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Unit 4: Earth's spheres are interconnected

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Topic 4.4: What interactions cycle matter through Earth's spheres?

- The water cycle is a continuous cycle driven by solar energy and gravity.
- Carbon is cycled through interactions between living and non-living things.
- Nitrogen is cycled through interactions between living and non-living things.
- Phosphorus is cycled through interactions between living and non-living things.

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Concept 1: The water cycle is a continuous cycle driven by solar energy and gravity.

All water on Earth continuously cycles through ecosystems by the interaction of three main processes in the water cycle:

- Evaporation
- Condensation
- Precipitation

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The Water Cycle: Water Moving Through Earth's Spheres

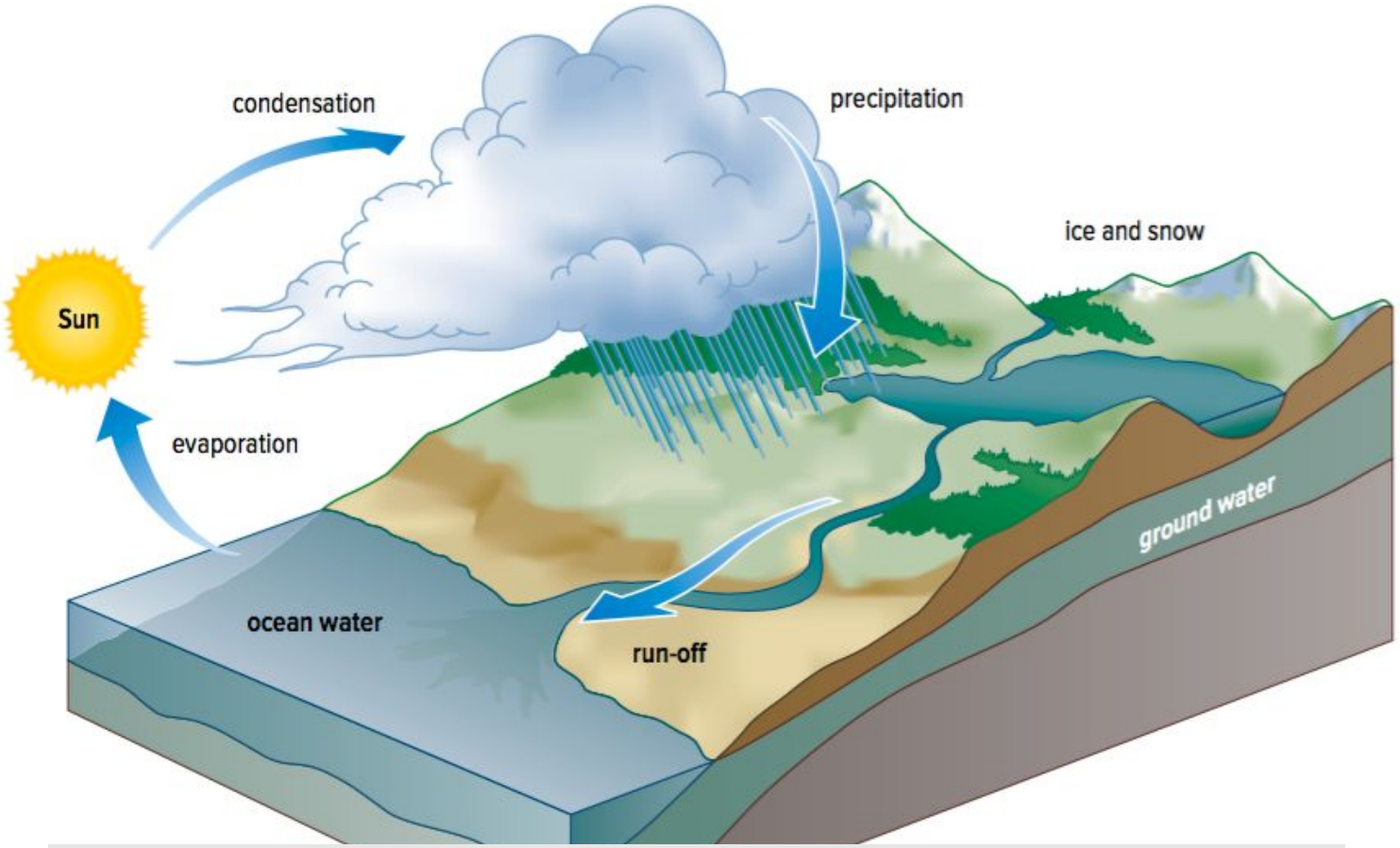

Figure 4.16: During the water cycle, water is exchanged among the hydrosphere, atmosphere, and geosphere.

