McGraw-Hill Ryerson

BC Science Connections 9

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Unit 4: Earth's spheres are interconnected

Topic 4.2: What is the role of the Sun's energy in Earth's spheres?

- Solar energy that reaches Earth is absorbed and reflected by Earth's atmosphere and Earth' surface.
- Solar energy heats Earth's surface unevenly and global winds help redistribute thermal energy around Earth.
- Ocean currents also redistribute thermal energy around Earth.
- Solar energy enters the biosphere through photosynthesis and cellular respiration.

Concept 1: Solar energy that reaches Earth is absorbed and reflected by Earth's atmosphere and Earth' surface.

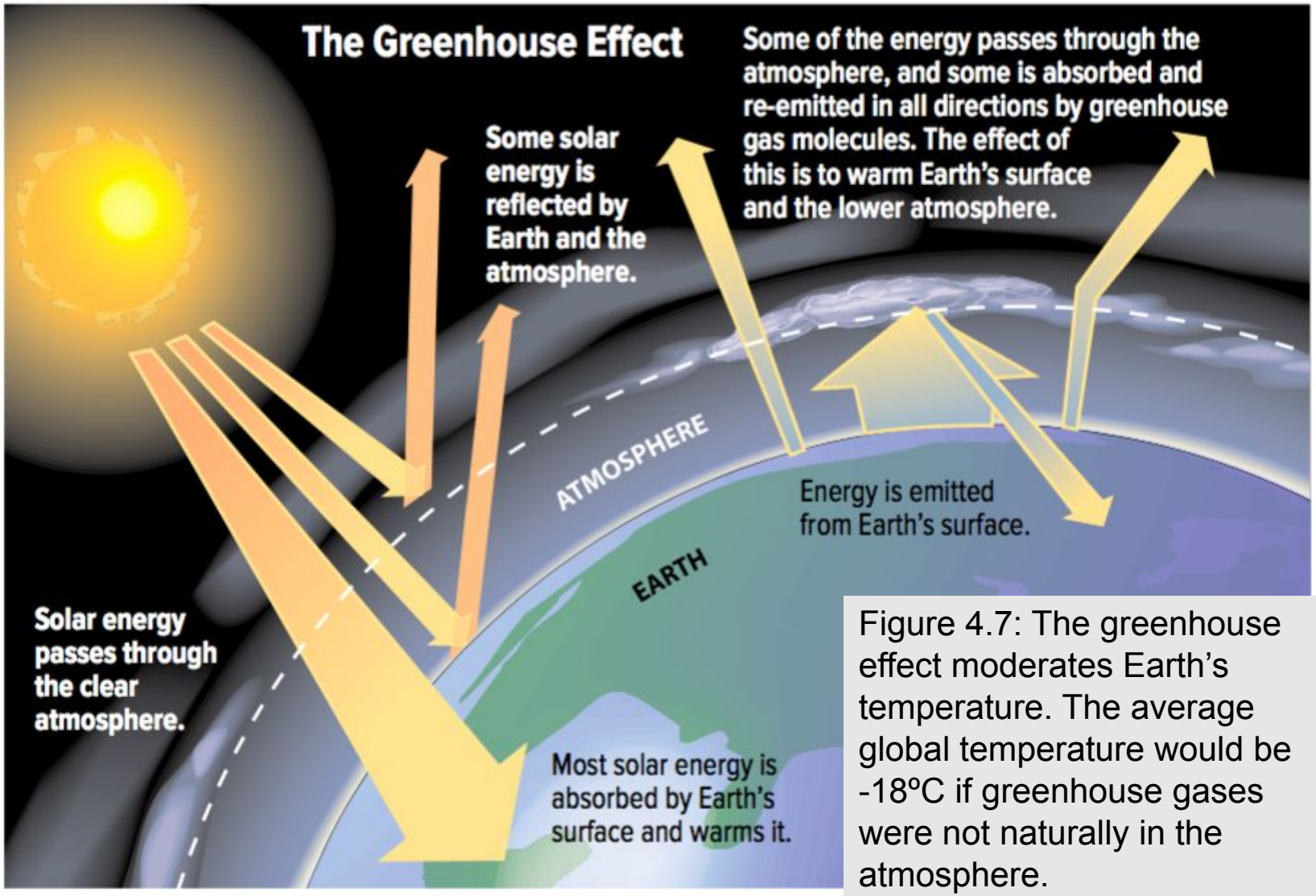


Figure 4.7: The greenhouse effect moderates Earth's temperature. The average global temperature would be -18ºC if greenhouse gases were not naturally in the atmosphere.

