

EWCE 131
Ecology and Environmental Pollution

Lecture 6

Instructor

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Lecture outline

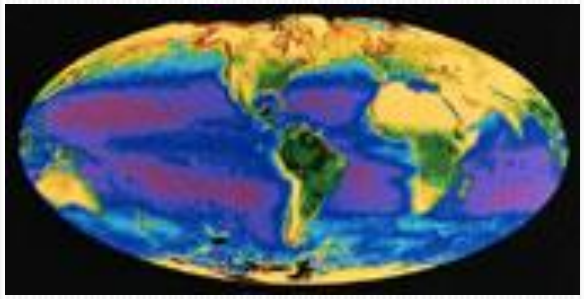
Biogeochemical Cycles

Topics

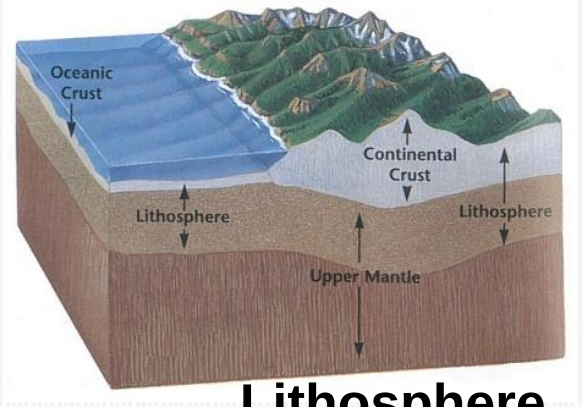
- General aspects of biogeochemical cycles
- Hydrologic cycle
- Carbon cycle

Biogeochemical Cycles

- A biogeochemical cycle is the complete path a chemical takes through the four major components, or reservoirs, of Earth's system:
- atmosphere,
- hydrosphere (oceans, rivers, lakes, groundwaters, and glaciers),
- lithosphere (rocks and soils),
- biosphere (plants and animals).



