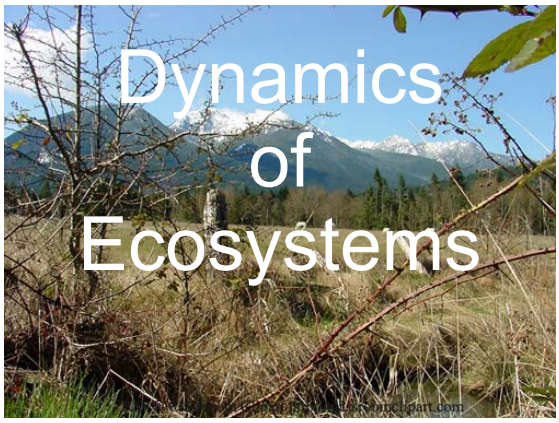
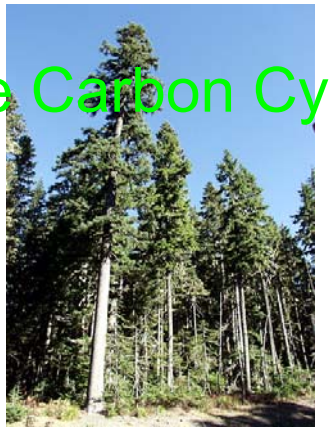


- Ecosystem - All the organisms in an area that interact with each other and with their environment of energy and matter.
- Sunlight is captured by green plants during photosynthesis and stored as chemical energy.
- The energy passes through the ecosystem from species to species when herbivores eat plants and carnivores eat herbivores.
- These interactions form food chains.

- All organisms in an ecosystem have a specific role or trophic level:
  - Producer – convert radiant energy into chemical energy for ecosystems (green plants)
  - Primary consumers – animals that eat plants (herbivores)
  - Secondary consumers – animals that eat other animals (carnivores)

The Carbon Cycle



The Carbon Cycle

- In the carbon cycle, carbon and oxygen move back and forth between living things and their surrounding environment.
- Consists of two processes:
  - Photosynthesis
  - Cellular Respiration

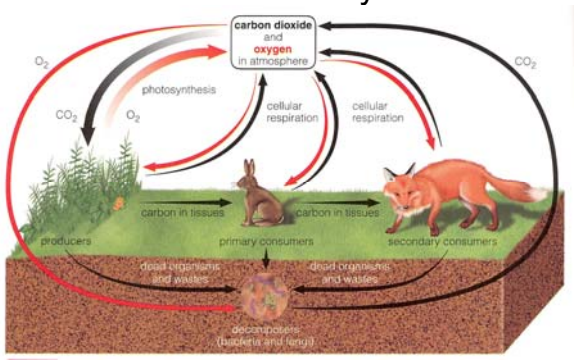
Photosynthesis

- Occurs in all plants
- Converts carbon dioxide and water to carbohydrates (sugar) and oxygen
- $6CO_2 + 6 H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$

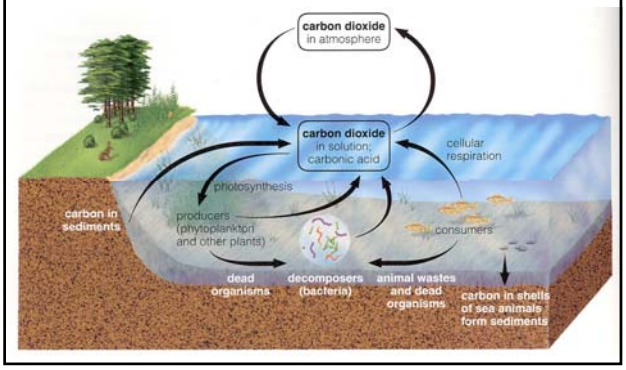
Cellular Respiration

- Converts oxygen to carbon dioxide
- Carried out by all living cells
- $6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ + energy

Carbon Cycle for a Terrestrial Ecosystem



Carbon Cycle for a Water Ecosystem



The Nitrogen Cycle

Nitrogen Fixation

- Plants use Nitrogen (N), Phosphorus (P), and potassium (K) for growth.
- These elements are found in plant fertilizer.
- How do plants get Nitrogen if they are not given fertilizer?
  - From the atmosphere.
  - The Earth's atmosphere is 80% Nitrogen
- But....

- Most plants cannot absorb nitrogen directly from the air.
- The nitrogen must first be “fixed” :
  - Pulled from the air and bonded to other elements to make new compounds
- This process is called **nitrogen fixation**.
- For example, nitrogen can combine with hydrogen to form ammonium (NH_4^+) or oxygen to form nitrate (NO_3^-)

- Plants absorb the nitrogen compounds through their roots
- Animals can obtain nitrogen only by eating plants or other animals.

