General Biology

Course No: BNG2003
Credits: 3.00

12. Viruses and Bacteria

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Bacteria, Viruses and Biomedical Engineering:

- Medicine ---> Biofilms etc

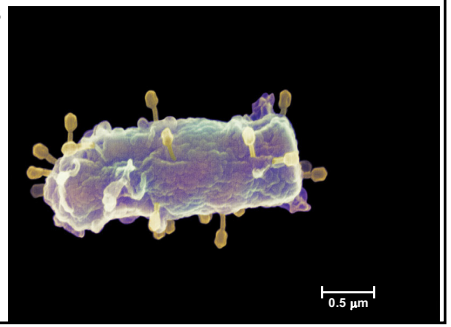
- Energy: Biofuel Cells

- Environment/Industries: Bioremediation

- Biotechnology: any kind of recombinant DNA applications – production of recombinant proteins for the treatment of human diseases.

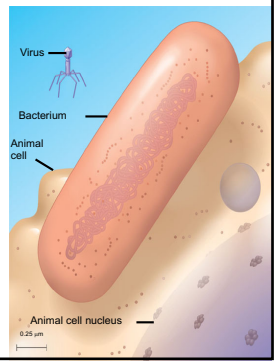
- Microbial Model Systems
- Viruses called bacteriophages can infect and set in motion a genetic takeover of bacteria, such as *Escherichia coli*
- *E. coli* and its viruses
  - are called model systems because of their frequent use by researchers in studies that reveal broad biological principles

Beyond their value as model systems
viruses and bacteria have unique genetic mechanisms that are interesting in their own right



- Recall that bacteria are prokaryotes with cells much smaller and more simply organized than those of eukaryotes
- Viruses are smaller and simpler still

- A virus has a genome but can reproduce only within a host cell
- Scientists were able to detect viruses indirectly long before they were actually able to see them



Structure of Viruses

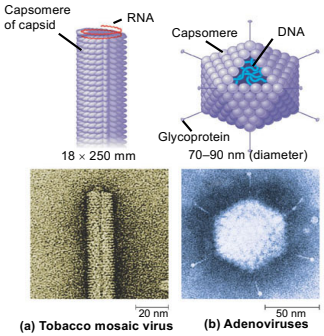
- Viruses are very small infectious particles consisting of nucleic acid enclosed in a protein coat and, in some cases, a membranous envelope.

Viral Genomes

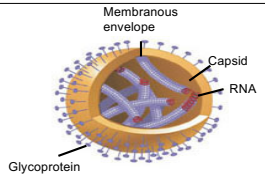
- Viral genomes may consist of
  - double- or single-stranded DNA
  - double- or single-stranded RNA

Capsids and Envelopes

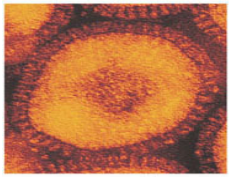
- A capsid is the protein shell that encloses the viral genome and can have various structures



- Some viruses have envelopes which are membranous coverings derived from the membrane of the host cell

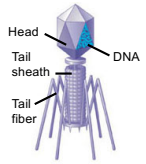


80–200 nm (diameter)

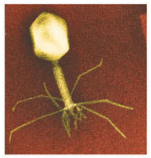


(c) Influenza viruses

- Bacteriophages, also called **phages** have the most complex capsids found among viruses



