Bacteria outline—CHAPTER 19

- **Bacteria**
  Structure and Function
- **Prokaryote & Eukaryote Evolution**
  Cellular Evolution
  - Current evidence indicates that eukaryotes evolved from prokaryotes between 1 and 1.5 billion years ago
  - Two theories:
    1. Infolding theory
    2. Endosymbiotic theory
  - **Infolding Theory**
    - The infolding of the prokaryotic plasma membrane gave rise to eukaryotic organelles.
  - **Endosymbiotic Theory**
    - Endosymbiosis refers to one species living within another (the host)
    - Movement of smaller photosynthetic & heterotrophic prokaryotes into larger prokaryotic host cells
    - Formed cell organelles
- **Prokaryotic & Eukaryotic Cells**

![Prokaryotic and Eukaryotic Cells](image)

- **Earliest Prokaryotes**
  - Most numerous organisms on Earth
  - Include all bacteria
  - Earliest fossils date 2.5 billion years old
- **Classification of Life**
  - Three Domains of Life
    - **Archaea**—prokaryotes living in extreme habitats
    - **Bacteria**—Cyanobacteria and eubacteria
    - **Eukarya**—Protozoans, fungi, plants, & animals
  - **Kingdoms of Bacteria**
    - **Archaeabacteria:**
      - Found in harsh environments
      - Undersea volcanic vents, acidic hot springs, salty water
    - **Eubacteria:**
      - Called the true bacteria
      - Most bacteria are in this group
      - Include photosynthetic Cyanobacteria

**Characteristics of Bacteria**
- **Bacterial Structure**
- Microscopic prokaryotes
- No nucleus or membrane-bound organelles
- Contain ribosomes
- Single, circular chromosome in nucleoid region

- Protection
  - Cell Wall made of Peptidoglycan
  - May have a sticky coating called the Capsule for attachment to host or other bacteria
  - Sticky Bacterial Capsule

- Bacterial Structure
  - Have small rings of DNA called Plasmids
  - Unicellular
  - Small in size (0.5 to 2μm)

- Bacterial Structure
  - Infoldings of cell membrane carry on photosynthesis & cellular respiration
  - Infoldings called Mesosomes

- Most grow best at pH of 6.5 to 7.0
  - Many act as decomposers recycling nutrients
  - Some cause disease
    - Staphylococcus Bacterial (aka --Staph infection)

- Useful Bacteria
  - Industry--Some bacteria can degrade oil, Used to clean up oil spills
    - Clean poison, wastes from water
    - Mine minerals from the ground
  - Food, beverages--Other uses for bacteria include making yogurt, cheese, and buttermilk.
  - Agriculture--Nitrogen fixers
  - Synthesize drugs through genetic engineering—insulin
  - Decomposers—like we saw in food web
• **Flagella**
  • Bacteria that are motile have appendages called flagella
  • Attached by Basal Body

  ![Diagram of Flagella](image)

• **A bacteria can have one or many flagella**
• **Made of Flagellin**
• **Used for Classification**
  • Monotrichous: 1 flagella
  • Lophotrichous: tuft at one end
  • Amphitrichous: tuft at both ends
  • Peritrichous: all around bacteria

• **Pili**
  • Short protein appendages
  • Smaller than flagella
  • Adhere bacteria to surfaces
  • Used in conjugation for Exchange of genetic information
  • Aid Flotation by increasing buoyancy

• **Pili in Conjugation**
• **Bacterial Shapes**
  • Shapes Are Used to Classify (DRAW shapes next to bacteria type)
    • Bacillus: Rod shaped
    • Coccus: Spherical (round)
    • Vibrio: Comma shaped with flagella
    • Spirillum: Spiral shape
    • Spirochete: wormlike spiral shape

• **Grouping of Bacteria**
  • Diplo- Groups of two
  • Strepto- chains
  • Staphylo- Grapelike clusters
    • Diplococcus
    • Staphylococcus
    • Streptobacilli
    • Spirillum
    • Spirochetes
    • *Leptospira*

• **Bacterial Kingdoms**
  • **Archaeabacteria**
    • Lack peptidoglycan in cell walls
    • Have different lipids in their cell membrane
    • Different types of ribosomes
    • Very different gene sequences
Archaebacteria can live in extremely harsh environments
• They do not require oxygen and can live in extremely salty environments as well as extremely hot environments
• Called the Ancient bacteria
• Subdivided into 3 groups:
  ✓ Methanogens
  ✓ Thermoacidophiles
  ✓ Extreme Halophiles

• Methanogens
  • Live in anaerobic environments (no oxygen)
  • Get energy by changing $H_2$ & $CO_2$ into methane gas
  • Found in swamps, sewage treatment plants, digestive tracts of animals
  • Break down cellulose in a cow’s stomach
  • Produce marsh (methane) gas

