**Chapter 11**

**Characterizing and Classifying Prokaryotes**

**Prokaryotes**

• Most diverse group of organisms

• Habitats

• From Antarctic glaciers to thermal hot springs

• From colons of animals to cytoplasm of other prokaryotes

• From distilled water to supersaturated brine

• From disinfectant solutions to basalt rocks

• Only a few capable of colonizing humans and causing disease

**Morphology of Prokaryotic Cells**

• Coccus

• Coccobacillus

• Bacillus

• Vibrio

• Spirillium

• Spirochete

• Pleomorphic

**Reproduction of Prokaryotic Cells**

• All reproduce asexually

• Three methods

• Binary fission (most common)

• Snapping division

• Budding

* Viviparity

**Arrangements of Prokaryotic Cells**

• Result from two aspects of division during binary fission

• Planes in which cells divide

* + Cocci divide in multiple places, bacilli in only one

• Separation of daughter cells

**Modern Prokaryotic Classification**

• Currently based on genetic relatedness of rRNA sequences

• Three domains

• Archaea

• Bacteria

• Eukarya

**Survey of Archaea**

• Common features

• Lack peptidoglycan

• Cell membrane lipids have branched hydrocarbon chains

• Lack tRNA specific for thymine

• AUG codon codes for methionine (prokaryotes – N-formylmethionine)

• Reproduce by binary fission, budding, or fragmentation

• Most are cocci, bacilli, or spiral forms; unusual shapes exist

• Not known to cause disease in humans or animals

**Extremophiles**

• Require extreme conditions of temperature, pH and/or salinity to survive

• Prominent members are thermophiles and halophiles

**Thermophiles**

• DNA, RNA, cytoplasmic membranes, and proteins do not function properly below 45ºC

• Hyperthermophiles – require temperatures over 80ºC

**Halophiles**

• Inhabit extremely saline habitats

• Depend on greater than 9% NaCl to maintain integrity of cell walls

• Contain red or orange pigments; protection from visible and UV light

• Most studied – *Halobacterium salinarium*

**Methanogens**

• Convert carbon dioxide, hydrogen gas, and organic acids to methane gas

• Largest group of archaea

• Convert organic wastes in pond, lake, and ocean sediments to methane

• Some live in colons of animals; are one of primary sources of environmental methane

• Have produced ~10 trillion tons of methane that is buried in mud on ocean floor

**Low G+C Gram-Positive Bacteria**

*. Clostridia*

* Rod-shaped, obligate anaerobes
* Important in medicine and industry
  + Produce toxins that cause diseases in humans
  + Endospores survive harsh conditions
* Related microbes include *Epulopiscium*, sulfate-reducing microbes, and *Selenomonas*

• *Mycoplasma*

• Facultative or obligate anaerobes

• Lack cell walls

• Smallest free-living cells

. *Bacillus*

* Endospore-forming aerobes and facultative anaerobes
* Many common in soil
* Bacillus thuringiensis toxin is used by farmers and gardeners as an insecticide
* Bacillus anthracis causes anthrax
* Other species synthesize antibiotics

. *Listeria*

* Contaminates milk and meat products
* Capable of reproducing under refrigeration
* Survives inside phagocytic white blood cells
* Rarely causes disease in adults
  + In pregnant women, can kill the fetus if crosses the placenta

. *Lactobacillus*

* Grows in the human mouth, stomach, intestinal tract, and vagina
* Rarely causes disease
* Inhibits the growth of pathogens within the body
* Used in the production of various foods

*. Streptococcus and Enterococcus*

* Cause numerous diseases
* Various strains of multi-drug-resistant streptococci

*. Staphylococcus*

* One of the most common inhabitants of humans
* Produces toxins and enzymes that contribute to disease

**High G + C Gram-Positive Bacteria**

*. Corynebacterium*

* Pleomorphic aerobes and facultative anaerobes
* *C. diptheriae causes* diptheria

*. Mycobacterium*

* Aerobic rods that sometimes form filaments
* Slow growth, partly due to mycolic acid in its cell walls
* Some species are pathogens of animals and humans

. Actinomycetes

* Form branching filaments resembling fungi
* Cause disease primarily in immunocompromised patients
* Important genera include *Actinomyces, Nocardia, Streptomyces*
  + *Actinomyces*
    - Normally present in oral cavity and throats of humans
  + *Nocardia*
    - Soil- and water-dwelling aerobes
    - Can degrade a variety of pollutants
  + *Streptomyces*
    - Recycles nutrients in the soil
    - Produces most of the important antibiotics

**Gram-Negative Proteobacteria**

Largest and most diverse group of bacteria

Five classes of proteobacteria

* Alphaproteobacteria
* Betaproteobacteria
* Gammaproteobacteria
* Deltaproteobacteria
* Epsilonproteobacteria

. Alphaproteobacteria

* + Nitrogen fixers
    - *Azospirillum*
    - *Rhizobium*
  + Nitrifying bacteria
    - *Nitrobacter*

. Betaproteobacteria

* + Pathogenic betaproteobacteria
    - *Neisseria*
      * Inhabits mucous membranes of mammals
      * Causes numerous diseases
    - *Bordetella*
      * Causes pertussis
    - *Burkholderia*
      * Colonizes moist environmental surfaces and respiratory passages of cystic fibrosis patients

. Gammaproteobacteria

* + Largest and most diverse class of proteobacteria
  + Divided into subgroups
    - Purple sulfur bacteria
    - Intracellular pathogens
    - Methane oxidizers
    - Glycolytic facultative anaerobes
    - Pseudomonads
  + Glycolytic facultative anaerobes
    - Largest group of gammaproteobacteria
    - Catabolize carbohydrates by glycolysis and the pentose phosphate pathway
    - Divided into three families

. Epsilonproteobacteria

* + - *Campylobacter*
    - Causes blood poisoning and intestinal inflammation
    - *Helicobacter*
    - Causes ulcers
  + Chlamydias
    - Grow intracellularly in mammals, birds, and some invertebrates
    - Some are smaller than viruses
    - Most common sexually transmitted bacteria in the United States
  + Spirochetes
    - Motile bacteria that move in a corkscrew motion
    - Have diverse metabolism and habitats
    - *Treponema* and *Borrelia* both cause disease in humans