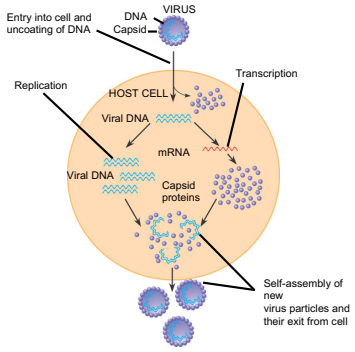
80 × 225 nm



(d) Bacteriophage T4

General Features of Viral Reproductive Cycles

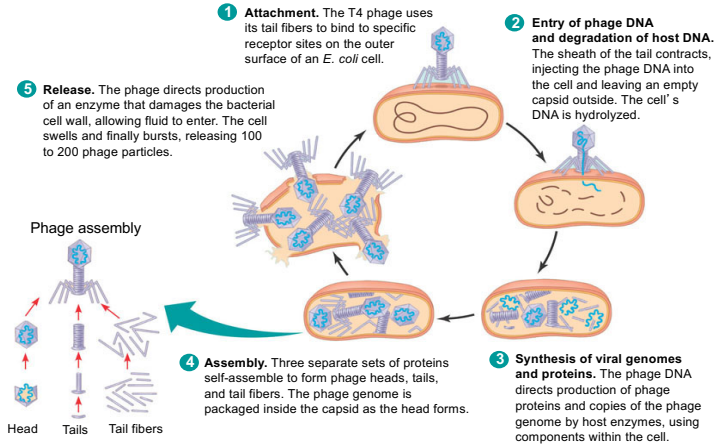
- Viruses are obligated intracellular parasites - they can reproduce only within a host cell
- Each virus has a host range - a limited number of host cells that it can infect
- Viruses use enzymes, ribosomes, and small molecules of host cells to synthesize progeny viruses



Reproductive Cycles of Phages

- Phages are the best understood of all viruses; they go through two alternative 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
  - produces new phages and digests the host's cell wall, releasing the progeny viruses

- The lytic cycle of phage T4, a virulent phage



The Lysogenic Cycle

- The lysogenic cycle
  - replicates the phage genome without destroying the host

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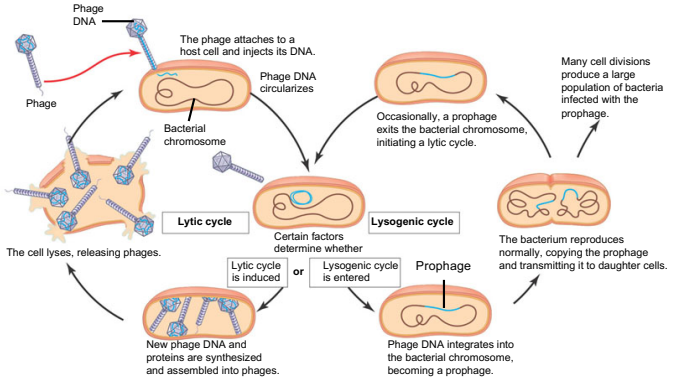
- Temperate phages
  - are capable of using both the lytic and lysogenic cycles of reproduction

The lytic and lysogenic cycles of phage λ (lambda), a temperate phage



Reproductive Cycles of Animal Viruses

- The nature of the genome is the basis for the common classification of animal viruses
  - Classes of animal viruses