- In nature, the job of nitrogen fixation is carried out by a few species of nitrogen-fixing bacteria.
- Rhizobia (most important)
  - Live in the nodules (rounded swellings) on the roots of legumes (peas, beans, alfalfa, clover)
- Before the development of artificial fertilizers, farmers planted legumes in their fields to help restore the fertility of the soil

- Once Nitrogen has been fixed it enters the soil and water where it becomes available for living organisms to use.
- Nitrogen compounds that enter plants move through food chains and return to the soil and water through dead organisms and waste materials
- These compounds can re-enter plants without being converted to Nitrogen gas.

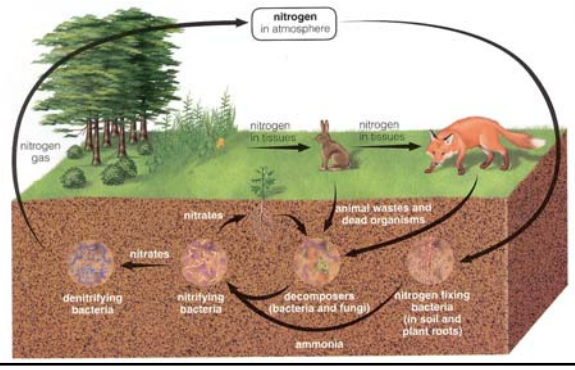
- In an aquatic ecosystem nitrogen fixation is carried out by cyanobacteria, also known as blue-green algae.

Nitrification

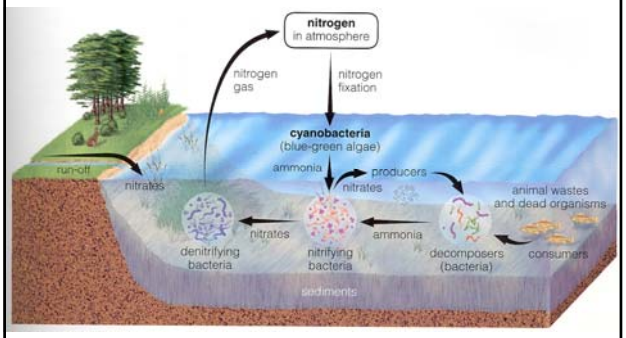
- Decomposers, such as bacteria, break down the waste and dead materials producing ammonia.
- Ammonia is used directly by some plants as a source of nitrogen.
- Ammonia is also converted into nitrates by nitrifying bacteria in a process called **nitrification**.

- The nitrates in the soil or water may be converted back into nitrogen gas by denitrifying bacteria.
- This process is called **denitrification**.

Nitrogen Cycle in a Terrestrial Ecosystem



Nitrogen Cycle in an Aquatic Ecosystem



Disturbing the Cycles

- What factors may disturb these cycles?
  - Overuse of fertilizers and herbicides
  - Combustion of fossil fuels
  - Deforestation
  - Human and animal waste mismanagement
  - Volcanic activity
  - Forest fires

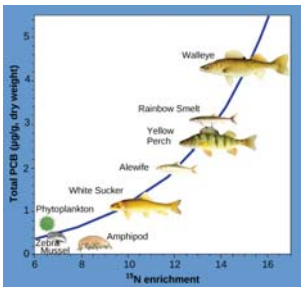
How Pollutants Move Through the Various Trophic Levels in an Ecosystem

Bioaccumulation

- increase in concentration of a pollutant from the environment in the first organism in a food chain
  - the pollutant is stored in the organism rather than being expelled as waste

Biomagnification

- increase in concentration of a pollutant from one link in a food chain to another



courses.lumenlearning.com/boundless-biology/chapter/energy-flow-through-ecosystems/

- For bioaccumulation and biomagnification to occur, the pollutant must be:
  - Long-lived
    - stays in the environment more than 15 years before it breaks down
  - Mobile
    - if it stays in one place it can be easily contained
  - Soluble in fats
    - it is absorbed and retained by animals
  - Biologically active
    - it affects biological organisms

DDT (dichloro, diphenyl trichloroethane)

- DDT has a “half-life” of 15 years
  - If there is 100kg, then after 15 years 50kg remains
  - After 30 years 25kg remains
  - After 90 years 1.56kg remains
- DDT is fat soluble and is stored in the bodies of organisms
- DDT has low toxicity in humans, but kills insects

Other Substances that can Biomagnify

- PCBs (polychlorinated biphenyls)
  - Uses:
    - coolant in transformers
    - sealing and caulking compounds
    - inks and paint additives
  - Problems:
    - severe form of acne (chloracne), swelling of the upper eyelids, discoloring of the nails and skin, numbness in the arms and/or legs, weakness, muscle spasms, chronic bronchitis, and problems related to the nervous system