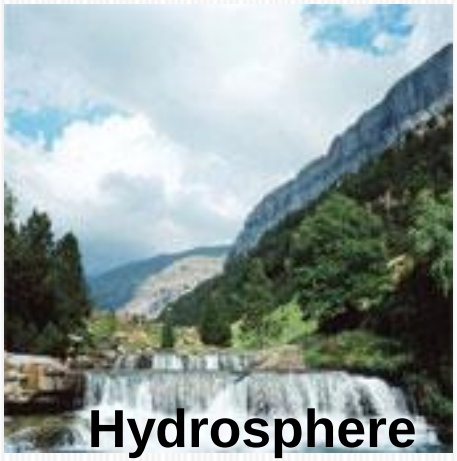
Biosphere



Lithosphere



Atmosphere



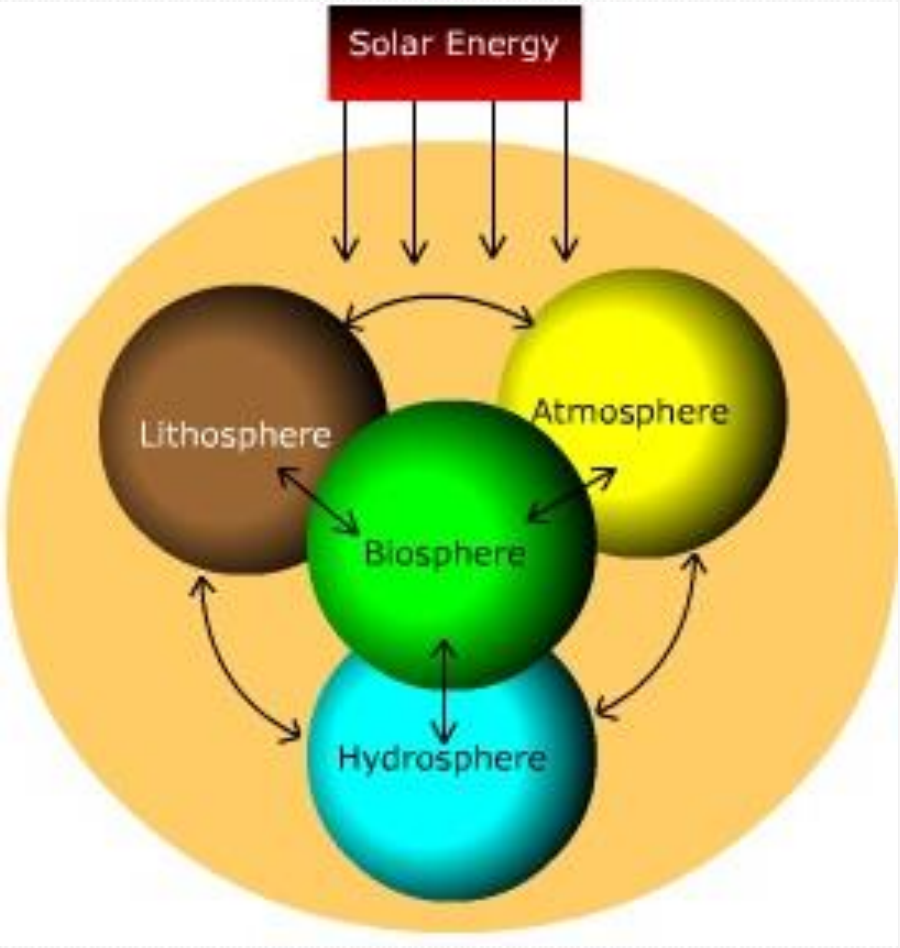
Hydrosphere

Implication of Biogeochemical Cycles

Biogeochemical cycle is-

- chemical - because chemicals are cycled,
- bio- because the cycle involves life, and
- geo- because a cycle

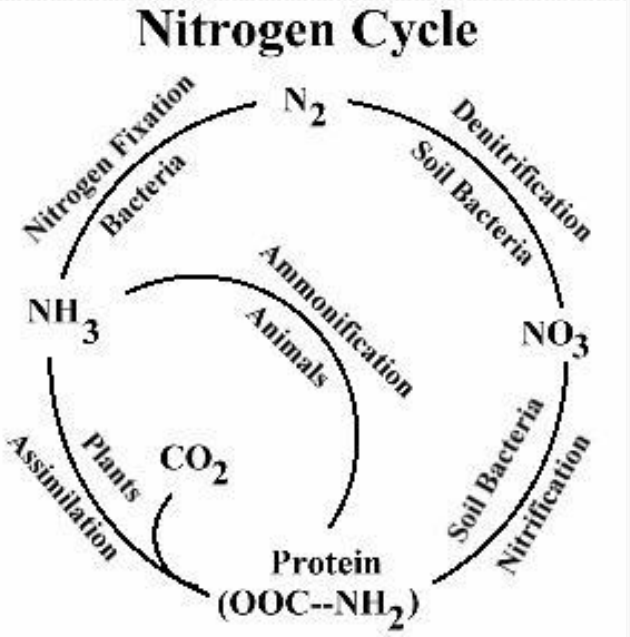
may include atmosphere, water, rocks, and soils.

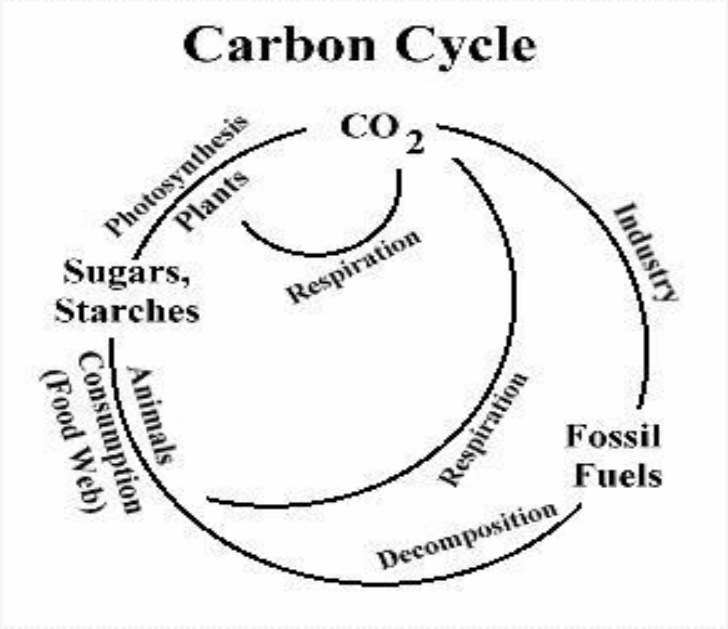


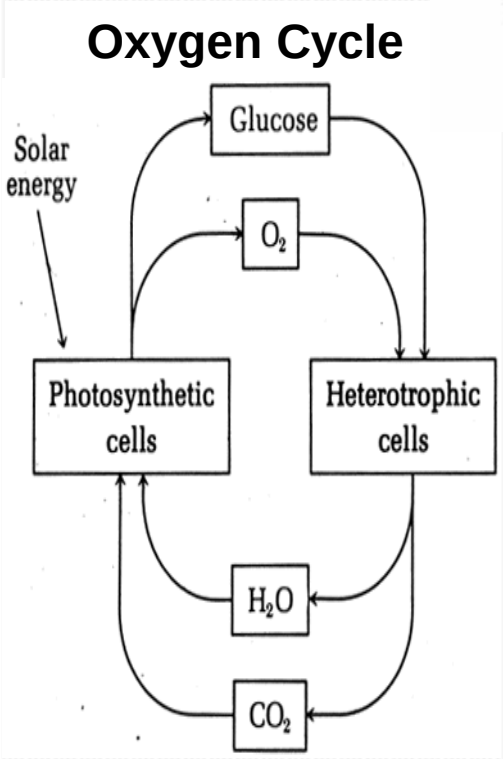
Phases in Biogeochemical Cycles

Gas Cycle

- Elements move through the atmosphere.
- Main reservoirs are the atmosphere and the ocean.