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The Water Cycle: Water Moving Through Earth's Spheres (continued)

- **Evaporation**: Heat from the Sun causes water at Earth's surface to evaporate
- **Condensation**: As warm air rises, it cools and condenses, forming clouds
- **Precipitation**: Water falls back to Earth's surface when it rains or snows
- Water moves over Earth's surface ("run-off") and moves downhill back into the ocean water due to gravity

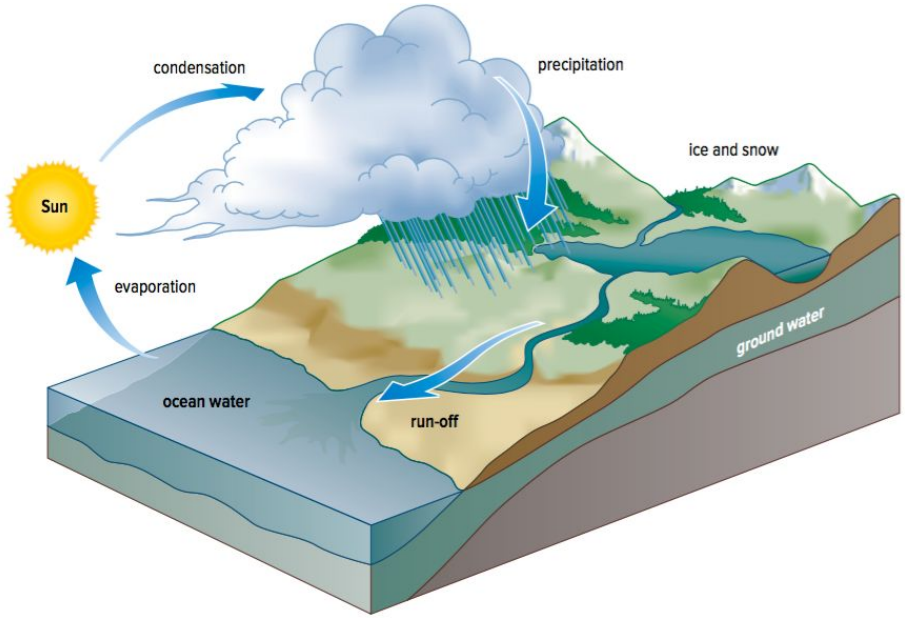

Figure 4.16

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The Water Cycle and Transpiration

Water moves through the biosphere by transpiration

- **Transpiration:** Process by which water is absorbed by the roots of plants, carried through the plant, and lost as water vapour through small pores in the leaves

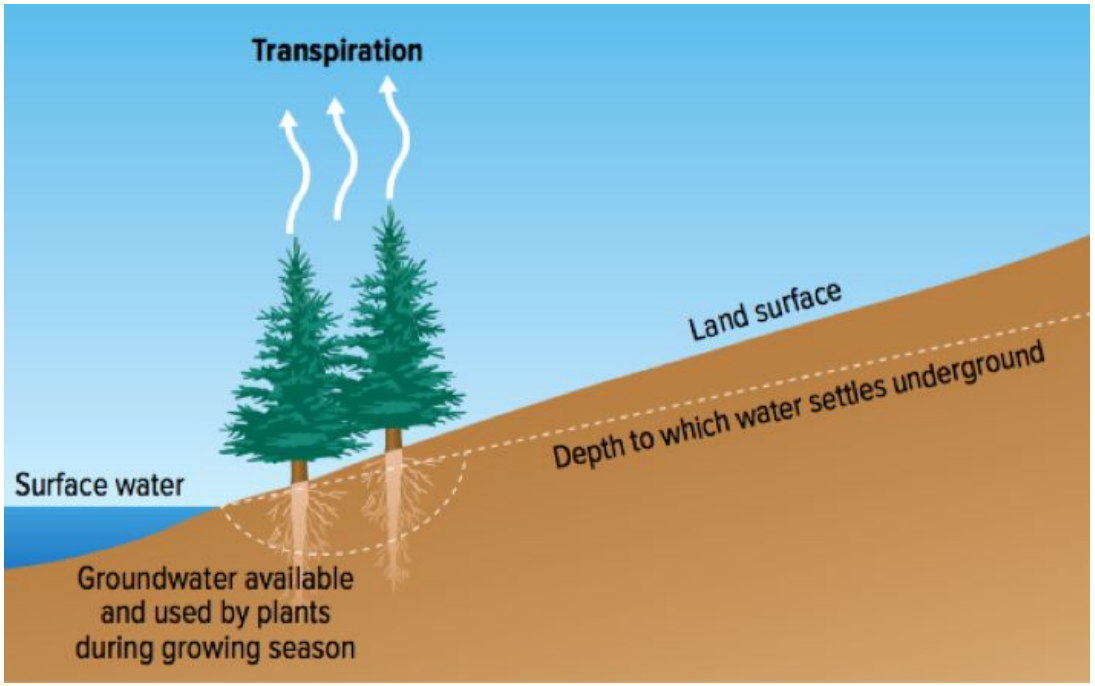

Figure 4.17: Studies show that about 10% of water vapour in the atmosphere is released by plants.

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Human Impact on the Water Cycle

Water pollution: Any physical, biological, or chemical change in water quality that has an adverse effect on organisms or that makes water unsuitable for desired uses

Source of pollution include:

- Point sources
- Non-point sources

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Point Sources and Non-Point Sources of Water Pollution

Point sources

- Examples: factories, power plants, sewage treatment plants, oil wells
- Easy to monitor and regulate

Non-point sources

- Examples: run-off from farms, lawns, construction sites, logging areas, roads, parking lots
- Difficult to monitor, regulate, and treat since pollution is periodic

Figure 4.18: (A) Industrial pipes that discharge waste are a point source of water pollution. (B) Run-off from construction sites is a non-point source of water pollution.

