Viruses, Archaea and Bacteria

Viruses and Viroids

Features of Prokaryotes

Bacterial Diversity

Archaeal Diversity
Viruses

A virus is a noncellular infectious agent

- Consists of a protein coat around a core of DNA or RNA
- Replicates only in a host cell
- Has no ribosomes or other metabolic machinery
A Tobacco mosaic virus, a nonenveloped plant virus.

B Herpesvirus, an enveloped animal virus.
**Bacteriophage Replication Pathways**

- **A** Phage binds to bacterial cell, inserts viral DNA (red).
- **A1** Phage DNA inserts into host chromosome (blue).
- **A2** Chromosome with integrated viral DNA is replicated.
- **A3** During cell division, new cells inherit a chromosome with viral DNA.
- **A4** Viral DNA is excised from chromosome and becomes active.
- **B** Host replicates viral DNA, builds viral proteins.
- **C** Viral components meet up and self-assemble.
- **D** New phage particles form inside the host cell.
- **E** Lysis of the host cell releases phages.

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**Retrovirus**: RNA virus that uses reverse transcriptase to produce viral DNA in a host cell
HIV Replication

- HIV replicates inside human white blood cells
- Spikes of viral protein attach to proteins in the cell’s plasma membrane
- Drugs that fight HIV interfere with viral binding to the host, reverse transcription, integration of DNA, or formation of viral proteins
Viral Diseases

- Caused by pathogenic viruses
- Usually produce mild symptoms
- Some persist in body for long periods (latent)/herpes virus
- Some increase the risk of cancer (HPV main cause of cervical cancer)
- High mutation rate especially in RNA viruses
- Viral recombination: viral genomes exchanging genes when two viruses infect a host at the same time
Common Viral Diseases

**Nonenveloped viruses:**
- Adenoviruses (colds)
- Viral gastroenteritis (stomach flu)
- Human papillomavirus (genital warts, cervical cancer)
Enveloped viruses:

- Herpes viruses (cold sores, genital herpes, infectious mononucleosis, chicken pox)
- Influenza (flu)
- Mumps, measles, and German measles

Emerging viral diseases:

- Changes to viral genomes as a result of mutation or gene exchanges can alter the properties of a viral disease
- A disease that was previously unknown, is new to humans, or has recently begun spreading to a new region
Viroids

A small RNA, circular and single-stranded without a protein coat

Do not encode proteins but interfere with normal gene expression
Prokaryotes
Bacteria and Archaea

- Unicellular

- Very small cells: 1-5 µm (1/10 the size of eukaryotes)

- Everywhere!!

- Both beneficial and harmful impacts on humans
The biological mass of prokaryotes is at least $10X$ that of all eukaryotes.

They play crucial roles in the biosphere:
- Photosynthetic
- Decomposers

Only a minority cause diseases in humans and other organisms / majority essential for life.
Prokaryotes
Bacteria and Archaea
**TABLE 19.1**

<table>
<thead>
<tr>
<th>Prokaryotic Traits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No nucleus, endoplasmic reticulum, Golgi bodies</td>
<td></td>
</tr>
<tr>
<td>2. Single chromosome (a circular DNA molecule); many species also contain plasmids</td>
<td></td>
</tr>
<tr>
<td>3. Cell wall (in most species)</td>
<td></td>
</tr>
<tr>
<td>4. Ribosomes distributed in the cytoplasm</td>
<td></td>
</tr>
<tr>
<td>5. Asexual reproduction by binary fission</td>
<td></td>
</tr>
<tr>
<td>6. Capacity for gene exchange among existing cells through conjugation, transduction, and transformation</td>
<td></td>
</tr>
</tbody>
</table>
Cell Shape

Important for identification and classification
Reproduction and Gene Exchange in Bacteria

Vertical gene transfer

Binary fission

Horizontal gene transfer

Conjugation

Transformation

Transduction
Binary Fission

1. A bacterium has one circular chromosome that attaches to the inside of the plasma membrane.

2. The cell duplicates its chromosome, attaches the copy beside the original, and adds membrane and wall material between them.

