Chapter 18: Viruses and Prokaryotes

Bacteria lining the esophagus
Viruses, bacteria, viroids, and prions can all cause infection.

- Any disease-causing agent is called a pathogen.

**VIRUSES**

- Viruses, bacteria, viroids, and prions can all cause infection.
- Any disease-causing agent is called a pathogen.

**Eukaryotic cells - prokaryotic cells – viruses – viroids - prion**
(based on largest to smallest in SIZE)
• A virus is made of DNA or RNA and a protein coat.
  – non-living pathogen
  – can infect many organisms
  – MUST have a host to replicate
• A viroid is made only of single-stranded RNA.
  – causes disease in plants
  – can stunt plant growth
  – passed through seeds or pollen
• A prion is made only of proteins.
  – causes misfolding of other proteins
  – results in diseases of the brain (mad cow disease)
  – can incubate for a long time but once symptoms appear they worsen quickly and are always fatal because the body has no immune response to a protein
Viruses differ in shape and in ways of entering host cells.

- Viruses have a simple structure.
  - genetic material (DNA or RNA)
  - Capsid - a protein shell
  - maybe a lipid envelope, a protective outer coat
Bacteriophages are viruses that infect bacteria.

- The bacteriophage attaches to the host with its tail and spikes
- The tail releases an enzyme that breaks down part of the bacteria’s cell wall
- The DNA is injected into the host cell
Viruses of eukaryotes fuse with the cell membrane
Viruses cause two types of infections: lytic or lysogenic

- A lytic infection causes the host cell to burst.

The bacteriophage attaches and injects its DNA into a host bacterium. The viral DNA forms a circle. The host bacterium breaks apart, or lyses. Bacteriophages are able to infect new host cells. The viral DNA directs the host cell to produce new viral parts. The parts assemble into new bacteriophages. (takes over the cell)
Viruses cause two types of infections: lytic or lysogenic

- A lysogenic infection does no immediate harm because it combines its DNA into the host cell’s DNA and remains dormant until a trigger (stress, etc.) causes it to enter the lytic cycle.

The prophage may leave the host’s DNA and enter the lytic cycle.

The viral DNA is called a prophage when it combines with the host cell’s DNA.

Many cell divisions produce a colony of bacteria infected with prophage.

Although the prophage is not active, it replicates along with the host cell’s DNA.
Viruses cause many infectious diseases

- There are many examples of viral infections.
  - common cold
    - There are more than 200 viruses that can cause a cold
    - They can mutate
  - Influenza (flu)
    - Spreads quickly and can result in epidemics (rapid outbreak of an infection that effects many people).
  - SARS
    - Severe Acute Respiratory Syndrome is a viral respiratory disease.
    - Causes fever, coughing, difficulty breathing
HIV

- Human immunodeficiency virus
- Is a retrovirus (virus that contains RNA and uses an enzyme to make a DNA copy).
  - DNA is usually made from RNA
- Can remain dormant for many years
- Destroys white blood cells of the host’s immune system

HIV-infected white blood cell
Vaccines are made from weakened pathogens.

- A vaccine stimulates the body’s own immune response.
- Vaccines prepare the immune system for a future attack.

<table>
<thead>
<tr>
<th>VIRAL INFECTION</th>
<th>SYMPTOMS OF DISEASE</th>
<th>TRANSMISSION OF DISEASE</th>
<th>U.S. VACCINE RECOMMENDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickenpox</td>
<td>rash, itchy skin, fever, fatigue</td>
<td>contact with rash, droplet inhalation</td>
<td>for children between 12 and 18 months</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>yellow skin, fatigue, abdomin al pain</td>
<td>contact with contaminated feces</td>
<td>for people traveling to infected locations and protection during outbreaks</td>
</tr>
<tr>
<td>Mumps</td>
<td>painful swelling in salivary glands, fever</td>
<td>droplet inhalation</td>
<td>for children between 12 and 15 months and again at 4 to 6 years</td>
</tr>
<tr>
<td>Rabies</td>
<td>anxiety, paralysis, fear of water</td>
<td>bite from infected animal</td>
<td>for veterinarians and biologists in contact with wildlife</td>
</tr>
<tr>
<td>West Nile</td>
<td>fever, headache, body ache</td>
<td>bite from infected mosquito</td>
<td>no available vaccine</td>
</tr>
</tbody>
</table>

- Vaccines are the only way to control the spread of viral disease.
13.1 Ecologists Study Relationships

**Prokaryotes**

- Bacteria and archaea are both single-celled prokaryotes.
  - Prokaryotes can be grouped by their need for oxygen.
    - **obligate anaerobes** are poisoned by oxygen (cannot live where oxygen is found)
    - **obligate aerobes** need oxygen
    - **facultative aerobes** can live with or without oxygen

One gram of soil can contain as many as 5 billion bacteria cells from up to 10,000 types of bacteria!!!!!
Bacteria and archaea are structurally similar but have different molecular characteristics.