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Organisms Magnify Water Pollutants

Pollutants that do not degrade easily stay in the environment for a long time

- Example: DDT pesticide, heavy metals (mercury), PCBs in plastics
- DDT and PCBs are banned in Canada
  - When they enter the water, microscopic organisms (phytoplankton, bacteria) take them up and they collect in their cells and tissues

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Organisms Magnify Water Pollutants (continued)

- **Bioaccumulation**: the process by which pollutants collect in the cells and tissues of organisms

- **Biomagnification**: the increase in concentration of pollutants in tissues of organisms that are at successively higher levels in a food chain or food web

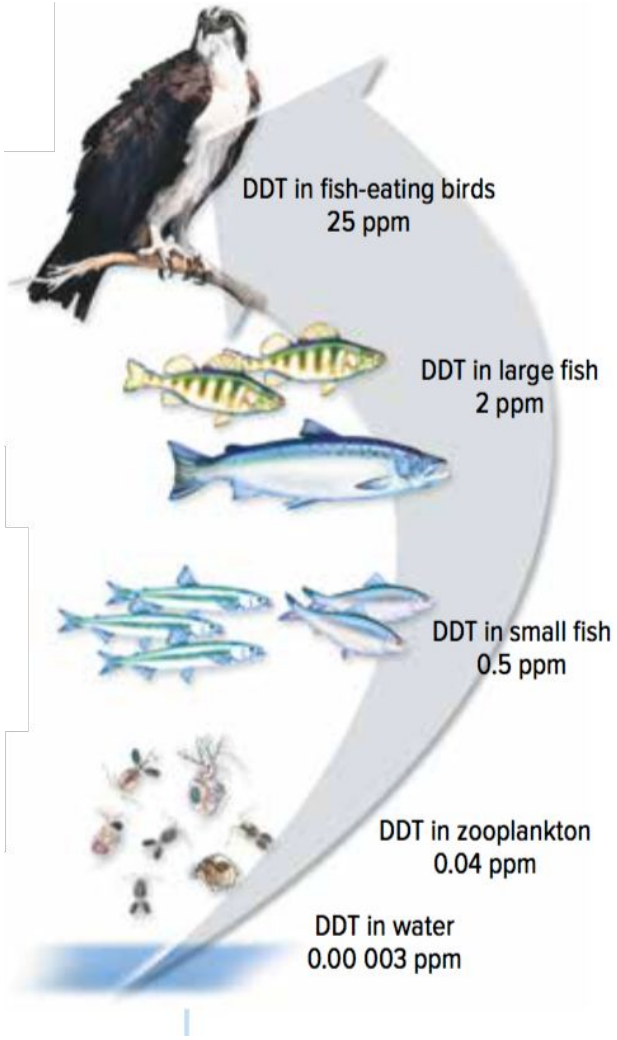

Figure 4.19: Bioaccumulation and biomagnification work together to magnify certain water pollutants in large predators. The unit ppm means "parts per million" of the pollutants.

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Discussion Questions

1. A cycle is a pattern of change that repeats itself forever. In what way does the water cycle demonstrate the features of a cycle?

2. Describe how transpiration ties the hydrosphere and the biosphere together.

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Discussion Questions (continued)

3. Make a T-chart to list the differences between point source and non-point source water pollution.

4. Compare and contrast bioaccumulation and biomagnification.

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Concept 2: Carbon is cycled through interactions between living and non-living things.

The carbon cycle:

- Carbon dioxide gas moves from the atmosphere into the biosphere through photosynthesis and cellular respiration
- Carbon dioxide also moves back to the atmosphere when organisms die and decompose
- Carbon enters the geosphere when the remains of organisms are trapped under sediment layers

