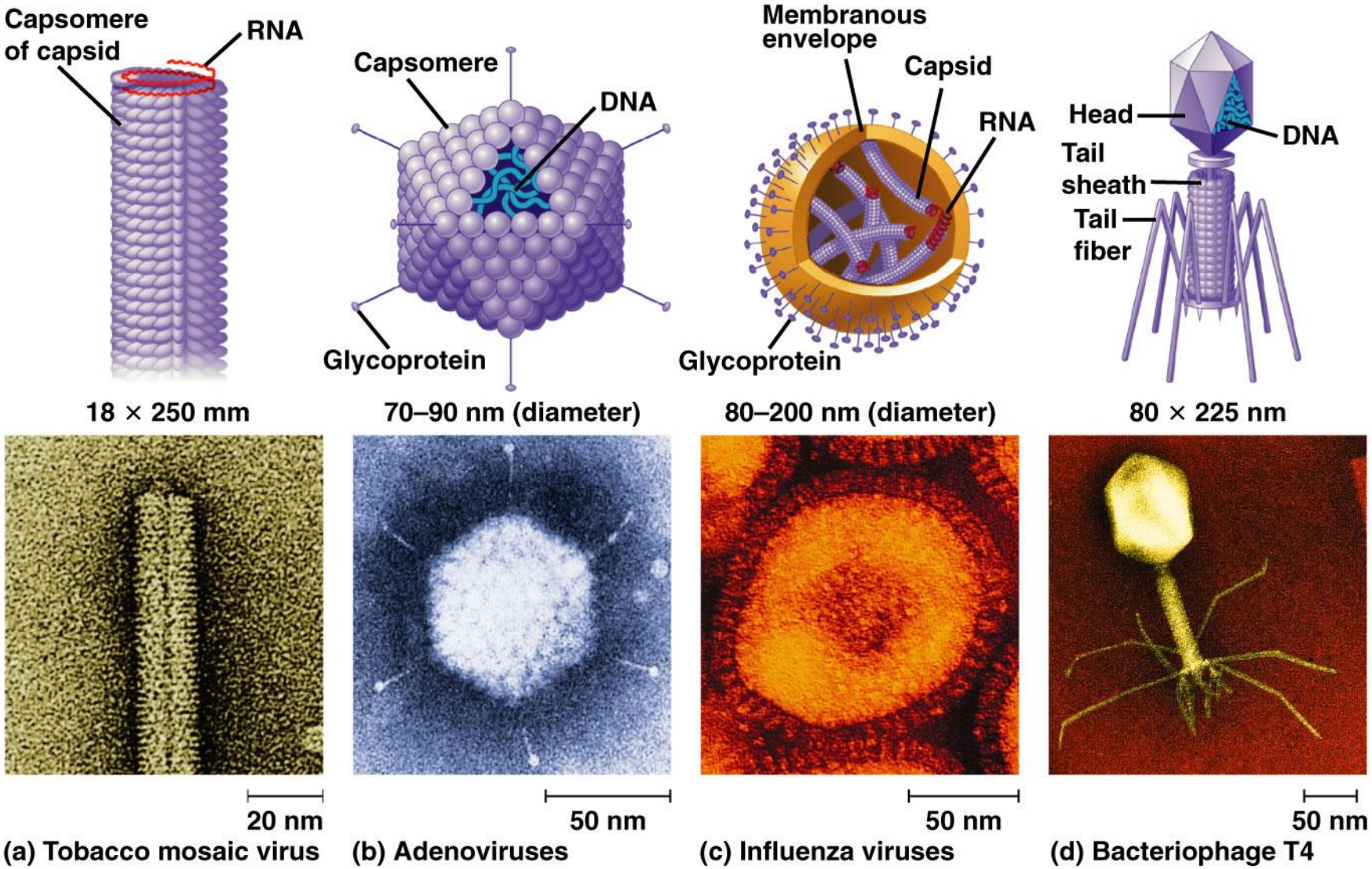


TABLE 6.5 Important Human Virus Families, Genera, Common Names, and Types of Diseases