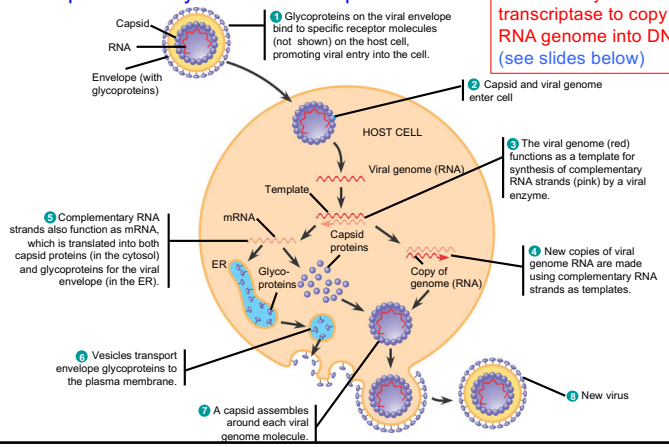
Table 18.1 Classes of Animal Viruses

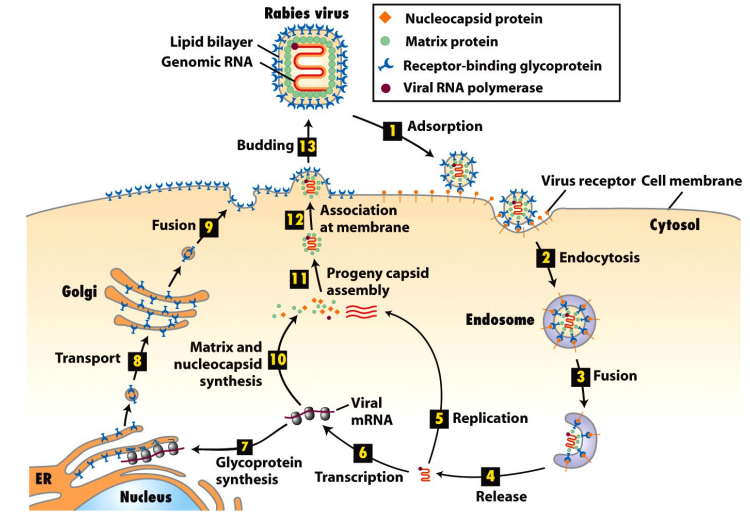
Class/ Family	Envelope	Examples/ Disease
I. Double-stranded DNA (dsDNA)		
Adenovirus (see Figure 18.4b)	No	Respiratory diseases; animal tumors
Papovavirus	No	Papillomavirus (warts, cervical cancer?; polyomavirus (animal tumors)
Herpesvirus	Yes	Herpes simplex I and II (cold sores, genital sores); varicella 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 (see Figure 18.11b)	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 (see Figure 18.4c)	Yes	Influenza virus
Paramyxovirus	Yes	Measles virus; mumps virus
Rhabdovirus	Yes	Rabies virus
VI. ssRNA; template for DNA synthesis		
Retrovirus (see Figure 18.9)	Yes	HIV, human immunodeficiency virus (AIDS); RNA tumor viruses (leukemia)

Viral Envelopes

- Many animal viruses have a membranous envelope
- Viral glycoproteins on the envelope bind to specific receptor molecules on the surface of a host cell
- The reproductive cycle of an enveloped RNA virus:

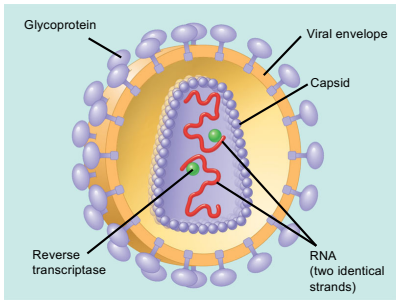
Retroviruses, such as HIV, use the enzyme reverse transcriptase to copy their RNA genome into DNA (see slides below)