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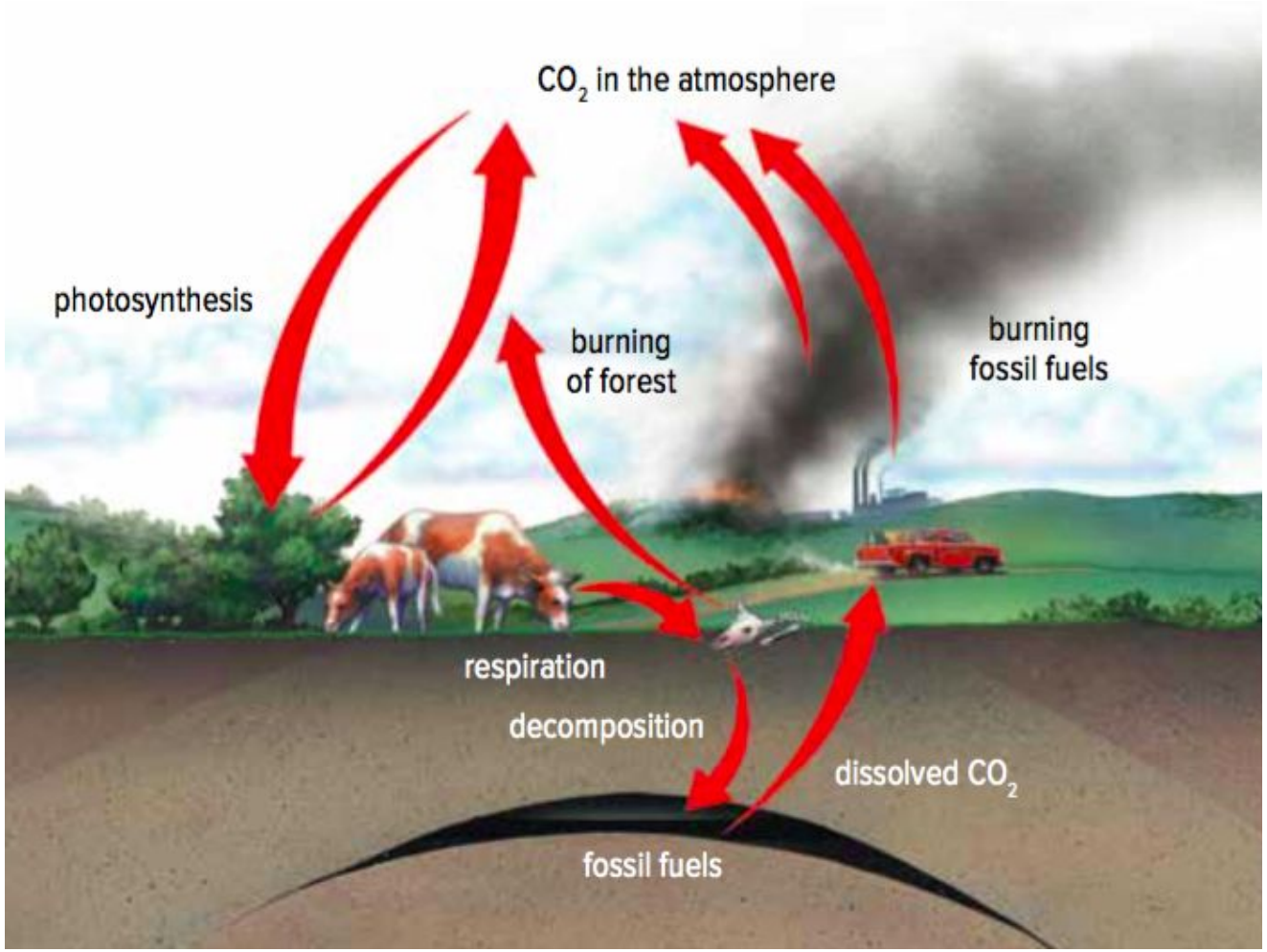
The Carbon Cycle: Carbon Moving Through Earth's Spheres

Figure 4.20: During the carbon cycle, carbon is exchanged among the biosphere, atmosphere, and geosphere.



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The Carbon Cycle: Carbon Moving Through Earth's Spheres (continued)

Not all carbon in the carbon cycle is used immediately by living things

- Some carbon is stored in the woody tissue of living trees
- Some carbon is stored in the decomposing remains of organisms buried deep in the ground
  - Over time, this stored carbon transforms into carbon-rich fossil fuels (coal, oil, natural gas)

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The Carbon Cycle: Upsetting the Balance

The amount of carbon dioxide used by photosynthesis and given off by cellular respiration is nearly the same (carbon dioxide is balanced)

- Human activities can upset this balance
- Examples: burning trees, coal, oil, and natural gas releases stored carbon into the air as carbon dioxide
- Carbon dioxide is a greenhouse gas
- Extra carbon dioxide in the air traps heat in the atmosphere leading to **global warming** and **global climate change**

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Global Warming and Global Climate Change

Global warming: An increase in the average temperature of Earth's surface

Global climate change: A long-term change in Earth's climate

- Can be caused by natural factors of human activity
- Natural: Natural variations in greenhouse gases (Figure 4.21), changes in ocean and atmospheric circulation, changes in Earth's orbit
- Human activity: Increase in greenhouse gases due to burning of fossil fuels

