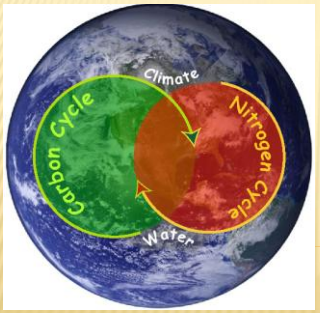
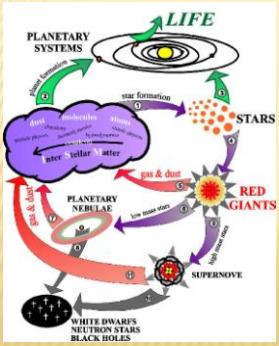


CHAPTER 3
THE BIOSHPERE

3.4 Cycles of Matter
Mrs. Michaelsen

THINK ABOUT IT



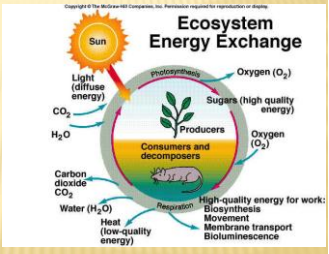
- A handful of elements combine to form the building blocks of all known organisms.
- Organisms cannot manufacture these elements and do not "use them up," so where do essential elements come from?

RECYCLING IN THE BIOSPHERE

- Matter is recycled within and between ecosystems.
- Elements are cycled through closed loops called **biogeochemical cycles.**

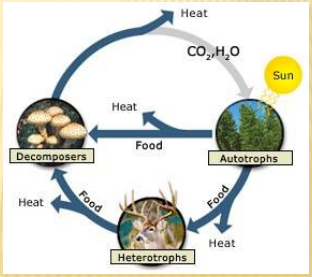
RECYCLING IN THE BIOSPHERE

- Cycles involve *biological*, *geological*, and *chemical* processes.
- As matter moves through these cycles, it is never created or destroyed—just changed.

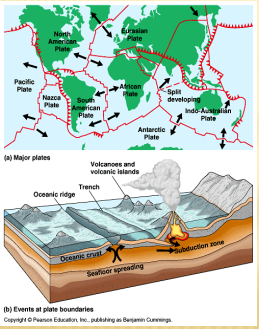


BIOLOGICAL PROCESSES

- Biological processes: All activities performed by living organisms.
- Include eating, breathing, "burning" food, and eliminating waste products.



GEOLOGICAL PROCESSES

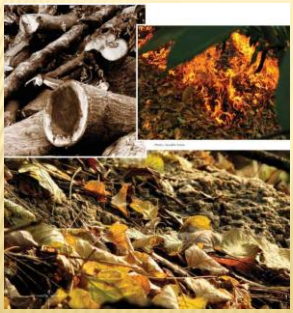


- Include volcanic eruptions, the formation and breakdown of rock, and major movements of matter within and below the surface of the earth.

CHEMICAL AND PHYSICAL PROCESSES

- Include the formation of clouds and precipitation, the flow of running water, and the action of lightning.

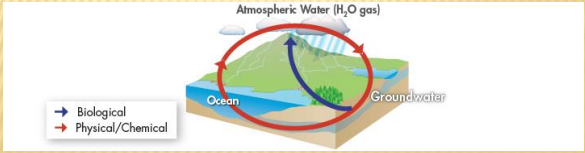
HUMAN ACTIVITY



- Affect cycles of matter on a global scale.
  - Mining and burning of fossil fuels, clearing of land for building and farming, burning of forests, and the manufacture and use of fertilizers.

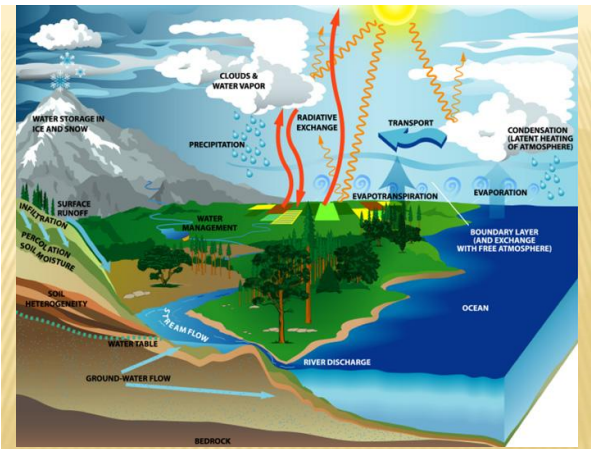
THE WATER CYCLE

- Water molecules enter the atmosphere as water vapor when they:
  - Evaporate from the ocean or other bodies of water.
  - Transpiration (evaporation) from the leaves of plants.