	Family	Genus of Virus	Common Name of Genus Members	Name of Disease
DNA Viruses				
	Poxviridae	*Orthopoxvirus*	Variola and vaccinia	Smallpox, cowpox
	Herpesviridae	*Simplexvirus*	Herpes simplex (HSV) 1 virus	Fever blister, cold sores
			Herpes simplex (HSV) 2 virus	Genital herpes
		Varicellovirus	Varicella zoster virus (VZV)	Chickenpox, shingles
		Cytomegalovirus	Human cytomegalovirus (CMV)	CMV infections
	Adenoviridae	*Mastadenovirus*	Human adenoviruses	Adenovirus infection
	Papovaviridae	*Papillomavirus*	Human papillomavirus (HPV)	Several types of warts
		Polyomavirus	JC virus (JCV)	Progressive multifocal leukoencephalopathy (PML)
	Hepadnaviridae	*Hepadnavirus*	Hepatitis B virus (HBV or Dane particle)	Serum hepatitis
	Parvoviridae	*Erythrovirus*	Parvovirus B19	Erythema infectiosum

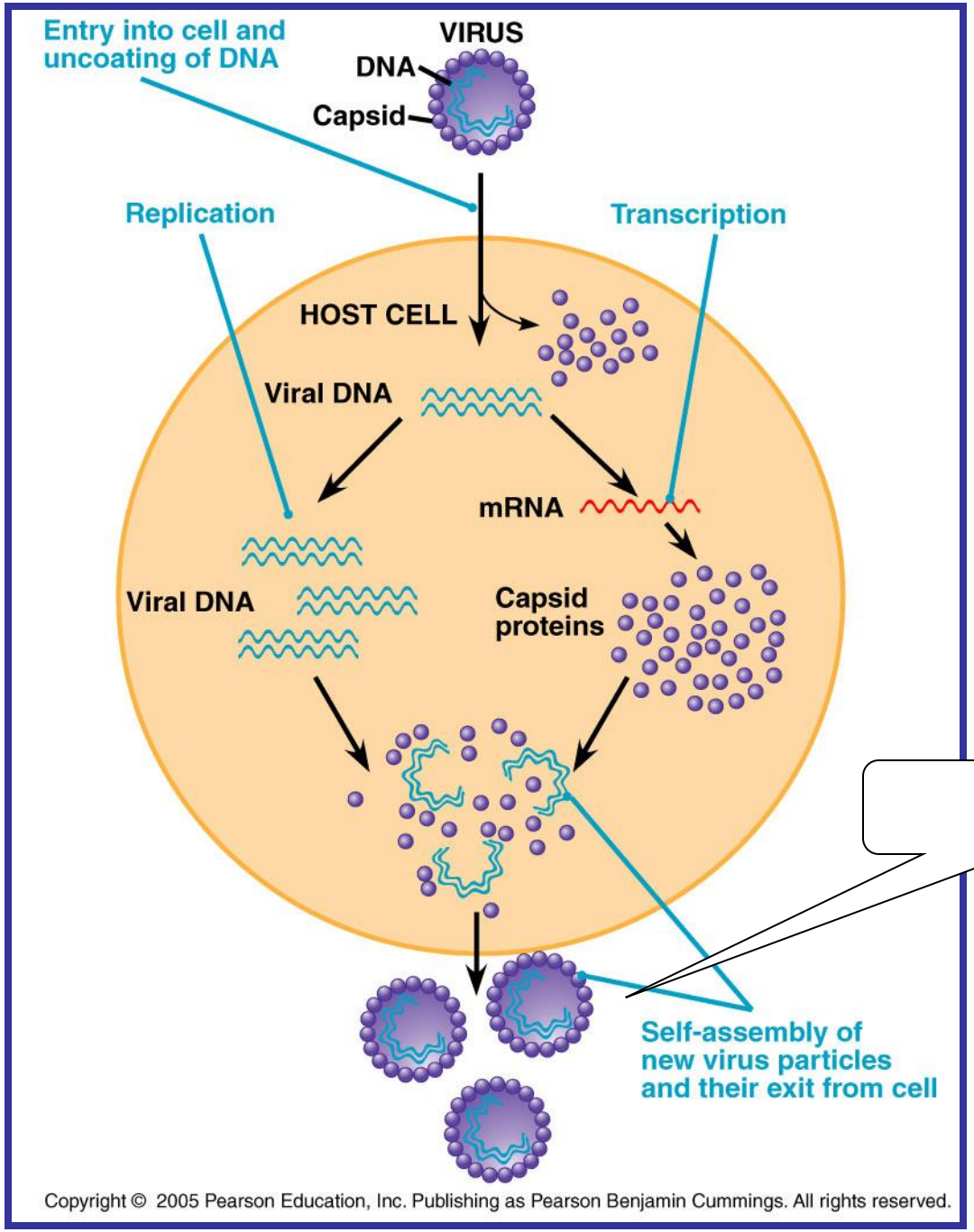
RNA Viruses				
	Picornaviridae	*Enterovirus*	Poliovirus	Poliomyelitis
			Coxsackievirus	Hand-foot-mouth disease
		Hepatovirus	Hepatitis A virus (HAV)	Short-term hepatitis
		Rhinovirus	Human rhinovirus	Common cold, bronchitis
	Caliciviridae	*Calicivirus*	Norwalk virus	Viral diarrhea, Norwalk virus syndrome
	Togaviridae	*Alphavirus*	Eastern equine encephalitis virus	Eastern equine encephalitis (EEE)
			Western equine encephalitis virus	Western equine encephalitis (WEE)
			Yellow fever virus	Yellow fever
			St. Louis encephalitis virus	St. Louis encephalitis
		Rubivirus	Rubella virus	Rubella (German measles)
	Flaviviridae	*Flavivirus*	Dengue fever virus	Dengue fever
			West Nile fever virus	West Nile fever
	Bunyaviridae	*Bunyavirus*	Bunyamwera viruses	California encephalitis
		Hantavirus	Sin Nombre virus	Respiratory distress syndrome
		Phlebovirus	Rift Valley fever virus	Rift Valley fever