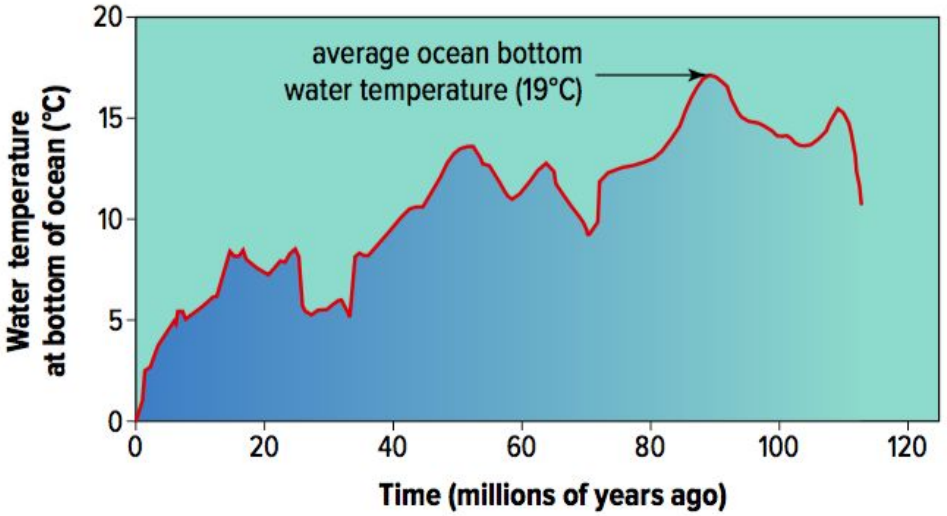

Figure 4.21: High levels of volcanic activity released greenhouse gases that warmed global temperature during the Cretaceous period. It is estimated that the water at the bottom of the ocean was 19Cº.

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The Effects of Excess Carbon in the Carbon Cycle

Earth's surface temperature: Increased by between 0.56°C and 0.92°C in the past 100 years

- This "small" change can affect conditions in all of Earth's spheres

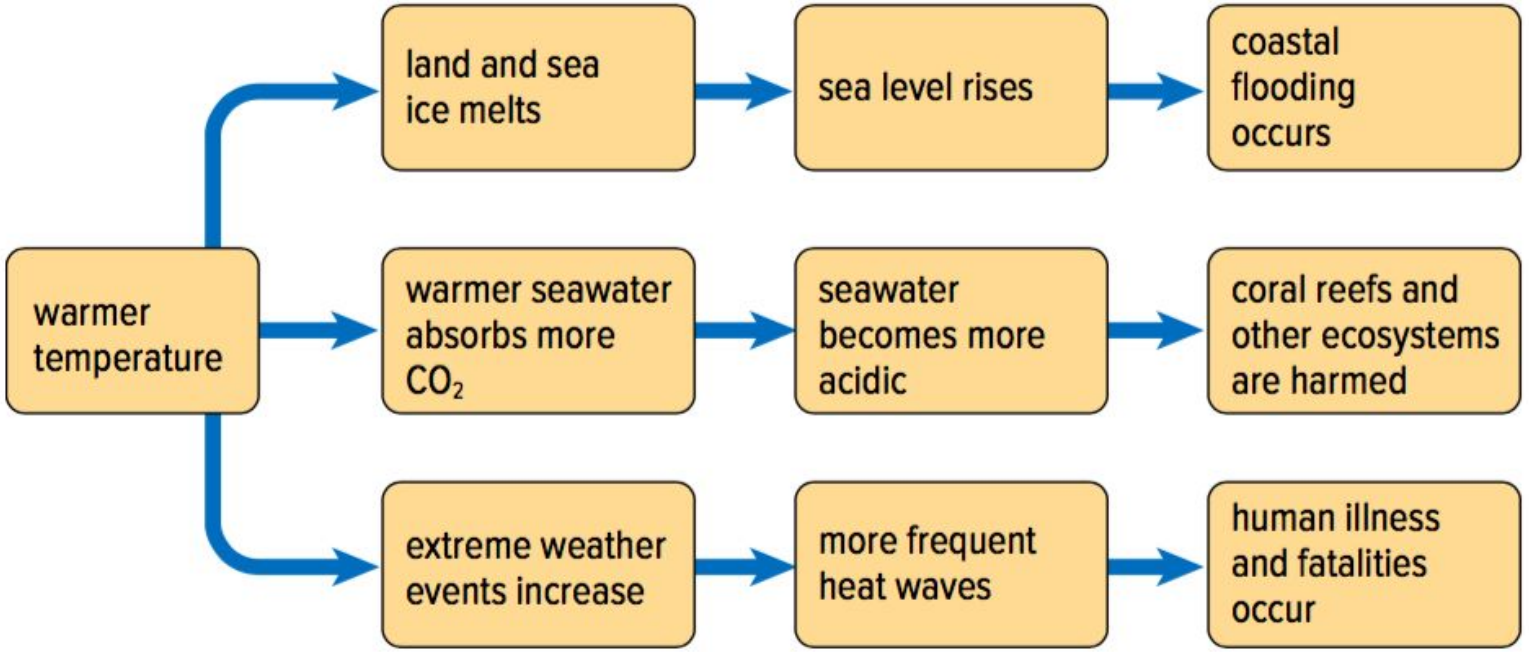

Figure 4.22: Warmer global temperatures are linked to changes in Earth's environment.

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The Effects of Excess Carbon in the Carbon Cycle: Melting Sea and Land Ice

Melting sea and land ice has led to destruction of habitats for polar organisms, increased local flooding, and release of methane gas (a greenhouse gas) from melting permafrost

Figure 4.23: Bear Glacier can be viewed from northern British Columbia. Photo (A) of the glacier was taken in 2002. Photo (B) shows the glacier in 2007. Between 2002 and 2007, the glacier retreated by several kilometres and decreased in height.