3. When the cell has almost doubled in size, new membrane and wall are deposited across its midsection.

4. Two genetically identical cells result.
Prokaryotic Conjugation
**Transformation**: introduction of foreign DNA/ *Streptococcus pneumoniae*

**Transduction**: process by which DNA is transferred from one bacterium to another by a virus
Metabolic Diversity

<table>
<thead>
<tr>
<th>ENERGY SOURCE</th>
<th>CARBON SOURCE</th>
<th>Inorganic source such as CO₂</th>
<th>Organic source such as glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td></td>
<td>Photoautotrophs bacteria, archaea, photosynthetic protists, plants</td>
<td>Photoheterotrophs bacteria, archaea</td>
</tr>
<tr>
<td>Chemicals</td>
<td></td>
<td>Chemoautotrophs bacteria, archaea</td>
<td>Chemoheterotrophs bacteria, archaea, fungi, animals, nonphotosynthetic protists</td>
</tr>
</tbody>
</table>

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Cell Wall in Bacteria

**Peptidoglycan**: Polymer of sugars cross-linked by short polypeptides
Some Major Bacterial Lineages

Oxygen-Producing Cyanobacteria

Proteobacteria

Gram positive bacteria

Spirochetes
Cyanobacteria

Partner with fungi and form lichens
Chloroplasts in eukaryotes evolved from cyanobacteria
Proteobacteria

All gram negative
Most diverse/ mode of nutrition and habitats
Share one RNA sequence

Thiomargarita namibiensis

The largest known bacterium
Has an enormous vacuole that holds sulfur and nitrate

E. Coli

Agrobacterium sp.

Rhizobium sp.
Diverse group
Include species that are very common soil/important organic matter decomposers
*Streptococcus, Bacillus, Lactobacillus*
Spirochetes

Free living and parasites
Cattle guts/ help with cellulose digestion
Notorious pathogens/ Syphilis and Lyme disease
How Do Bacteria Affect Human Health?

- Normal flora
  - Normally harmless or beneficial microorganisms that typically live in or on a body: *E. coli* (vit. K)/**Lactobacillus sp.* (vit. E)

- Some endospore*-forming bacteria make deadly toxins:
  - *Bacillus anthracis*: anthrax
  - *Clostridium tetani*: tetanus
  - *C. botulinum*: botulism
Infectious Bacteria

About one half of the human illnesses are caused by pathogenic bacteria: **most produce poison**
Exotoxins: secreted proteins (*E. coli*)
Endotoxins: components of the outer membrane (*Salmonella sp.*)

- *Mycobacterium tuberculosis*: tuberculosis
- *Streptococcus*: strep throat
- *Staphylococcus aureus*: Antibiotic-resistant staph infections
Archaea

prokaryotes  eukaryotes  bacteria  archaea  eukaryotes
Comparing Archaea & Bacteria

Archaea share some traits with Bacteria, some with Eukarya, some unique

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Bacteria</th>
<th>Archaea</th>
<th>Eukarya</th>
</tr>
</thead>
<tbody>
<tr>
<td>rRNA sequences</td>
<td>Some unique to bacteria</td>
<td>Some unique to archaea; some match eukaryotic sequences</td>
<td>Some unique to eukaryotes; some match archaeal sequences</td>
</tr>
<tr>
<td>RNA polymerase</td>
<td>One kind; relatively small and simple</td>
<td>Several kinds; complex</td>
<td>Several kinds; complex</td>
</tr>
<tr>
<td>Introns</td>
<td>Rare</td>
<td>In some genes</td>
<td>Present</td>
</tr>
<tr>
<td>Peptidoglycan in cell wall</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Histones associated with DNA</td>
<td>Absent</td>
<td>Present in some species</td>
<td>Present</td>
</tr>
</tbody>
</table>

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Archaea

- Extreme Halophiles
- Extreme Thermophiles
- Methanogens