Phases in Biogeochemical Cycles

Gas Cycle

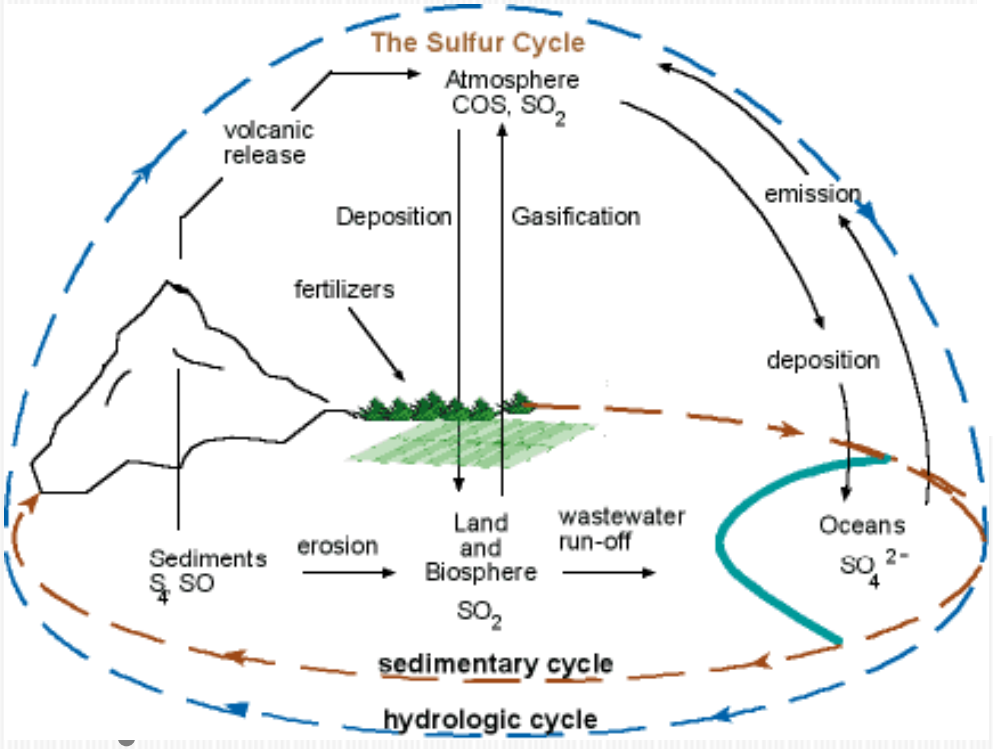
- Gaseous chemical elements, such as **oxygen** and **nitrogen**, cycle quickly and are readily regenerated for biological activity.

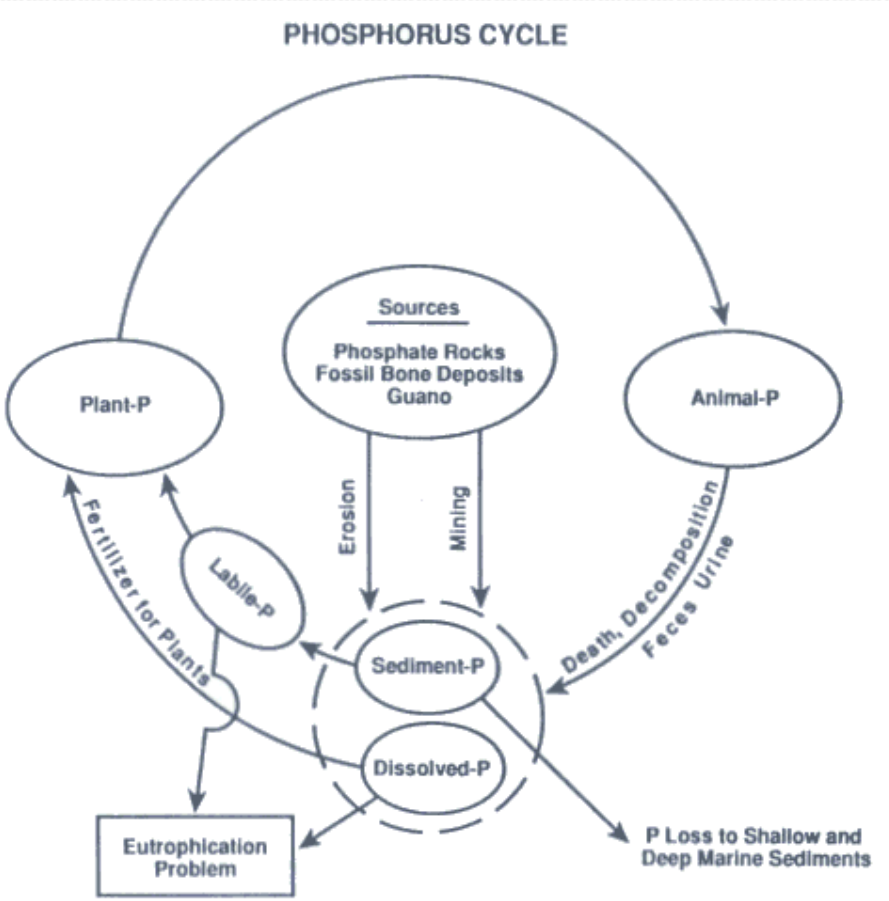
- These elements are present in the atmosphere and/or easily dissolved in water and carried by the hydrologic cycle.