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The Effects of Excess Carbon in the Carbon Cycle: Rising Sea Level and Changing Ocean Chemistry

Rising sea level

- Some islands have gone underwater
- Salt water gets into the drinking water supply
- Coastal flooding and destruction of wetlands

Changing ocean chemistry

- Ocean becomes more acidic because it absorbs more carbon dioxide from the air
- An acidic and warming ocean can destroy coral reefs and corals themselves (acidity dissolves the organisms' shells)

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Discussion Questions

1. How does burning fossil fuels upset the balance of the carbon cycle?

2. Make a table to describe the effects of excess carbon in the carbon cycle on each of Earth's spheres.

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Concept 3: Nitrogen is cycled through interactions between living and non-living things.

The nitrogen cycle:

- Nitrogen is a nutrient that cells need to build proteins
- Nitrogen makes up 78% of air, but organisms cannot use this form of nitrogen
- Nitrogen-fixing bacteria in soil and water change nitrogen into forms that plants can use

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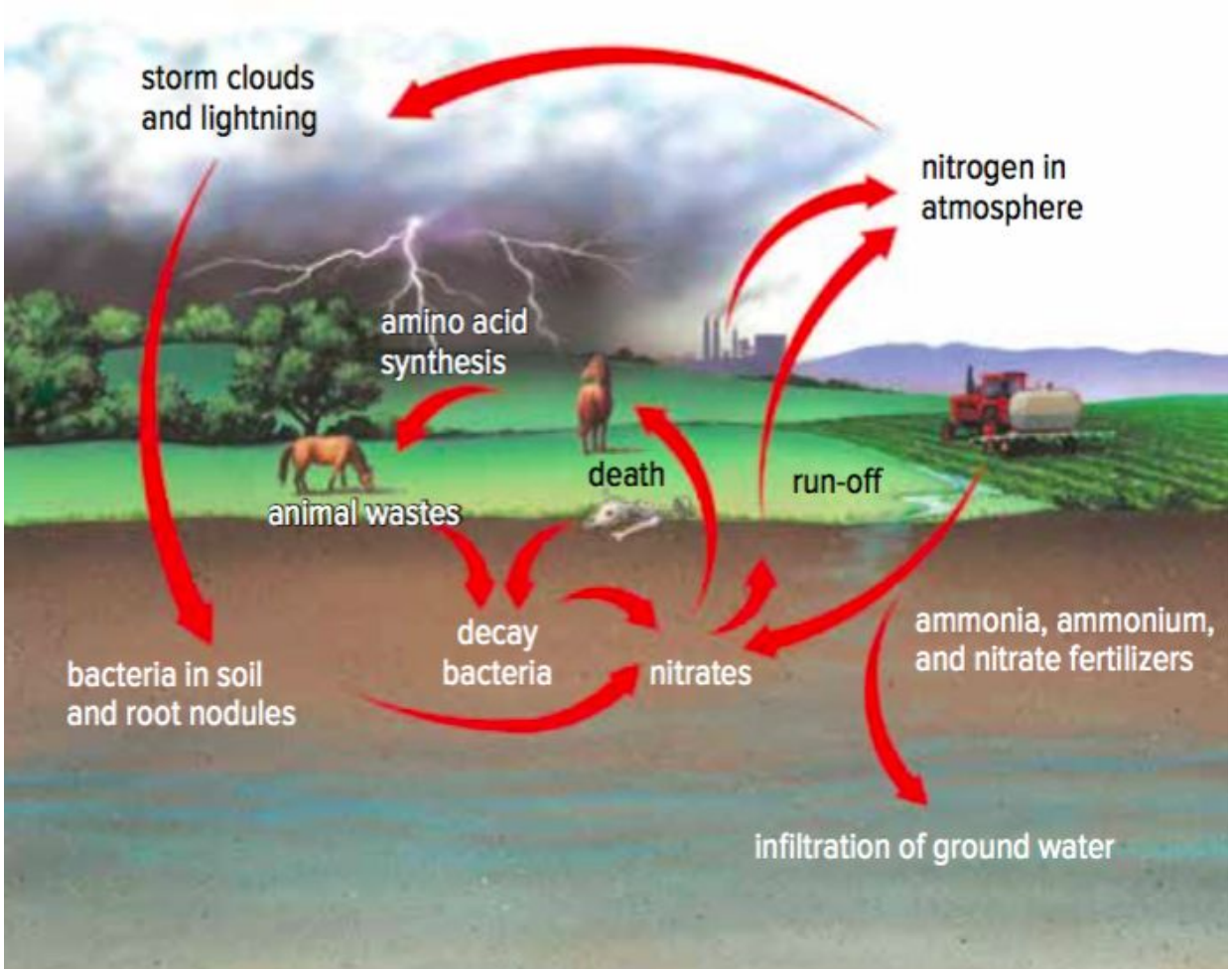
The Nitrogen Cycle: Nitrogen Moving Through Earth's Spheres

Figure 4.24: During the nitrogen cycle, nitrogen is exchanged among the atmosphere, biosphere, and geosphere.