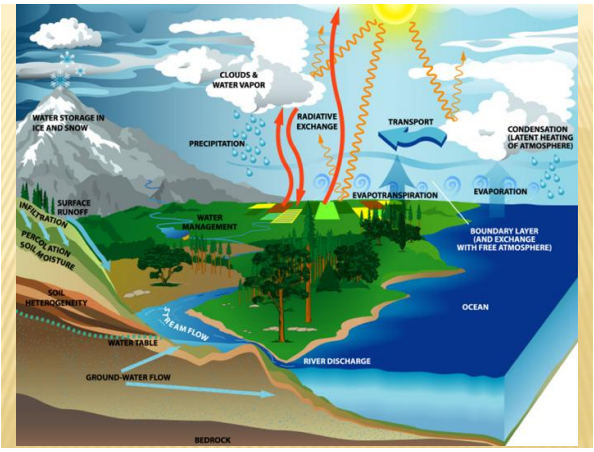
THE WATER CYCLE

- If the air cools, water vapor condenses into clouds.
- When the droplets become large enough, they fall in the form of rain, snow, sleet, or hail.
- On land, some precipitation flows as runoff, until it enters a river or stream that carries it to an ocean or lake.



THE WATER CYCLE

- Precipitation can also be absorbed into the soil, and is then called groundwater.
- Groundwater can enter plants through their roots, or flow into rivers, streams, lakes, or oceans.
- Some groundwater penetrates deeply enough to become part of underground reservoirs.

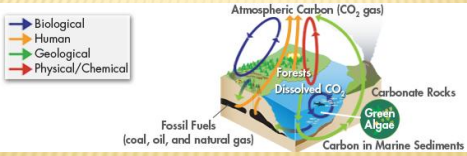


NUTRIENT CYCLES

- The chemical substances that an organism needs to sustain life are called **nutrients.**
- Needed to build tissues and carry out life functions.

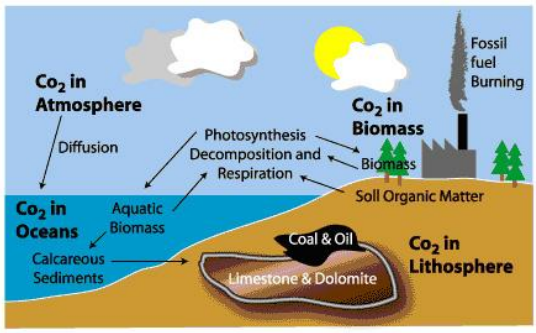
THE CARBON CYCLE

- Carbon is a major component of all organic compounds: carbohydrates, lipids, proteins, and nucleic acids.



THE CARBON CYCLE

- Carbon dioxide (gas) is continually exchanged through chemical and physical processes between the atmosphere and oceans.
- Plants take in carbon dioxide during photosynthesis and use the carbon to build carbohydrates.
- Carbohydrates then pass through food webs to consumers.

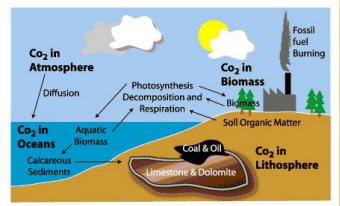


THE CARBON CYCLE

- Organisms release carbon in the form of carbon dioxide gas by respiration.
- When organisms die, decomposers break down the bodies, releasing carbon to the environment.
- Geologic forces can turn accumulated carbon into carbon-containing rocks or fossil fuels.

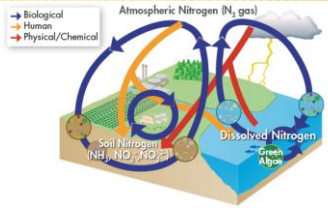
THE CARBON CYCLE

- Carbon dioxide is released into the atmosphere by volcanic activity or by human activities, such as the burning of fossil fuels and the clearing and burning of forests.