		Nairovirus	Crimean–Congo hemorrhagic fever virus (CCHF)	Crimean–Congo hemorrhagic fever
	Filoviridae	*Filovirus*	Ebola, Marburg virus	Ebola fever
	Reoviridae	*Coltivirus*	Colorado tick fever virus	Colorado tick fever
		Rotavirus	Human rotavirus	Rotavirus gastroenteritis
	Orthomyxoviridae	*Influenza virus*	Influenza virus, type A (Asian, Hong Kong, and swine influenza viruses)	Influenza or "flu"
	Paramyxoviridae	*Paramyxovirus*	Parainfluenza virus, types 1–5	Parainfluenza
			Mumps virus	Mumps
		Morbillivirus	Measles virus	Measles (red)
		Pneumovirus	Respiratory syncytial virus (RSV)	Common cold syndrome
	Rhabdoviridae	*Lyssavirus*	Rabies virus	Rabies (hydrophobia)
	Retroviridae	*Oncornavirus*	Human T-cell leukemia virus (HTLV)	T-cell leukemia
		Lentivirus	HIV (human immunodeficiency viruses 1 and 2)	Acquired immunodeficiency syndrome (AIDS)
	Arenaviridae	*Arenavirus*	Lassa virus	Lassa fever
	Coronaviridae	*Coronavirus*	Infectious bronchitis virus (IBV)	Bronchitis
			Enteric corona virus	Coronavirus enteritis
			SARS virus	Severe acute respiratory syndrome

Steps of Virus Replication

1. **Attachment** – binds to cell
2. **Entry** (nucleic acid release)
3. **Synthesis** (viral genome and proteins)
4. **Assembly** (build virus)
5. **Release** (lysis or chronic release, e.g. budding – includes release of various enveloped viruses)

Host range = limited variety of hosts to infect

DNA Virus Life Cycle



Viral Replication

- Viral replication differs from other reproductive strategies and generates **genetic variation** through various mechanisms

- Viruses have highly efficient replicative capabilities that allow for **rapid evolution** and **acquisition of new phenotypes**