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Excess Nitrogen: Overgrowth of Algae (Algal Bloom)

Excess nitrogen is due to human activities

- Burning of fossil fuels (emits nitrogen oxide gases)
- Clearing of forests and grasslands
- Fertilizer use (contain nitrates)
  - Not all fertilizer is used by the plants; some stays in the soil
  - Excess nitrogen in the fertilizer gets carried into aquatic ecosystems when it rains
  - Nitrogen in waterways leads to an overgrowth of algae (algal bloom) since there is too much of the nutrient
  - The algae blocks the sunlight from reaching organisms in the deep waters

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Excess Nitrogen: Overgrowth of Algae (Algal Bloom) (continued)

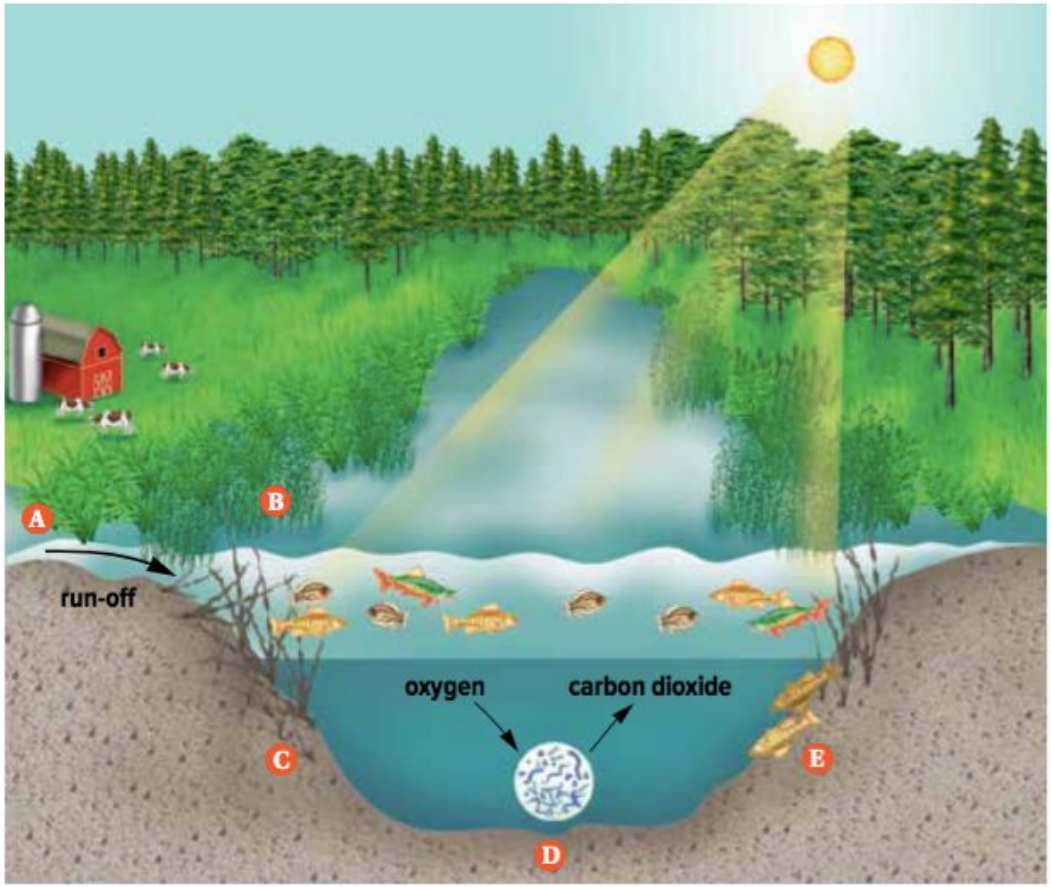

Figure 4.25: An algal bloom is caused by too much of a nutrient, such as nitrogen, entering an aquatic ecosystem.

- **A** Rain carries nitrogen from farms, gardens, and lawns into aquatic ecosystems.
- **B** Algae and plants at the water's surface grow quickly. This blocks sunlight from reaching deeper water.
- **C** Deep-water plants get no sunlight. They cannot carry out photosynthesis, so they no longer give off oxygen, and they soon starve to death.
- **D** When the plants die, decomposers have lots of food. The number of decomposers increases quickly. They use up the oxygen in the water as they carry out cellular respiration.
- **E** As oxygen in the water is used up, aquatic organisms that need the oxygen suffocate and die.

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Discussion Questions

1. Why are bacteria an important part of the nitrogen cycle?

2. How does excess nitrogen in the nitrogen cycle affect the biosphere?

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Concept 4: Phosphorus is cycled through interactions between living and non-living things.