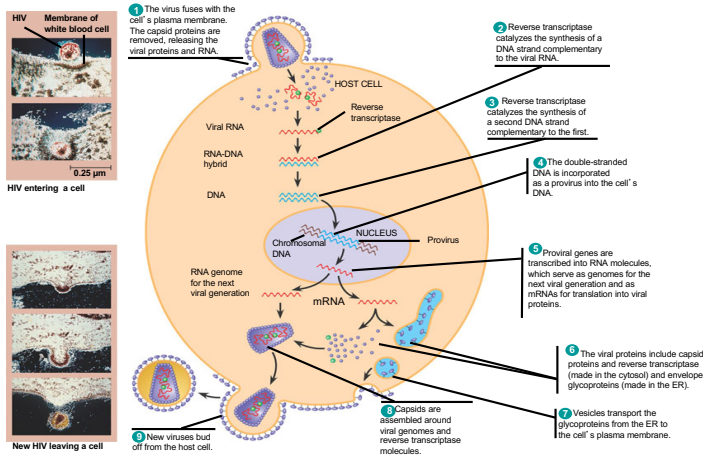


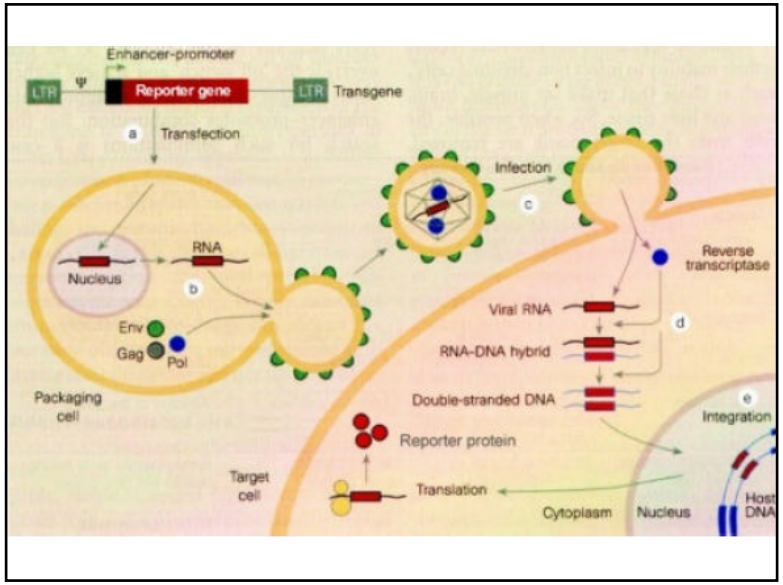
RNA as Viral Genetic Material

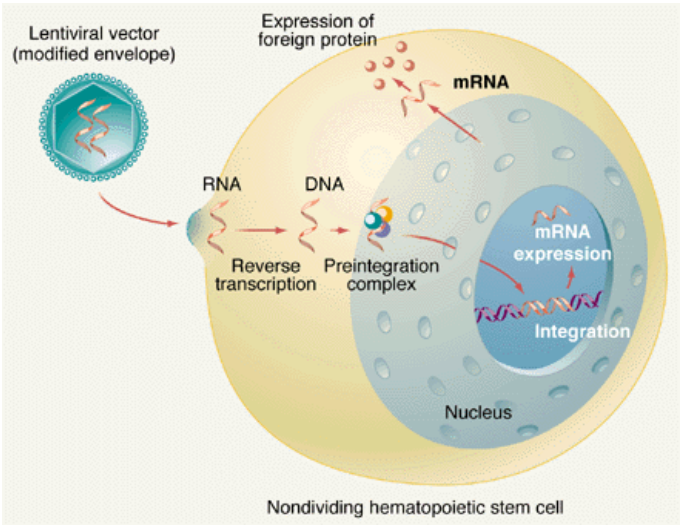
- The broadest variety of RNA genomes is found among the viruses that infect animals
- Retroviruses, such as HIV, use the enzyme reverse transcriptase to copy their RNA genome into DNA, which can then be integrated into the host genome as a provirus



• The reproductive cycle of HIV, a retrovirus

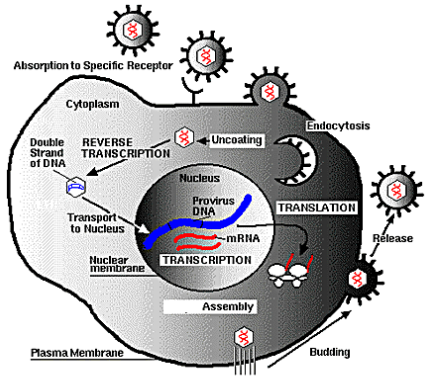






Lentiviruses

- **Retrovirus Family**
- **Single Strand (+) RNA virus**
- **Contains 2 copies**
- **Can infect non-dividing cells**
- **Contains regulatory proteins**
- **Latent or active viral states**
- **Spread by blood and other bodily fluids**
- **Long lived virus leading to reservoir for persistent infection**
- **Virus type present in many vertebrate species**



Retrovirus replication

Evolution of Viruses

- Viruses do not really fit our definition of living organisms
- Since viruses can reproduce only within cells, they probably evolved after the first cells appeared, perhaps packaged as fragments of cellular nucleic acid
- Viruses, viroids, and prions are formidable pathogens in animals and plants
- Diseases caused by viral infections affect humans, agricultural crops, and livestock worldwide

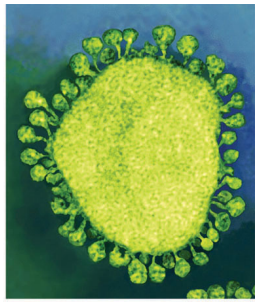
Viral Diseases in Animals

- 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

- Vaccines
  - are harmless derivatives of pathogenic microbes that stimulate the immune system to mount defenses against the actual pathogen
  - can prevent certain viral illnesses
- Emerging Viruses
  - are those that appear suddenly or suddenly come to the attention of medical scientists

- A few years ago, the Severe Acute Respiratory Syndrome (SARS) appeared in China

(a) Young ballet students in Hong Kong wear face masks to protect themselves from the virus causing SARS.