Phases in Biogeochemical Cycles

Sedimentary Cycle

- Elements move from land to water to sediment.
- Main reservoirs are the soil and sedimentary rocks.





Phases in Biogeochemical Cycles

Sedimentary Cycle

- Chemical elements like **phosphorus** are easily tied up in relatively immobile forms.
- Cycling of these chemicals are relatively slow, which occur through geologic processes, and hence are not readily reused by life.
- Typically, they lack a gaseous phase and are not found in significant concentrations in the atmosphere.
- They also are relatively insoluble in water.

Biogeochemical Cycles – **System Diagram**

- The simplest way to visualize a biogeochemical cycle is as a box-and-arrow diagram of a system.
- The boxes represent places where a chemical is stored (storage compartments) and the arrows represent pathways of transfer.

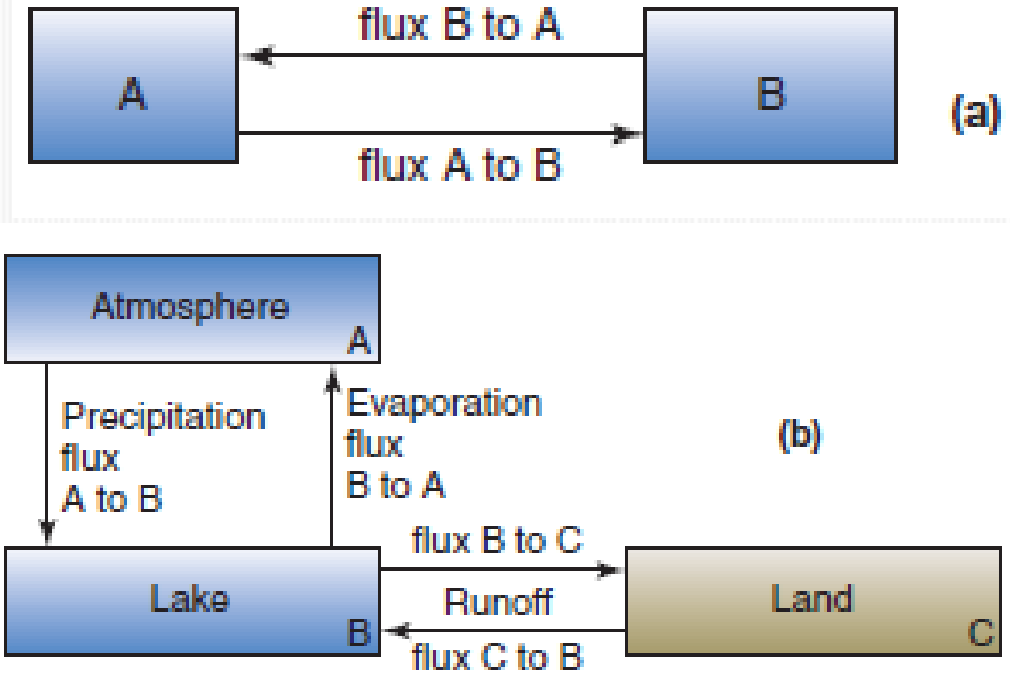


FIGURE 6.9 **(a)** A unit of a biogeochemical cycle viewed as a systems diagram; **(b)** a highly simplified systems diagram of the water cycle.

Biogeochemical Cycles – **System Diagram**

In the system diagram,

- **flow** is the amount of chemical moving from one compartment to another
- **flux** is the rate of transfer— the amount of chemicals that entering or leaving a storage compartment per unit time.

- The **residence time** is the average time that an atom is stored in a compartment.

- The donating compartment is a **source**, and the receiving compartment is a **sink**.

Biogeochemical Cycles – **System Diagram**

- A biogeochemical cycle is generally drawn for a single chemical element (N, P), but sometimes it is drawn for a compound—for example, water (H_2O).

- Figure 6.9b shows the basic elements of a biogeochemical cycle for water, represented about as simply as it can be.