The phosphorus cycle:

- Phosphorus is a nutrient essential for the growth and development of organisms
- Phosphorus is stored in the geosphere
- When rock is broken down through weathering, phosphorus is released into the soil and water
- Plants absorb the phosphorus, and animals obtain it when they eat plants and other animals
- Decomposers return phosphorus to soil and water as they break down dead organisms

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The Phosphorus Cycle: Phosphorus Moves Through Earth's Spheres

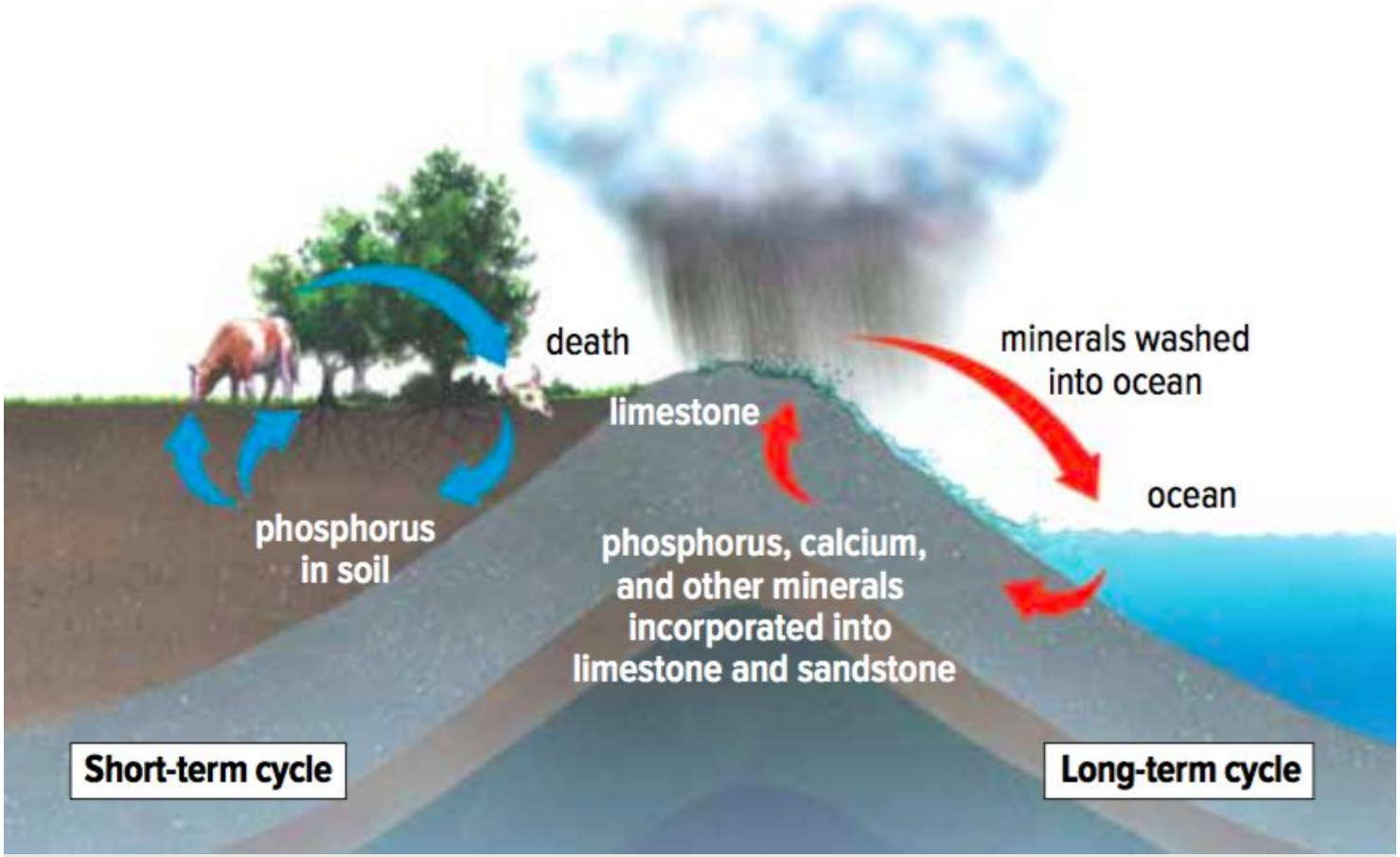

Figure 4.26: During the phosphorus cycle, phosphorus is exchanged among the biosphere, hydrosphere, and geosphere.

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Excess Phosphorus: Overgrowth of Algae (Algal Blooms)

Excess phosphorus is due to human activities

- Found in dishwashing and laundry detergents
- Fertilizer use
  - Similar to excess nitrogen, phosphorus in run-off from agricultural fields can lead to overgrowth of algae (algal blooms)
  - The algae blocks the sunlight from reaching organisms in the deep waters (organisms die)

Figure 4.27: 1 kg of phosphorus can produce up to 500 kg of algae in a marine environment.

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Discussion Questions

1. What is the role of the geosphere in the phosphorus cycle?

2. What are some sources of excess phosphorus?

3. What actions could you take to help reduce the amount of excess phosphorus entering the phosphorus cycle?

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Topic 4.4 Summary: What interactions cycle matter through Earth's spheres?

- The water cycle is a continuous cycle driven by solar energy and gravity.
- Carbon is cycled through interactions between living and non-living things.
- Nitrogen is cycled through interactions between living and non-living things.
- Phosphorus is cycled through interactions between living and non-living things.

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