- RNA viruses **lack replication error-checking mechanisms**, and thus have higher rates of mutations

- Virus replication allows for mutations to occur through the usual host pathways

Viral Replication

- Related viruses can combine/recombine information if they infect the same host cell

- Viruses replicate via a **component assembly model** allowing one virus to produce many progeny simultaneously via the **lytic cycle**

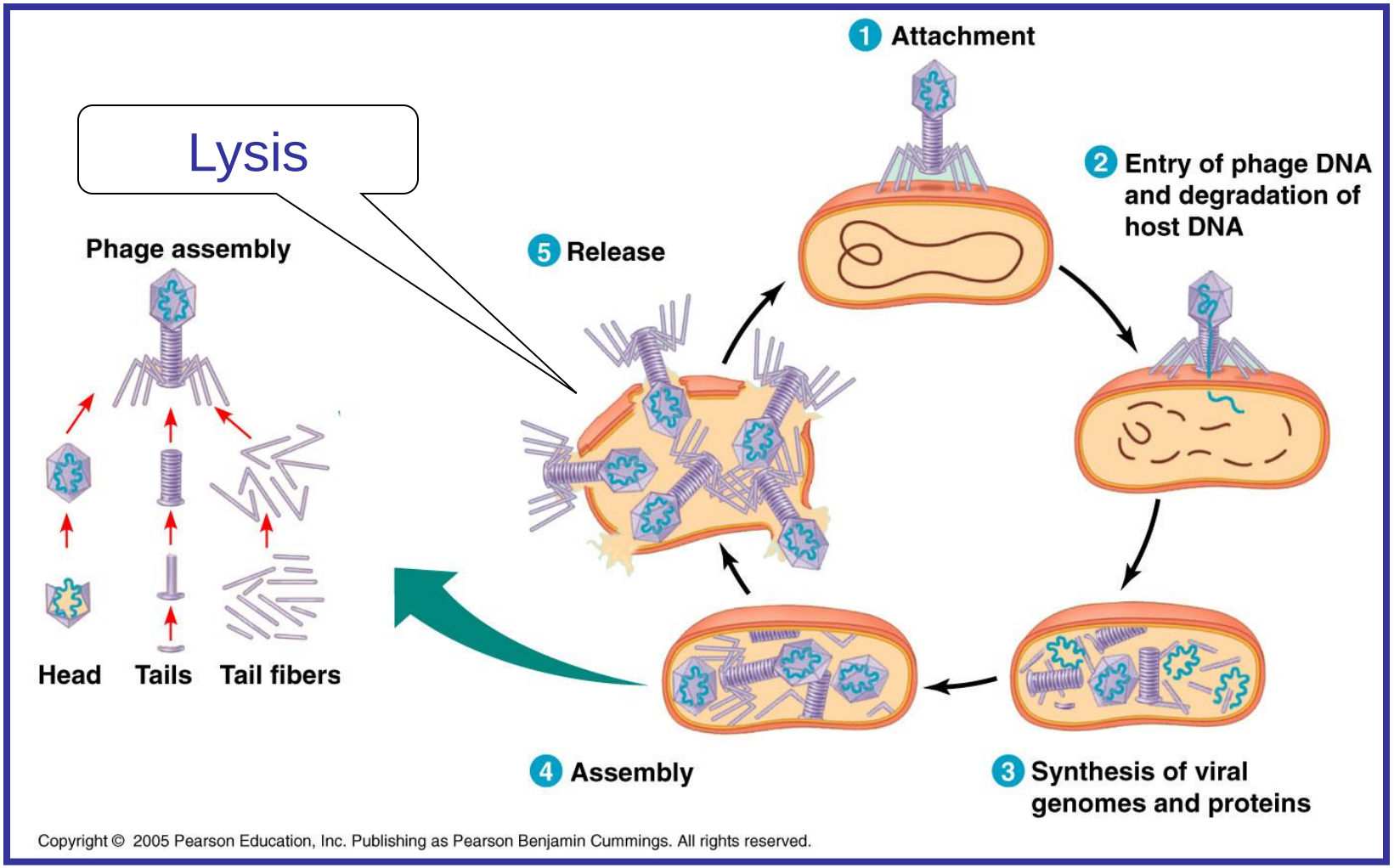
Viral Replication

- The reproductive cycles of viruses facilitate transfer of genetic information
  - Viruses transmit DNA or RNA when they infect a host cell
    - Ex: transduction in bacteria
    - Ex: transposons present in incoming DNA
      - "Jumping genes"