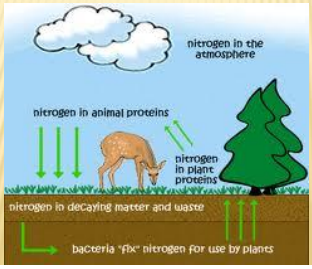
THE NITROGEN CYCLE

- All organisms require nitrogen to make amino acids, which are used to build proteins and nucleic acids, which combine to form DNA and RNA.



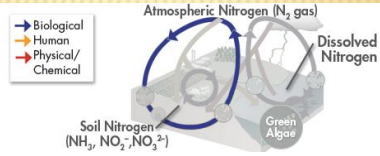
THE NITROGEN CYCLE

- Nitrogen gas (N_2) makes up 78% of Earth's atmosphere.



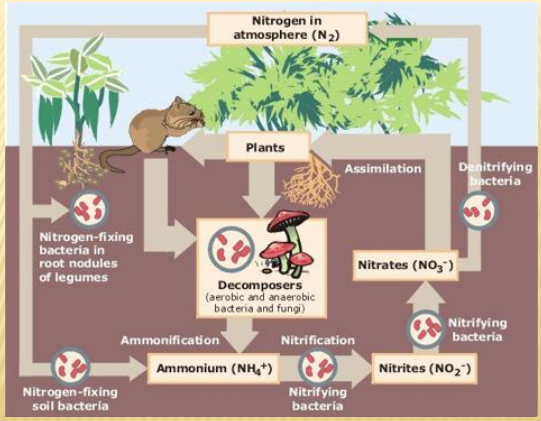
THE NITROGEN CYCLE

- Nitrogen-containing substances such as ammonia (NH_3), nitrate ions (NO_3), and nitrite ions (NO_2) are found in soil, in the wastes produced by many organisms, and in dead and decaying organic matter.
- Dissolved nitrogen exists in several forms in the ocean and other large water bodies.



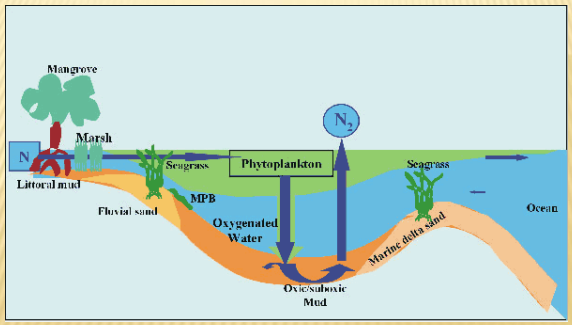
THE NITROGEN CYCLE

- Nitrogen is mostly found as a gas and is unusable.
  - Certain types of bacteria that live in the soil and on the roots of legumes can use nitrogen as a gas.
- The bacteria convert nitrogen gas into ammonia, in a process known as **nitrogen fixation.**
- Other soil bacteria convert fixed nitrogen into nitrates and nitrites that primary producers can use to make proteins and nucleic acids.



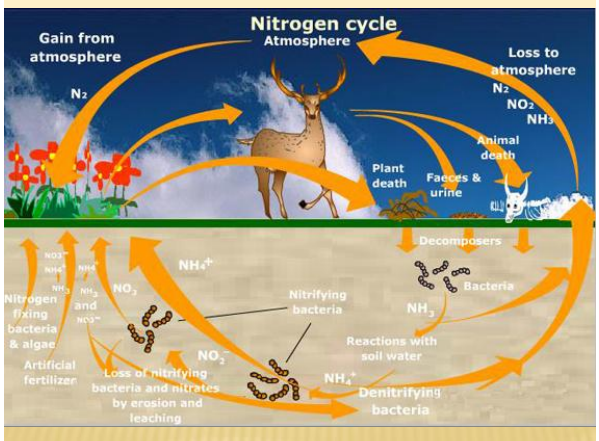
THE NITROGEN CYCLE

- Consumers eat the producers and reuse nitrogen to make their own nitrogen-containing compounds.
- Decomposers release nitrogen from waste and dead organisms as ammonia, nitrates, and nitrites that producers may take up again.
- Other soil bacteria obtain energy by converting nitrates into nitrogen gas, which is released into the atmosphere in a process called **denitrification.**



THE NITROGEN CYCLE

- A small amount of nitrogen gas is converted to usable forms by lightning in a process called atmospheric nitrogen fixation.
- Humans add nitrogen to the biosphere through the manufacture and use of fertilizers. Excess fertilizer is often carried into surface water or groundwater by precipitation.