- Bacteria commonly come in three forms.
  - rod-shaped, called bacilli
  - spiral, called spirilla or spirochetes
  - spherical, called cocci

- Archaea have many shapes.
Bacteria and archaea have similar structures.

- They are made up of:
  - plasmid (circular piece of genetic material in bacteria that can replicate separately from the prokaryote’s main chromosome)
  - flagellum
  - pili
  - cell wall
  - DNA

This diagram shows the typical structure of a prokaryote. Archaea and bacteria look very similar, although they have important molecular differences.
Bacteria and archaea have molecular differences.

- The amount of peptidoglycan within the cell wall can differ between bacteria

  **GRAM NEGATIVE**
  **GRAM POSITIVE**

- Bacteria have peptidoglycan in the cell walls, but Archaea DO NOT!!!

- Gram staining identifies bacteria.
  - stains polymer peptidoglycan
    - gram-positive stains purple, more peptidoglycan
    - gram-negative stains pink, less peptidoglycan
Bacteria have various strategies for survival.

- Prokaryotes exchange genes during conjugation (process by which a prokaryote transfers part of its chromosome to another prokaryote).
  - This is a way to exchange genetic information.
- Bacteria may survive by forming endospores (prokaryotic cell with a thick, protective wall surrounding its DNA).
  - Helps it to survive harsh conditions such as drying out, temperature change, etc..
Prokaryotes provide nutrients to humans and other animals.

- Prokaryotes live in digestive systems of animals.
  - make vitamins (vitamin B)
  - break down food
Bacteria help ferment (chemically break down) many foods to give them their flavors.

- yogurt, cheese
- pickles, sauerkraut
- soy sauce, vinegar
Prokaryotes play important roles in ecosystems.

- Prokaryotes have many functions in ecosystems.
  - photosynthesize (cyanobacteria help to produce oxygen through photosynthesis)
  - recycle carbon, nitrogen, hydrogen, sulfur through the ecosystem
  - fix nitrogen (nitrogen from the air cannot be used by plants, so bacteria convert the nitrogen into ammonia and other nitrogen compounds that plants need)
Prokaryotes play important roles in ecosystems.

- Bioremediation uses prokaryotes to break down pollutants.
  - oil spills (certain bacteria can be used to clean up oil spills and other industrial accidents)
  - biodegradable materials (this means bacteria can break down the materials)
Some bacteria cause disease.

- Bacteria cause disease by invading tissues or making toxins.
  - A toxin is a poison released by an organism.
- Tuberculosis (TB) bacteria multiply in the lungs and kill white blood cells that respond to the invasion.
- *Staphylococcus aureus* can be transferred by contaminated food and can cause food poisoning.
- *Clostridium botulinum* causes a serious illness called botulism from improperly canned foods. This can kill you!
• Normally harmless bacteria can become destructive when introduced to a part of the host not adapted to them.

  ▪ May happen if a bacteria get into tissues that they do not usually colonize (occupy) through a cut, scrape, or surgical incision.
  ▪ *Streptococci* bacteria are normally found on the skin BUT if it comes in contact with tissues (muscle or fat) then they can become “flesh eating”
Normally harmless bacteria can become destructive.

- immune system may be lowered

<table>
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<th>SYMPTOMS</th>
<th>CAUSES</th>
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</thead>
<tbody>
<tr>
<td>Acne</td>
<td><em>Propionibacterium</em></td>
<td>chronic cysts, blackheads</td>
<td>increased oil production in skin</td>
</tr>
<tr>
<td>Anthrax</td>
<td><em>Bacillus anthracis</em></td>
<td>fever, trouble breathing</td>
<td>inhaling endospores</td>
</tr>
<tr>
<td>Lyme disease</td>
<td><em>Borrelia burgdorferi</em></td>
<td>rash, aching, fever, swelling of joints</td>
<td>bite from infected tick</td>
</tr>
<tr>
<td>Tetanus</td>
<td><em>Clostridium tetani</em></td>
<td>severe muscle spasms, fever, lockjaw</td>
<td>wound contaminated with soil</td>
</tr>
<tr>
<td>Tooth decay</td>
<td><em>Streptococcus mutans</em></td>
<td>tooth cavities</td>
<td>large populations of bacteria in mouth</td>
</tr>
</tbody>
</table>
Antibiotics are used to fight bacterial disease.

- Antibiotics are chemicals that kill or slow the growth of bacteria.
  - Stop bacteria from making cell walls
- Antibiotics do not work on viruses.
  - Viruses DO NOT have cell walls!!!
- Prevention is best method to fight bacterial disease.
Bacteria can evolve resistance to antibiotics.

- Bacteria are gaining resistance to antibiotics.
  - overuse
  - underuse
  - misuse
- Antibiotics must be used properly.
- “Superbugs” are bacteria that are multidrug resistant and are almost impossible to treat.