(b) The SARS-causing agent is a coronavirus like this one (colorized TEM), so named for the "corona" of glycoprotein spikes protruding from the envelope.

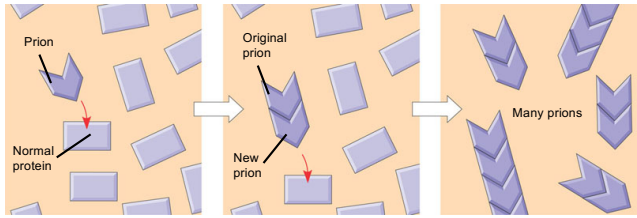
- Outbreaks of "new" viral diseases in humans are usually caused by existing viruses that expand their host territory

Viral Diseases in Plants

- More than 2,000 types of viral diseases of plants are known
- Common symptoms of viral infection include spots on leaves and fruits, stunted growth, and damaged flowers or roots
- 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

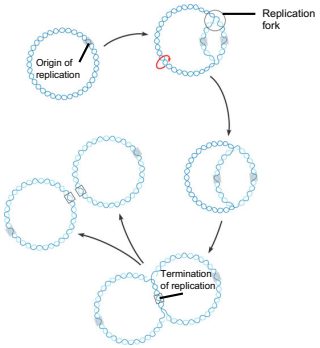
- Viroids are circular RNA molecules that infect plants and disrupt their growth
- ***Prions*** are slow-acting, virtually indestructible **infectious proteins** that cause brain diseases in mammals; prions propagate by converting normal proteins into the prion version



- Rapid reproduction, mutation, and genetic recombination contribute to the genetic diversity of bacteria
- Bacteria allow researchers to investigate molecular genetics in the simplest true organisms

The Bacterial Genome and Its Replication

- The bacterial chromosome is usually a circular DNA molecule with few associated proteins
- In addition to the chromosome, many bacteria have plasmids, smaller circular DNA molecules that can replicate independently of the bacterial chromosome
- Bacterial cells divide by binary fission which is preceded by replication of the bacterial chromosome

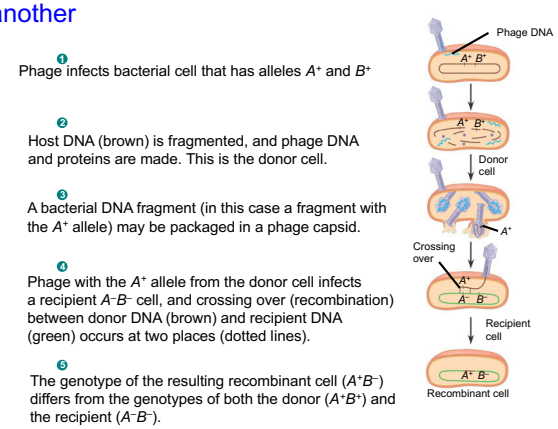


Mechanisms of Gene Transfer and Genetic Recombination in Bacteria

- Three processes bring bacterial DNA from different individuals together
  - Transformation
  - Transduction
  - Conjugation
- ***Transformation*** is the alteration of a bacterial cell's genotype and phenotype by the uptake of naked, foreign DNA from the surrounding environment

Transduction

- In the process known as transduction
  - Phages carry bacterial genes from one host cell to another



❶ Phage infects bacterial cell that has alleles A^+ and B^+

❷ Host DNA (brown) is fragmented, and phage DNA and proteins are made. This is the donor cell.

❸ A bacterial DNA fragment (in this case a fragment with the A^+ allele) may be packaged in a phage capsid.

❹ Phage with the A^+ allele from the donor cell infects a recipient A^-B^- cell, and crossing over (recombination) between donor DNA (brown) and recipient DNA (green) occurs at two places (dotted lines).

❺ The genotype of the resulting recombinant cell (A^+B^-) differs from the genotypes of both the donor (A^+B^+) and the recipient (A^-B^-).

Conjugation and Plasmids

- Conjugation is the direct transfer of genetic material between bacterial cells that are temporarily joined