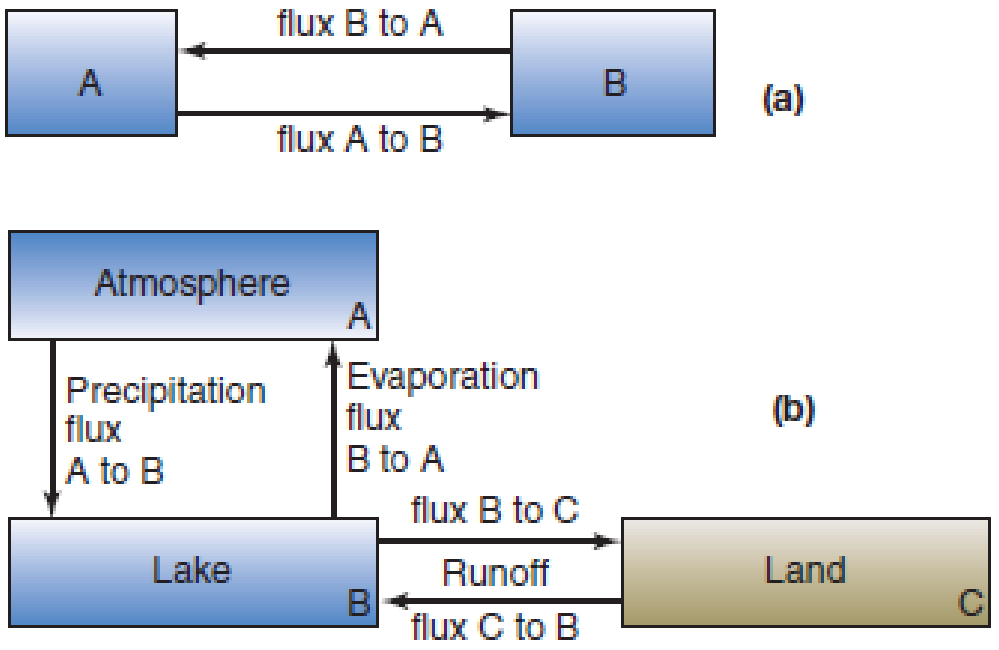
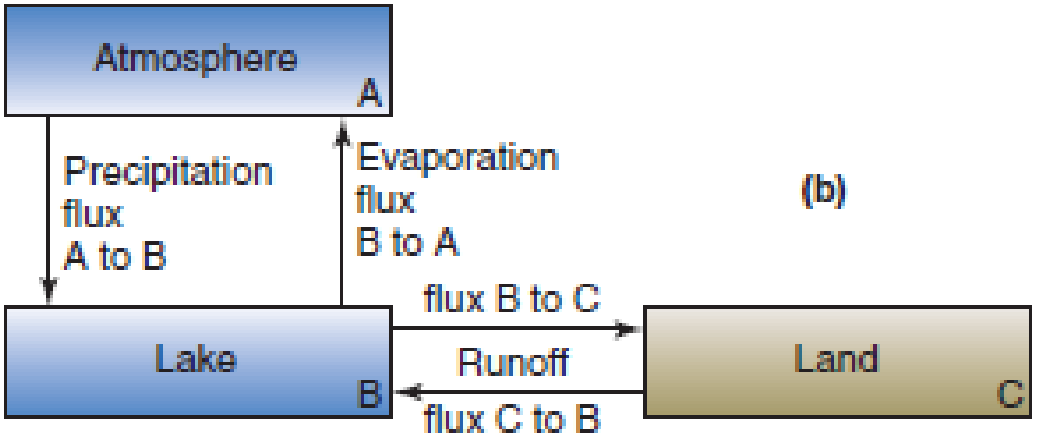


FIGURE 6.9 **(a)** A unit of a biogeochemical cycle viewed as a systems diagram; **(b)** a highly simplified systems diagram of the water cycle.