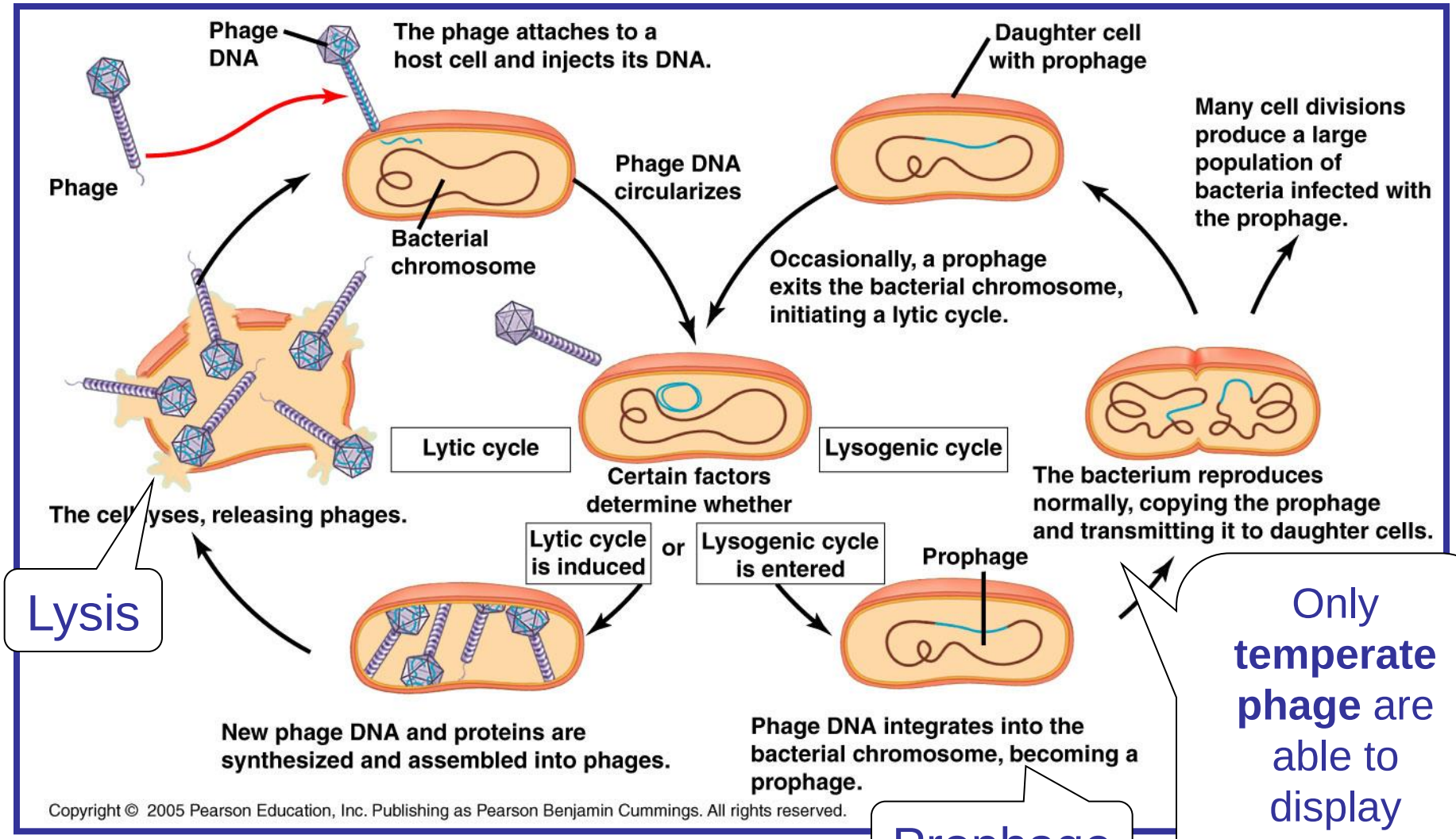
Viral Replication

- Some viruses are able to integrate into the host DNA and establish a latent (lysogenic) infection. These latent viral genomes can result in new properties for the host such as increased pathogenicity in bacteria
  - Pathogenicity = whether a virus causes a disease