• Extreme Halophiles
  • Live in very salty water
  • Use salt to generate ATP (energy)
  • Dead Sea, Great Salt Lake inhabitants

• Thermoacidophiles or Thermophiles
  • Live in extremely hot environments
  • Found in volcanic vents, hot springs, cracks on ocean floor that leak acid

• Kingdom Eubacteria—True bacteria (See p 472, FIGURE 19-2 in book)
  • Characteristics
    • 3 basic shapes (coccus, bacillus, spirilla)
    • Most are heterotrophic (can’t make their own food)
    • May be aerobic or anaerobic
    • Identified by Gram staining

• Gram Staining
  • Developed in 1884 by Hans Gram
  • Bacteria treated with purple Crystal Violet & red Safranin stains
  • Cell walls either stain purple or reddish pink

• Gram Positive
  • Have thick layer of peptidoglycan (protein-sugar complex)
  • Single lipid layer
  • Stain purple
  • Can be treated with antibiotics

• Gram Positive Bacteria
  ✓ Lactobacilli (makes yogurt & buttermilk)
  ✓ Actinomycetes (make antibiotics)
  ✓ Clostridium (lockjaw bacteria)
  ✓ Streptococcus (strep throat)
  ✓ Staphylococcus (staph infections)

• Gram Negative Bacteria
  • Thin layer of peptidoglycan in cell wall
  • Extra thick layer of lipids
  • Stain pink or reddish
  • Hard to treat with antibiotics
  • Some photosynthetic but make sulfur not oxygen
  • Some fix nitrogen for plants
- **Gram Negative**
  - Rhizobacteria grow in root nodules of legumes (soybeans, peanuts)
  - Fix N\textsubscript{2} from air into usable ammonia
  - Rickettsiae are parasitic bacteria carried by ticks
  - Cause Lyme disease & Rocky Mountain Spotted Fever

- **Cyanobacteria**
  - Gram negative
  - Photosynthetic
  - Called blue-green bacteria
  - Contain phycocyanin (red-blue) pigments & chlorophyll
  - May be red, yellow, brown, black, or blue-green
  - May grow in chains (*Oscillatoria*)
  - Have Heterocysts to help fix N\textsubscript{2}
  - First to re-enter devastated areas
  - Some cause Eutrophication (use up O\textsubscript{2} when die & decompose in water)

- **Spirochetes**
  - Gram positive
  - Flagella at each end
  - Move in corkscrew motion
  - Some aerobic; others anaerobic
  - May be free living, parasitic, or symbiotic

- **Enteric Bacteria**
  - Gram negative
  - Can live in aerobic & anaerobic habitats
  - Includes *E. coli* in intestines
  - *Salmonella* – causes food poisoning

- **Chemoautotrophs**
  - Gram negative
  - Obtain energy from minerals like iron
  - Found in freshwater ponds

**Nutrition, Respiration, and Reproduction**

- **Modes of Nutrition**
  - Saprobes – feed on dead organic matter
  - Parasites – feed on a host cell
  - Photoautotroph – use sunlight to make food
  - Chemoautotroph – oxidize inorganic matter such as iron or sulfur to make food

- **Methods of Respiration**
  - Obligate Aerobes – require O\textsubscript{2} (tuberculosis bacteria)
  - Obligate Anaerobes – die if O\textsubscript{2} is present (tetanus)
  - Facultative Anaerobes – don’t need O\textsubscript{2}, but aren’t killed by it (*E. coli*)

- **Bacterial Respiration**
  - Anaerobes carry on fermentation
  - Aerobes carry on cellular respiration

- **Reproduction**
  - Bacteria reproduce asexually by binary fission
  - Single chromosome replicates & then cell divides
  - Rapid
  - All new cells identical (clones)

- **Binary Fission *E. Coli***
Reproduction
- Bacteria reproduce sexually by Conjugation
- Form a tube between 2 bacteria to exchange genetic material
- Held together by pili
- New cells NOT identical

Spore Formation
- Form endospore whenever habitat conditions become harsh (little food)
  - Able to survive for long periods of time as endospore
  - Difficult to destroy (heat resistant)

Transduction & Transformation
- Genetically change bacteria
- May become antibiotic resistant
- Transformed bacteria pick up pieces of DNA from dead bacterial cells
- Transduction – viruses carry foreign DNA to bacteria; used to make insulin

Pathogenic Bacteria
- Pathogens
  - Called germs or microbes
  - Cause disease
  - May produce poisons or toxins
  - Endotoxins released after bacteria die (E. coli)
  - Exotoxins released by Gram + bacteria (C. tetani)

GERM theory: Infectious diseases are caused by microorganisms of different types.
- Some diseases are caused by viruses, bacteria, and fungi.
- Others caused by materials in the environment
- Others are inherited

- Diseases caused by bacteria—see p 486 FIG 19-13
- Diseases caused by viruses—see p 488 FIG 19-14