1 **Nutrient Cycles, Bioremediation, and Symbioses**
Chapter 1

2 **24.1 The Carbon Cycle**
- Carbon is cycled through all of Earth's major carbon reservoirs
  - atmosphere, land, oceans, sediments, rocks, and biomass

3 **24.1 The Carbon Cycle**
- CO_2 in the atmosphere is rapidly transferred
  - fixed by land plants and marine microbes
  - returned to atmosphere by respiration of animals & microbes
  - Microbial decomposition
    - largest source of CO_2 released to the atmosphere
    - major end products of decomposition are CH_4 and CO_2
- The carbon and oxygen cycles are intimately linked

4 **24.1 The Carbon Cycle**
- Photosynthesis and respiration are reverse reactions
- Photosynthesis

  $CO_2 + H_2O \quad (CH_2O) + O_2$
- Respiration

  $(CH_2O) + O_2 \quad CO_2 + H_2O$

5 **24.2 Syntrophy and Methanogenesis**
- Methanogenesis
  - carbon cycling in anoxic environments
  - reduce CO_2 to CH_4 with H_2 as an electron donor
  - team up with syntrophs that supply substrates

6 **24.3 The Nitrogen Cycle**
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7 **24.4 The Sulfur Cycle**

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9 **24.5 The Iron Cycle**
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10 **24.6 Microbial Leaching of Ores**
- *Bioremediation*
  - cleanup of oil, toxic chemicals, or other pollutants from environment by microorganisms
  - Often a cost-effective and practical method for cleanup
- *Microbial Leaching*
  - removal of valuable metals, such as copper, from sulfide ores by microbial activities
  - Particularly useful for copper ores

11 **24.7 Mercury and Heavy Metal Transformations**
- Mercury
  - tendency to concentrate in living tissues
  - highly toxic

- major form of mercury in the atmosphere is elemental mercury (Hg^o)
  - which is volatile and oxidized to mercuric ion (Hg^{2+}) photochemically

- Most mercury enters aquatic environments as Hg^{2+}

12 **24.7 Mercury and Heavy Metal Transformations**
- Hg^{2+} readily absorbs to particulate matter where it can be metabolized by microbes
- Microbes form methylmercury (CH_3Hg^+)
  - extremely soluble and toxic compound
- Several bacteria can transform toxic mercury to nontoxic forms

13 **24.8 Petroleum Biodegradation**
- bioremediation of several major crude oil spills

14 **24.8 Petroleum Biodegradation**
- Some microbes can produce petroleum
  - Particularly certain green algae

15 **24.9 Biodegradation of Xenobiotics**
- Pesticides
  - Common components of toxic wastes
  - Include *herbicides*, *insecticides*, and *fungicides*
  - Represent a wide variety of chemistries
    - Some of which can be used as carbon sources and electron donors by microbes

16 **24.10 The Rumen and Ruminant Animals**
- *Ruminants*
  - Herbivorous mammals (cows, sheep, goats)
  - Possess a special digestive organ (the r*umen*)
    - cellulose and other plant polysaccharides are digested with the help of microbes

17 **24.11 Hydrothermal Vent Microbial Ecosystems**
- fueled by chemolithotrophic microbes

18 **24.13 Lichens and Mycorrhizae**
- *Lichens*
  - mutalistic relationship between a fungus and an alga (or cyanobacterium)
    - Alga is photosynthetic produces organic matter for the fungus
    - fungus provides protection from erosion by rain or wind

19 **24.13 Lichens and Mycorrhizae**
- *Mycorrhizae*
  - Mutalistic associations of plant roots and fungi
    - Ectomycorrhizae
    - Endomycorrhizae

20 **24.15 The Legume–Root Nodule Symbiosis**
- mutalistic relationship between leguminous plants and nitrogen-fixing bacteria
  - soybeans, clover, alfalfa, beans, and peas
- Rhizobia nitrogen-fixing bacteria engaging in symbioses