Bacteriophage Lytic Cycle (Virulent Phage)



Lysogenic Cycle (Temperate Phage)

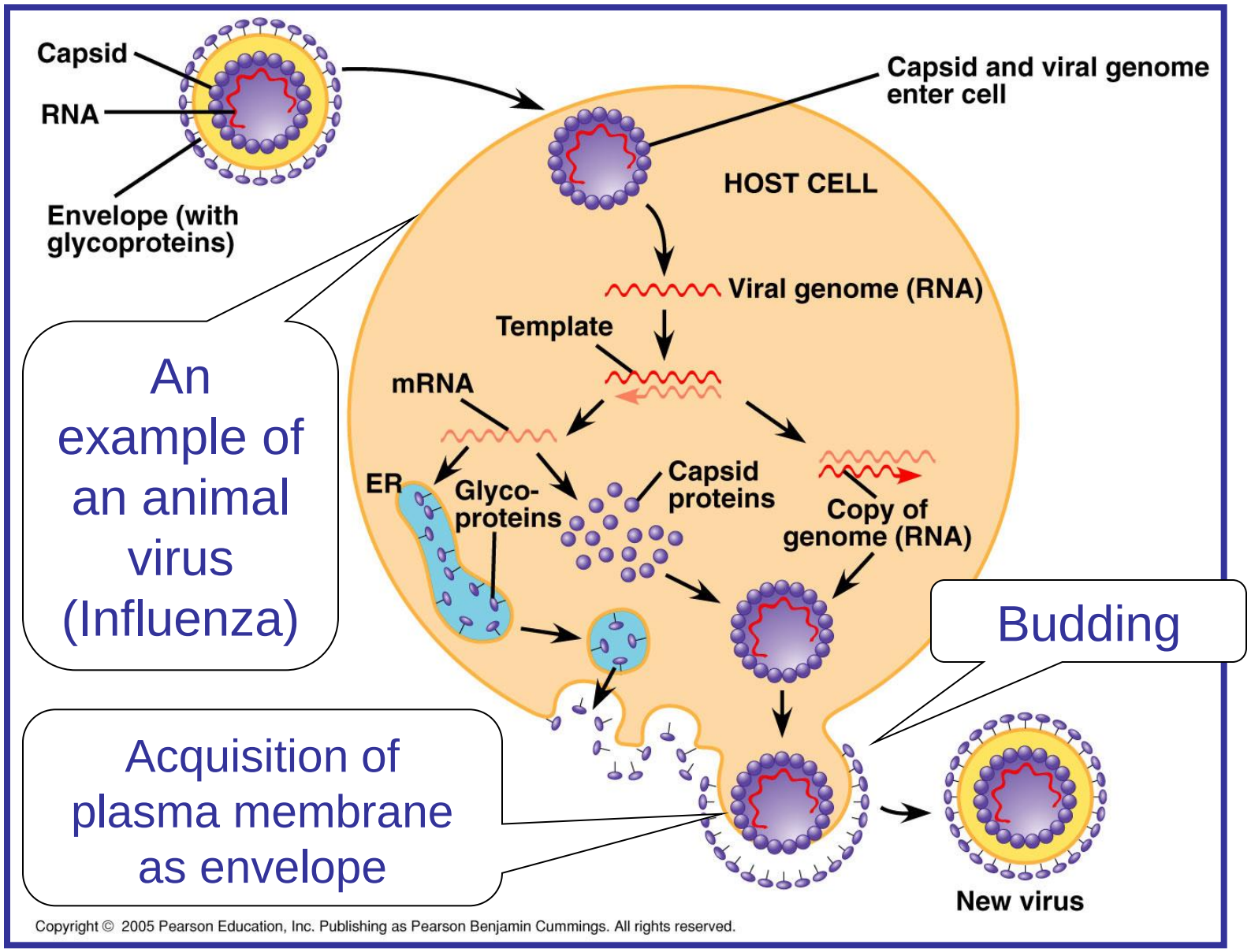


Lysis

Prophage

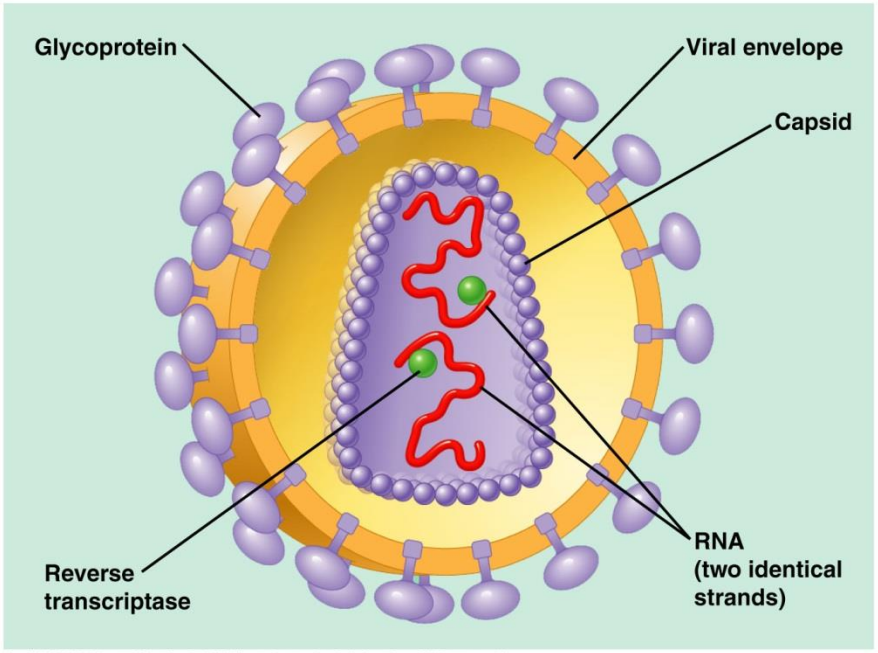
Only **temperate phage** are able to display lysogeny

Enveloped RNA Virus

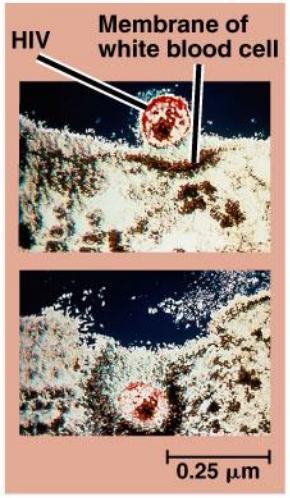


HIV Life Cycle

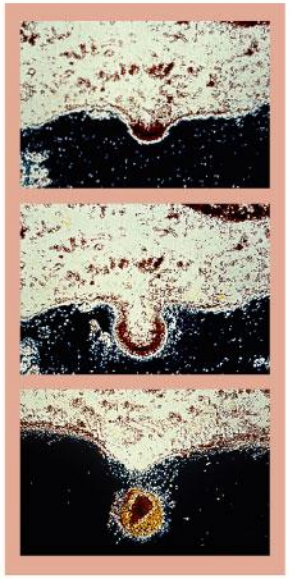
- HIV is a well-studied system where the rapid evolution of a virus within the host contributes to the pathogenicity of viral infection



