Study Outline Chapter 27

Metabolic Diversity (pp. 714- 716)

- Microorganisms live in a wide variety of habitats because of their metabolic diversity, their ability to use a variety of carbon and energy sources and grow under different physical conditions.

Habitat Variety (p. 714)

- Extremophiles live in extreme conditions of temperature, acidity, alkalinity, or salinity.

Symbiosis (pp. 715- 716)

- Symbiosis is a relationship between two different organisms or populations.
- Parasitism is a type of symbiosis in which one organism gets its nutrients and reproductive capability from another organism.
- Mutualism is a type of symbiosis in which both partners benefit.
- Symbiotic fungi called mycorrhizae live in and on plant roots; they increase the surface area and nutrient absorp-tion of the plant.
- Up to 40% of fecal mass is microbial cells.

Soil Microbiology and Biogeochemical Cycles (pp. 716- 725)

- In biogeochemical cycles, certain chemical elements are recycled.
- Microorganisms in the soil decompose organic matter and transform carbon-, nitrogen-, and sulfur-containing compounds into usable forms.
- Microbes are essential to the continuation of biogeochemical cycles.
- Elements are oxidized and reduced by microorganisms during these cycles.

The Carbon Cycle (pp. 716- 717)

- Carbon dioxide is incorporated, or fixed, into organic compounds by photoautotrophs and chemoautotrophs.
- These organic compounds provide nutrients for chemoheterotrophs.
- Chemoheterotrophs release CO_2 that is then used by photoautotrophs.
- Carbon is removed from the cycle when it is in $CaCO_3$ and fossil fuels.

The Nitrogen Cycle (pp. 717- 721)

- Microorganisms decompose proteins from dead cells and release amino acids.
- Ammonia is liberated by microbial ammonification of the amino acids.
- The nitrogen in ammonia is oxidized to produce nitrates for energy by nitrifying bacteria.
- Denitrifying bacteria reduce the nitrogen in nitrates to molecular nitrogen (N_2).
- N_2 is converted into ammonia by nitrogen-fixing bacteria.
- Nitrogen-fixing bacteria include free-living genera such as *Azotobacter, cyanobacteria,* and the symbiotic bacteria *Rhizobium* and *Frankia*.
- Ammonium and nitrate are used by bacteria and plants to synthesize amino acids that are assembled into proteins.

The Sulfur Cycle (pp. 721- 723)

- Hydrogen sulfide (H_2S) is used by autotrophic bacteria; the sulfur is oxidized to form S^0 or SO_4^{2-}.
- Winogradsky discovered that Beggiatoa bacteria oxidize sulfur (H_2S and S^0) for energy.
- Plants and other microorganisms can reduce SO_4^{2-} to make certain amino acids.
- These amino acids are in turn used by animals.
- H_2S is released by decay or dissimilation of these amino acids.

The Phosphorus Cycle (p. 723)

- Phosphorus (as PO_4^{3-}) is found in rocks and bird guano.
- When solubilized by microbial acids, the PO_4^{3-} is available for plants and microorganisms.
- Endolithic bacteria live in solid rock; these autotrophic bacteria use hydrogen as an energy source.

The Degradation of Synthetic Chemicals in Soil and Water (pp. 723- 725)

- Many synthetic chemicals, such as pesticides, are resistant to degradation by microbes.
- Ecologists are trying to use bacteria to degrade PCBs.

Bioremediation (p. 724)

- The use of microorganisms to remove pollutants is called bioremediation.
- The growth of oil-degrading bacteria can be enhanced by the addition of nitrogen and phosphorus fertilizer.

Solid Municipal Waste (pp. 724- 725)

- Municipal landfills prevent decomposition of solid wastes because they are dry and anaerobic.
- In some landfills, methane produced by methanogens can be recovered for an energy source.
- Composting can be used to promote biodegradation of organic matter.

Aquatic Microbiology and Sewage Treatment (pp. 725- 738)

Aquatic Microorganisms (pp. 725- 726)

- The study of microorganisms and their activities in natural waters is called aquatic microbiology.
- Natural waters include lakes, ponds, streams, rivers, estuaries, and the oceans.
- The concentration of bacteria in water is proportional to the amount of organic material in the water.
- Most aquatic bacteria tend to grow on surfaces rather than in a free-floating state.

Freshwater Microbiota (p. 726)

- The number and location of freshwater microbiota depend on the availability of oxygen and light.
- Photosynthetic algae are the primary producers of a lake; they are found in the limnetic zone.