Biogeochemical Cycles – **System Diagram**

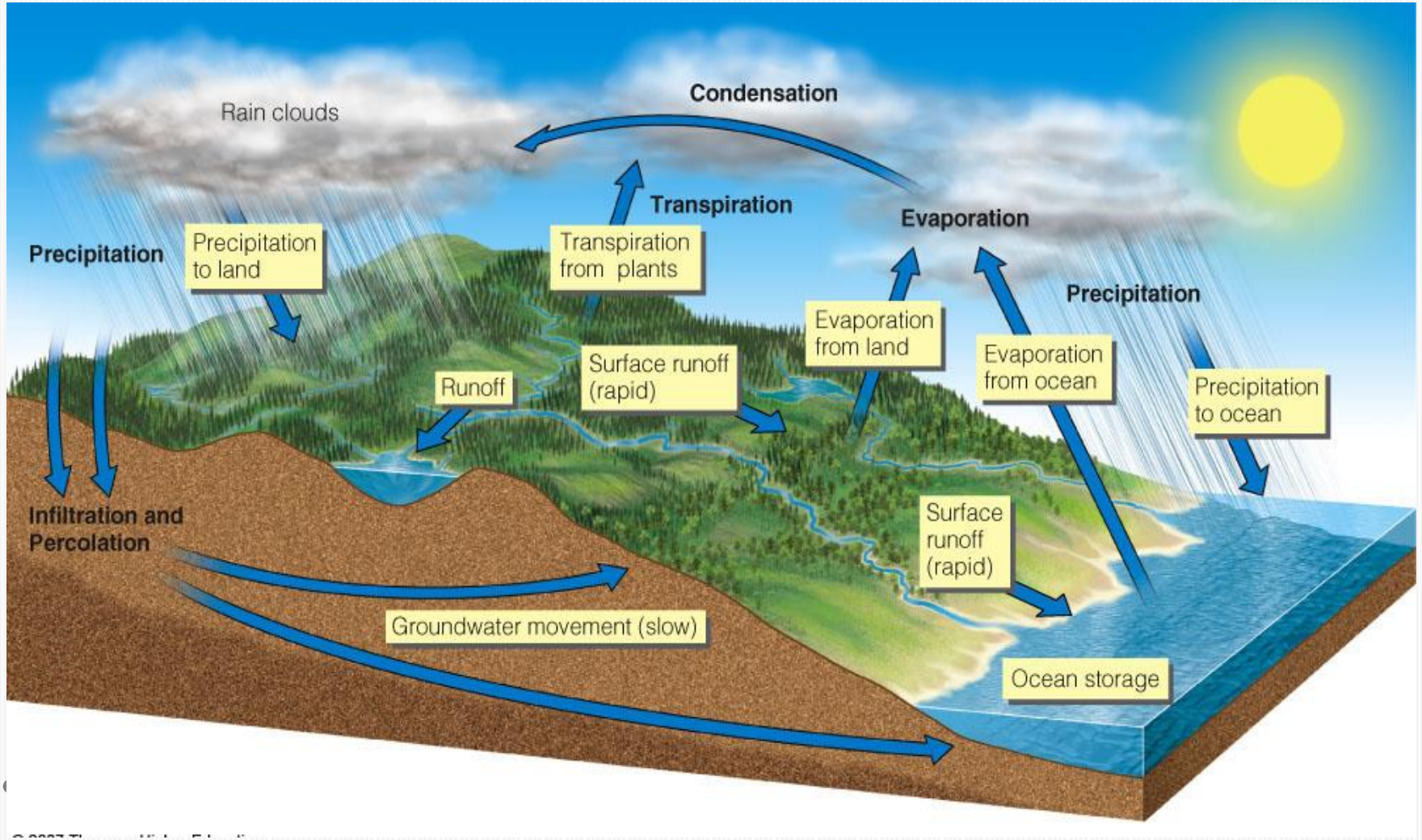
- Among three compartments (A, B and C):



- Water **stored** temporarily in a lake (B);
- Water **enter** the lake (B) from the atmosphere (A) as precipitation and from the land around the lake as runoff (C).
- It **leaves** the lake (B) through evaporation to the atmosphere (A) or as runoff via a surface stream or subsurface flows (C).

The Hydrologic Cycle – **Water Cycle**

- The hydrologic cycle is the transfer of water from the oceans to the atmosphere to the land and back to the oceans.



The Hydrologic Cycle – **Water Cycle**

- **Reservoir**

– oceans, air (as water vapor), groundwater, lakes and glaciers

– precipitation on land

– runoff from streams, rivers, and subsurface groundwater

– evaporation, wind and precipitation (rain) move water from oceans to land

- **Assimilation**

– plants absorb water from the ground

– animals drink water or eat other organisms which are composed mostly of water

The Hydrologic Cycle – **Water Cycle**

- **Release**

– evaporation of water from the oceans

– evaporation from land

– transpiration of water by plants

– runoff from stream

– animals breathe and expel liquid wastes

Importance of Hydrologic Cycle

- Solar energy drives the hydrologic cycle by evaporating water from oceans, freshwater bodies, soils, and vegetation.

- Of the total 1.3 billion km^3 of water on Earth –
- about 97% is in oceans
- about 2% is in glaciers and ice caps;
- 0.76% is shallow groundwater;
- 0.013% is in lakes and rivers;
- only 0.001% is in the atmosphere.

Importance of Hydrologic Cycle

- Although water on land and in the atmosphere accounts for only a small fraction of the water on Earth, this water is important in –

- moving chemicals,
- sculpting landscape,
- weathering rocks,
- transporting sediments, and
- providing our water resources