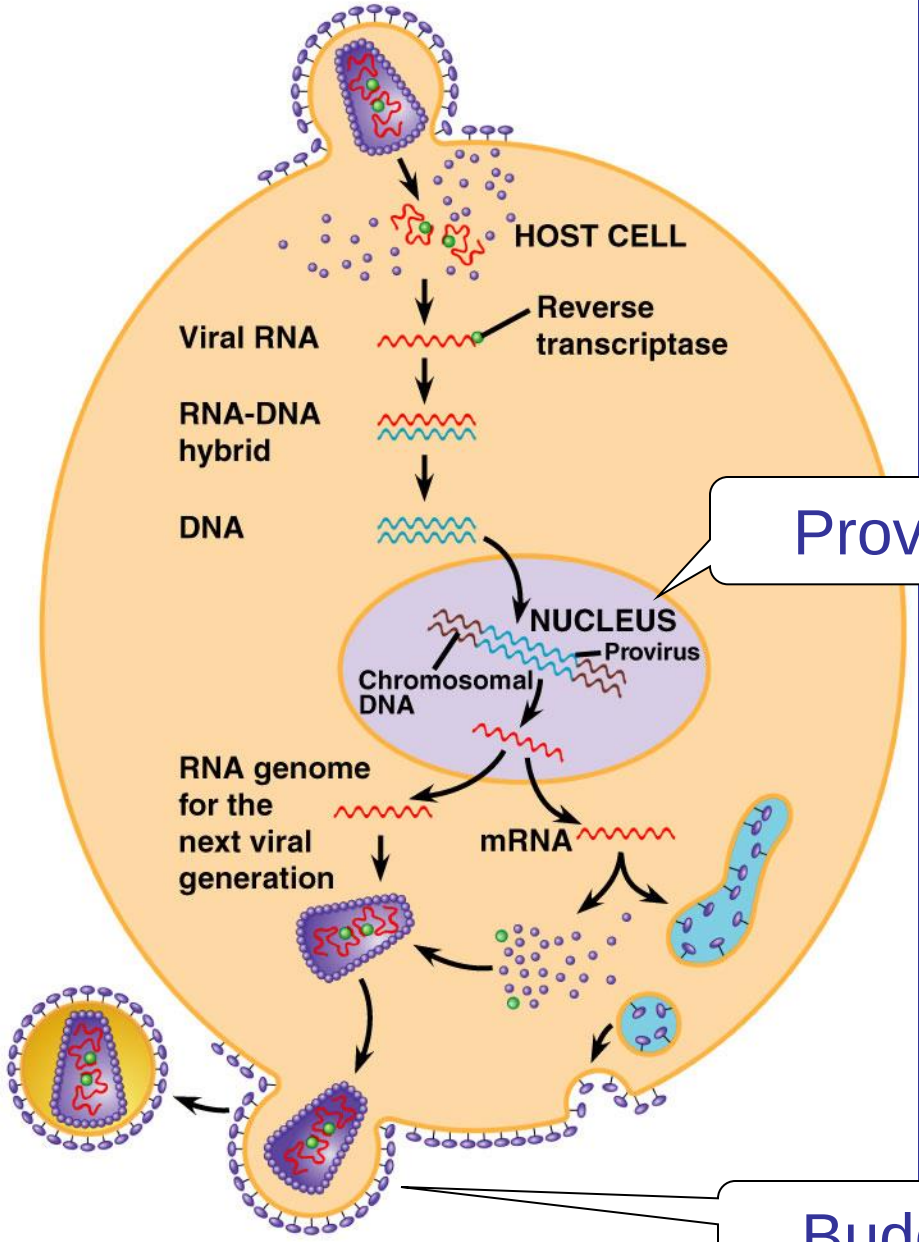
HIV Life Cycle



HIV entering a cell



New HIV leaving a cell



Animal Pathogens

- Emergence of new viruses
  - Mutations can lead to epidemics = new strains of a virus arise and people don't have an immunity for it
  - Dissemination of disease from small, isolated human population
  - Spread from other animals
  - Can lead to pandemics = global epidemic

Viroids and Prions

- Viroids = small, circular RNA molecule that infects plants
  - Not enclosed in proteins and disrupts growth of plants
- Prions = infectious proteins
  - Converts normal proteins into infectious proteins and are virtually indestructible
  - Causes brain deterioration
  - Ex: Mad cow disease

Learning Objectives

- The student is able to construct an explanation of how viruses introduce genetic variation in host organisms.
- The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population.