- Pseudomonads, *Cytophaga, Caulobacter,* and *Hyphomicrobium* are found in the limnetic zone, where oxygen is abundant.
- Microbes in stagnant water use available oxygen and can cause odors and the death of fish.
- The amount of dissolved oxygen is increased by wave action.
- Purple and green sulfur bacteria are found in the profundal zone, which contains light and H_2S but no oxygen.
- *Desulfovibrio* reduces SO_4^{2-} to H_2S in benthic mud.
- Methane-producing bacteria are also found in the benthic zone.

Seawater Microbiota (p. 726)

- Phytoplankton, consisting mainly of diatoms, are the primary producers of the open ocean.
- Some algae and bacteria are bioluminescent. They possess the enzyme luciferase, which can emit light.

The Role of Microorganisms in Water Quality (pp. 726- 738)

Water Pollution (pp. 726- 728)

- Microorganisms are filtered from water that percolates into groundwater supplies.
- Some pathogenic microorganisms are transmitted to humans in drinking and recreational waters.
- Resistant chemical pollutants may be concentrated in animals in an aquatic food chain.
- Mercury is metabolized by certain bacteria into a soluble compound that is concentrated in animals.
- Nutrients such as phosphates cause algal blooms, which can lead to eutrophication of aquatic ecosystems.
- Eutrophication, meaning well nourished, is the result of the addition of pollutants or natural nutrients.
- *Thiobacillus ferrooxidans* produces sulfuric acid at coal- mining sites.

Water Purity Tests (pp. 729- 730)

- Tests for the bacteriological quality of water are based on the presence of indicator organisms, the most common of which are coliforms.
- Coliforms are aerobic or facultatively anaerobic, gram- negative, non-endospore-forming rods that ferment lactose with the production of acid and gas within 48 hours of being placed in a medium at 35¡C.
- Fecal coliforms, predominantly *E. coli*, are used to indicate the presence of human feces.

Water Treatment (pp. 730- 731)

- Drinking water is held in a holding reservoir long enough that suspended matter settles.
- Flocculation treatment uses a chemical such as alum to coalesce and then settle colloidal material.
- Filtration removes protozoan cysts and other microorganisms.
- Drinking water is disinfected with chlorine to kill remaining pathogenic bacteria.

Biofilms (p. 731)

- Microbes adhere to surfaces and accumulate as biofilms on solid surfaces in contact with water.

Sewage (Wastewater) Treatment (p. 731- 738)

- Domestic wastewater is called sewage; it includes household water, toilet wastes, industrial wastes, and rainwater.

Primary Sewage Treatment (p. 732)

- Primary sewage treatment is the removal of solid matter called sludge.
- Biological activity is not very important in primary treatment.

Biochemical Oxygen Demand (p. 732)

- Biochemical oxygen demand (BOD) is a measure of the biologically degradable organic matter in water.
- Primary treatment removes about 25- 35% of the BOD of sewage.
- BOD is determined by measuring the amount of oxygen bacteria require to degrade the organic matter.

Secondary Sewage Treatment (pp. 733- 735)

- Secondary sewage treatment is the biological degradation of organic matter after primary treatment.
- Activated sludge systems, trickling filters, and rotating biological contactors are methods of secondary treatment.
- Microorganisms degrade the organic matter aerobically.
- Secondary treatment removes up to 95% of the BOD.

Disinfection and Release (p. 735)

- Treated sewage if disinfected, usually by chlorination, before discharge onto land or into water.

Sludge Digestion (pp. 735-736)

- Sludge is placed in an anaerobic sludge digester; bacteria degrade organic matter and produce simpler organic compounds, methane, and CO_2.
- The methane produced in the digester is used to heat the digester and operate other equiptment.
- Excess sludge is periodically removed from the digester, dried and disposed of (as landfill or as soil conditioner) or incinerated.

Septic Takns (p. 736)

- Septic tanks can be used in rural areas to provide primary treatment of sewage.
- They require a large leaching field for the effluent.

Oxidation Ponds (pp. 736- 737)

- Small communities can use oxidation ponds for secondary treatment.
- These require a large area in which to build an artificial lake.

Tertiary Sewage Treatment (p. 737-738)

- Tertiary Sewage treatment uses physical filtration and chemical precipitation to remove all the BOD, nitrogen and phosphorus from water.
- Tertiary treatment provides drinkable water, whereas secondary treatment provides water usuable only for irrigation.