Impacts of Human Activities on Hydrologic Cycle

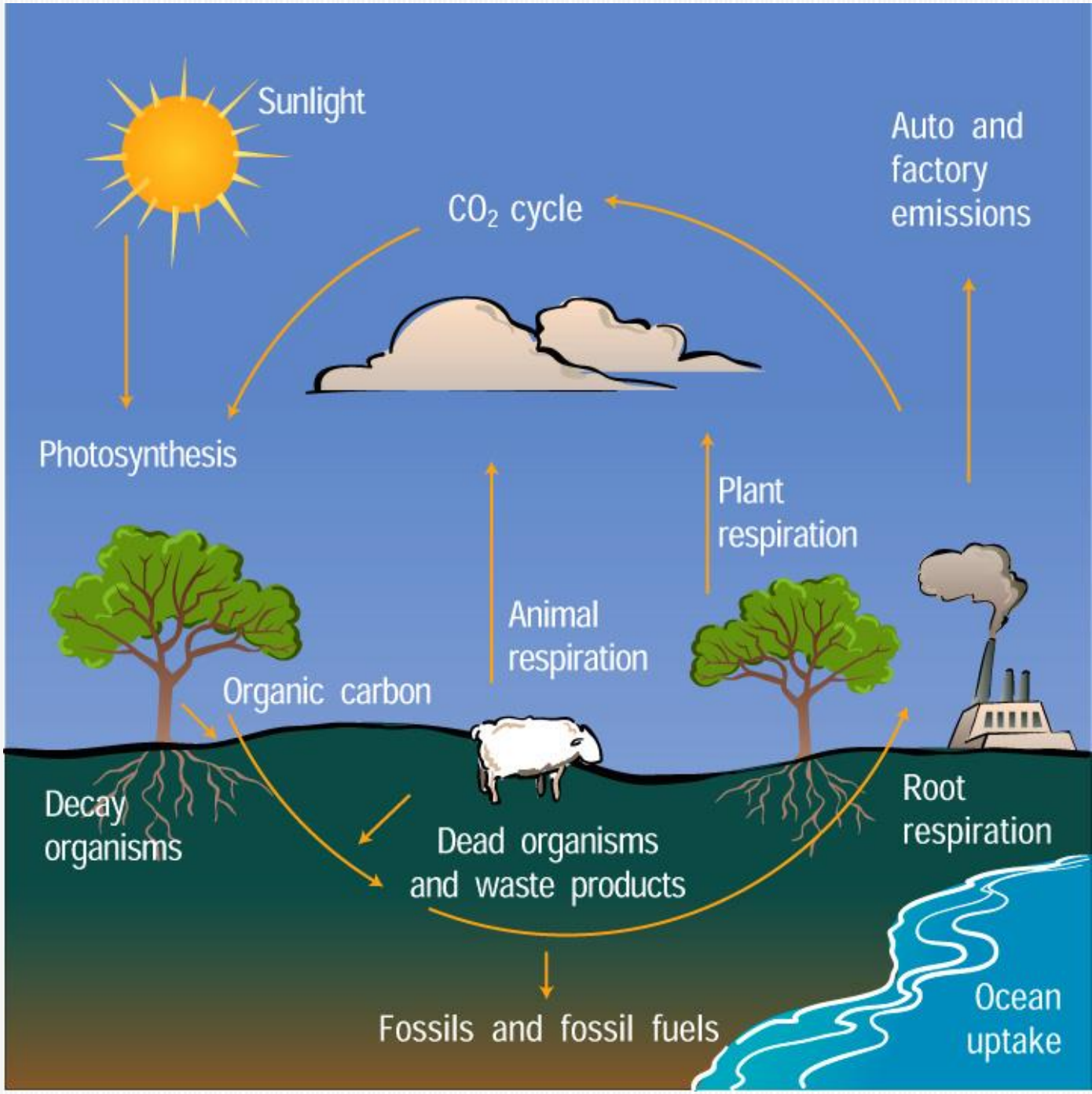
We alter the water cycle by –

- Withdrawing large amounts of freshwater.
- Clearing vegetation and eroding soils.
- Polluting surface and underground water.
- Contributing to climate change.

Carbon Cycle

- Carbon is the basic building block of life.
- It anchors all organic substances, from coal and oil to DNA (deoxyribonucleic acid).
- Although of central importance to life, carbon is not one of the most abundant elements in Earth's crust.
- It contributes only 0.032% of the weight of the crust.

Carbon Cycle



Carbon Cycle

- **Reservoir**

– atmosphere (as CO_2), fossil fuels (oil, coal), durable organic materials (for example: cellulose).

- **Assimilation**

– plants use CO_2 in photosynthesis; animals consume plants.

- **Release**

– plants and animals release CO_2 through respiration and decomposition; CO_2 is released as wood and fossil fuels are burned.

Carbon Cycle

Atmospheric Carbon

- Carbon has a gaseous phase as part of its cycle, occurring in the atmosphere as carbon dioxide (CO_2) and methane (CH_4), both greenhouse gases.

- Carbon enters the atmosphere through the respiration of living things, through fires that burn organic compounds, and by diffusion from the ocean.

- It is removed from the atmosphere by photosynthesis of green plants, algae, and photosynthetic bacteria and enters the ocean from the atmosphere by the simple diffusion of carbon dioxide.

Carbon Cycle

Aquatic Carbon

- The carbon dioxide dissolves into ocean from atmosphere, some of it remaining in that state [$CO_{2(aq)}$] and the rest converting to carbonate (CO_3) and bicarbonate (HCO_3).

- Marine algae and photosynthetic bacteria obtain the carbon dioxide they use from the water in one of these three forms.

- Carbon is transferred from the land to the ocean in rivers and streams as dissolved carbon, including organic compounds, and as organic particulates (fine particles of organic matter) and seashells and other forms of calcium carbonate ($CaCO_3$).