- PAH (polynuclear aromatic hydrocarbons)
  - Uses:
    - component of petroleum products
  - Problems:
    - possible carcinogen

- Heavy metals (mercury, copper, cadmium, chromium, lead, nickel, zinc, tin)
  - Uses:
    - mercury from gold mining
    - many from metal processing
  - Problems:
    - may affect nervous system
    - may affect reproduction

- Cyanide
  - Uses:
    - leaching gold from ore
  - Problems:
    - toxic

- Selenium
  - Uses:
    - plays a key role in metabolism
  - Problems:
    - liver, kidney and heart problems
    - at high enough levels it is toxic

Populations

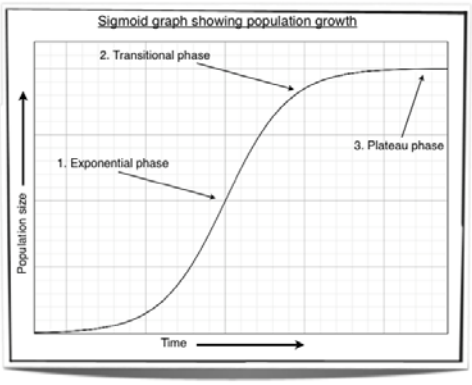
Population Size

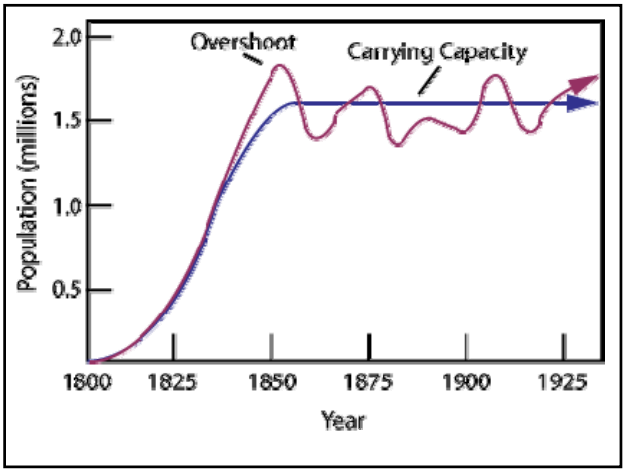
- Population can <u>increase</u> due to:
  - Natality
    - Offspring added to population
  - Immigration
    - Individuals moving into the area
- Population can <u>decrease</u> due to:
  - Mortality
    - Individual dies (eaten, sickness, old age)
  - Emmigration
    - Individuals moving out of the area

Population Growth

- Population growth goes through three phases:
  - Exponential
    - Quick growing when there are very few limiting factors
      - Plants germinating in spring
  - Transitional
    - Slowing of growth rate as the population approaches the carrying capacity
  - Population plateau
    - The population remains constant or stable
      - Note: the plateau may have variations year to year around an average value

Population Growth Curve





Carrying Capacity

- The largest population of a species that an environment can support is called the **carrying capacity**.
- Four main factors affect carrying capacity:
  - Materials and energy
  - Food chains
  - Competition
  - Density

Materials and Energy

- All populations of organisms are ultimately limited by amount of usable energy from the sun, as well as the supply of water, carbon, and other essential materials.

Food Chains

- The population size at any trophic level is limited by the population (or biomass) in all the levels below it.
- Populations are limited by food.
- Populations are also limited by organisms in the trophic levels above them.
- Animal populations are limited by predators.
- Plant populations are limited by herbivoires.

Competition

- Each organism has the same needs as other organisms.
  - Food, water, mates, space
- This demand results in competition.
  - Foxes in an area may eat rabbits for lunch. A rabbit population is low and the fox population is high, competition for food among foxes increases.

- Competition among members of the same species is called **intraspecific competition**.
  - Foxes in an area may also compete with wolves and coyotes for rabbits.
- Competition between species is called **interspecific competition**.
  - All of the herbivores in an area compete for the same food.
- Both intraspecific and interspecific competition can limit population growth.

Density

- Different species have different needs for space depending on their size, environment and way of life.
  - Grizzly bears space themselves out
  - Penguins live together in large groups
- This need for space determines an organism's **population density**.
  - How many individuals can live in an area at one time.

- If a population density increases beyond a suitable level for a particular species, conditions are produced that tend to limit growth.
  - Overcrowding may increase the spread of disease or parasites
  - Overcrowding in some species increases aggression and neglect of offspring (increases death rate and lowers birth rate)
- Factors that increase in significance as a population grows are called **density-dependent factors**.

- Other factors can limit a population, regardless of its size.
  - A forest fire may kill most of the snakes in the forest, whether there are 10 or 10 000 of them.
- Such factors are called **density-independent factors** because their effect on population size does not depend on how many individuals there are in the population.