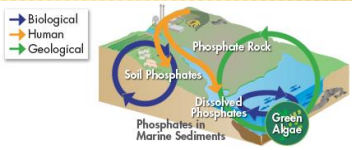


THE PHOSPHORUS CYCLE

- Phosphorus forms a part of vital molecules such as DNA and RNA.
- Not abundant in the biosphere.

THE PHOSPHORUS CYCLE

- Inorganic phosphate remains mostly on land, in the form of phosphate rock and soil minerals, and in the ocean, as dissolved phosphate and phosphate sediments.



THE PHOSPHORUS CYCLE

- As rocks and sediments wear down, phosphate is released.
- Some phosphate stays on land and cycles between organisms and soil.
- Plants bind phosphate into organic compounds when they absorb it from soil or water.

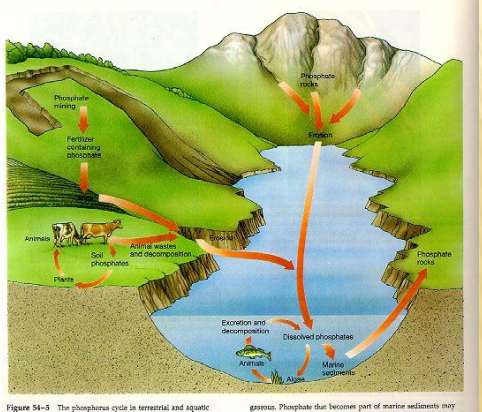


Figure 54–5 The phosphorus cycle in terrestrial and aquatic environments. Recycling of phosphorus (as phosphate, PO_4^{3-}) is slow because no biologically important form of phosphorus is gaseous. Phosphate that becomes part of marine sediments may take millions of years to solidify into rock, uplift as mountains, and erode again to become available to living things.

THE PHOSPHORUS CYCLE

- Organic phosphate moves through the food web, from producers to consumers, and to the rest of the ecosystem.
- Other phosphate washes into rivers and streams, where it dissolves. This phosphate makes its way to the ocean, where marine organisms process and incorporate it into biological compounds.

NUTRIENT LIMITATION

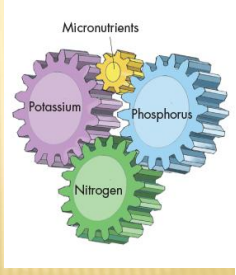
- Ecologists are often interested in an ecosystem's primary productivity—the rate at which primary producers create organic material.
- The nutrient whose supply limits productivity is called the **limiting nutrient.**

NUTRIENT LIMITATION IN SOIL

- The growth of crop plants is typically limited by one or more nutrients that must be taken up by plants through their roots.
- Most fertilizers contain large amounts of nitrogen, phosphorus, and potassium, which help plants grow better in poor soil. Carbon is not included in chemical fertilizers because plants acquire carbon dioxide from the atmosphere.
- Micronutrients such as calcium, magnesium, sulfur, iron, and manganese are necessary in relatively small amounts, and are sometimes included in specialty fertilizers.

NUTRIENT LIMITATION IN SOIL

- All nutrient cycles work together like the gears shown.
- If any nutrient is in short supply—if any wheel "sticks"—the whole system slows down or stops altogether.



NUTRIENT LIMITATION IN AQUATIC ECOSYSTEMS

- Oceans are nutrient-poor compared to many land areas.
  - Nitrogen is often the limiting nutrient.
- In streams, lakes, and freshwater environments, phosphorus is typically the limiting nutrient.

NUTRIENT LIMITATION IN AQUATIC ECOSYSTEMS

- Sometimes an aquatic ecosystem receives a large input of a limiting nutrient—for example, runoff from heavily fertilized fields.