Carbon Cycle

Carbon in Biota

- Carbon enters the biota—the term for all life in a region—through photosynthesis and is returned to the atmosphere or waters by respiration or by wildfire.

- When an organism dies, most of its organic material decomposes into inorganic compounds, including carbon dioxide.

- Some carbon may be buried where there is not sufficient oxygen to make this conversion possible or where the temperatures are too cold for decomposition. In these locations, organic matter is stored.

Carbon Cycle

Carbon in Biota

- Over years, decades, and centuries, storage of carbon occurs in wetlands, including parts of floodplains, lake basins, swamps, deep-sea sediments, and near-polar regions.

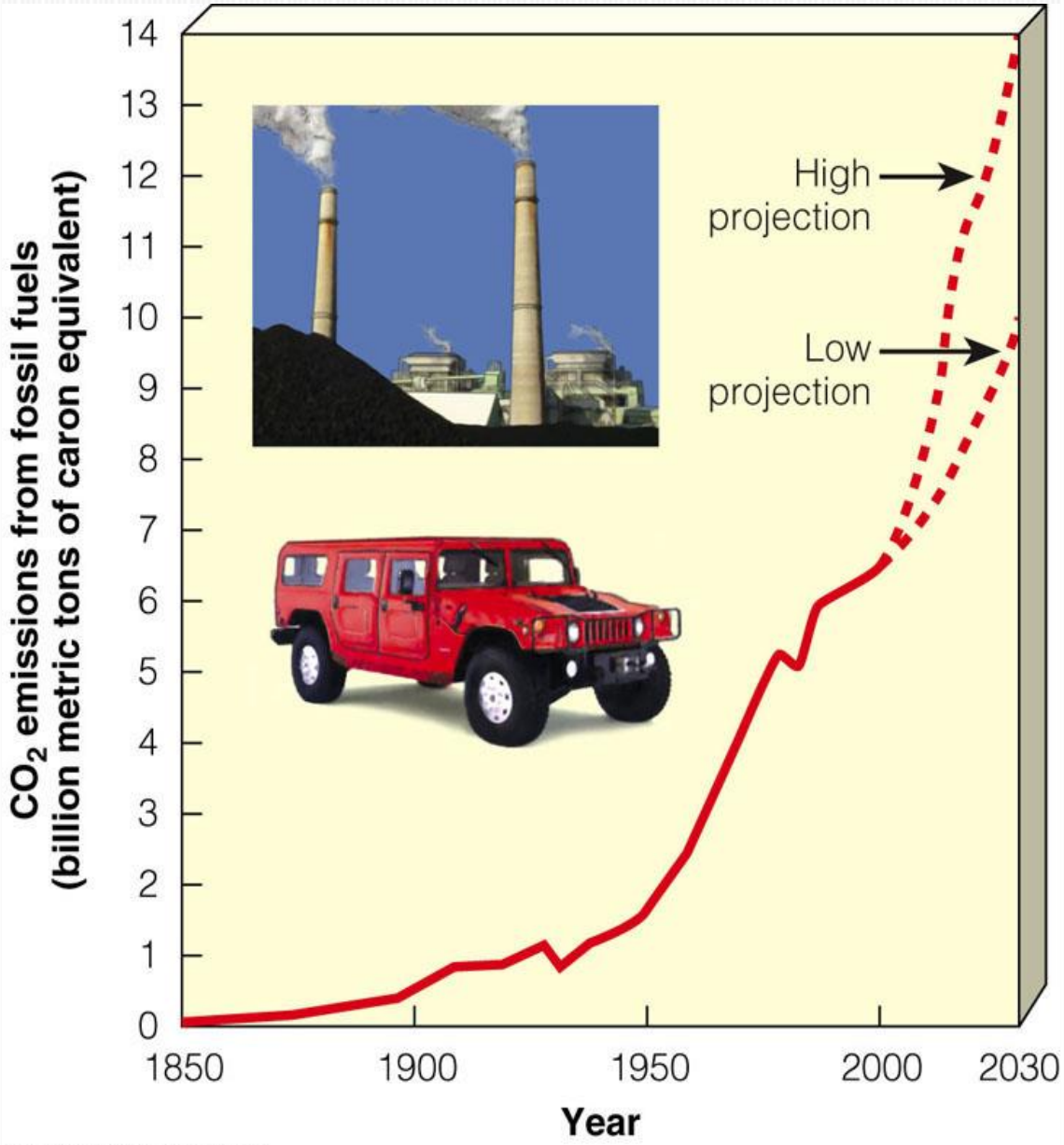
- Over longer periods (thousands to several million years), some carbon may be buried with sediments that become sedimentary rocks. This carbon is transformed into fossil fuels.

- Nearly all of the carbon stored in the lithosphere exists as sedimentary rocks, mostly carbonates, such as limestone, much of which has a direct biological origin.

Impacts of Human Activities on Carbon Cycle

We alter the carbon cycle by adding excess CO_2 to the atmosphere through:

- Burning of fossil fuels.
- Clearing vegetation faster than it is replaced.



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