Greenhouse Gases

Greenhouse gases: Absorb solar energy in Earth's atmosphere; many occur naturally in the atmosphere

Table 4.3 Natural Greenhouse Gases

Greenhouse Gas	Sources	Other Details
water vapour	• evaporation from water • given off by plants, animals, and other organisms	• most abundant greenhouse gas • produced during cellular respiration and certain plant processes
carbon dioxide	• living organisms • volcanoes, forest fires, decaying organisms, release from oceans	• second most abundant greenhouse gas • produced in and by the cells of most living organisms through cellular respiration
methane	• certain species of bacteria and other micro-organisms that live in and around bogs, wetlands, melting permafrost • certain species of bacteria that live in the gut of animals such as cows and termites • vents and other openings in Earth's crust on land and the ocean floor	• a by-product of cellular processes used by some micro-organisms to extract energy from food in the absence of oxygen
nitrous oxide	• bacteria that live in oceans and wet, warm soils such as those in the tropics	• produced when certain species of bacteria break down nitrogen-rich compounds for food

Greenhouse Gases (continued)

Greenhouse gases can also be released into the atmosphere from human activities

- Carbon dioxide: Released when fossil fuels (oil, natural gas, coal) are burned
- Nitrous oxide: Enters the atmosphere when fertilizer is applied to crops
- Methane: Released in large amounts by livestock
- Excess release of greenhouse gases can impact Earth's climate

Discussion Questions

1. Explain the role that greenhouse gases play in the greenhouse effect.

2. Predict what would happen to Earth's other spheres if the concentration of greenhouse gases in the atmosphere increased.

Concept 2: Solar energy heats Earth's surface unevenly and global winds help redistribute thermal energy around Earth.

The amount of solar energy that reaches different regions of Earth varies

- Earth is spherical
- Solar energy strikes the Earth at different angles
- Receives more direct solar energy at lower latitudes (equator / tropics)
- Therefore, atmosphere heats up unevenly
- Lower latitudes becomes warmer

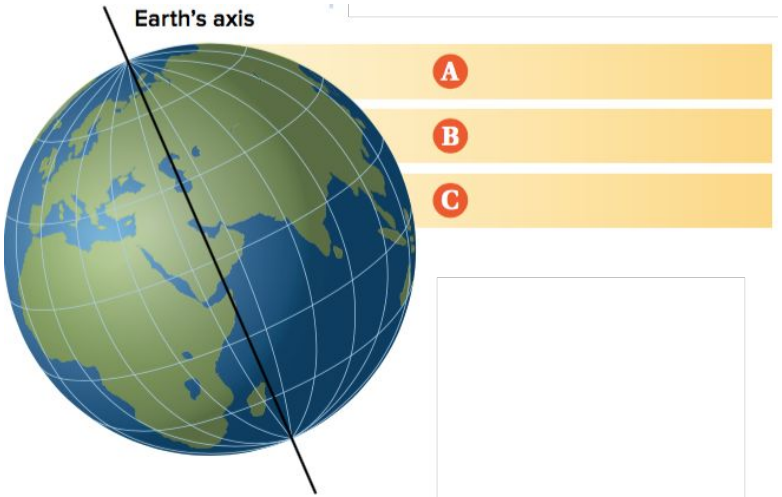


Figure 4.8: Earth's curved surface affects the concentration of light and warming at different parts of its surface.

Global Wind Systems

Wind (moving air) results from unequal heating of Earth's surface

- Wind redistributes thermal energy around Earth
- Warm air near Earth's surface rises and cools
- Cool air is denser and sinks, creating wind that moves warm and cool air around Earth

Global Wind Systems (continued)

Earth's major wind systems result from

- Convection currents
- Coriolis effect (a change in the direction of moving air, water, or other objects due to Earth's rotation)

- Global wind systems move thermal energy around Earth, and distribute it more evenly throughout the atmosphere

Global Wind Systems: Trade Winds

Trade winds:

- Move east to west
- Air near the equator warms, rises, and travels north or south
- At the north or south, the air cools, sinks, and moves west

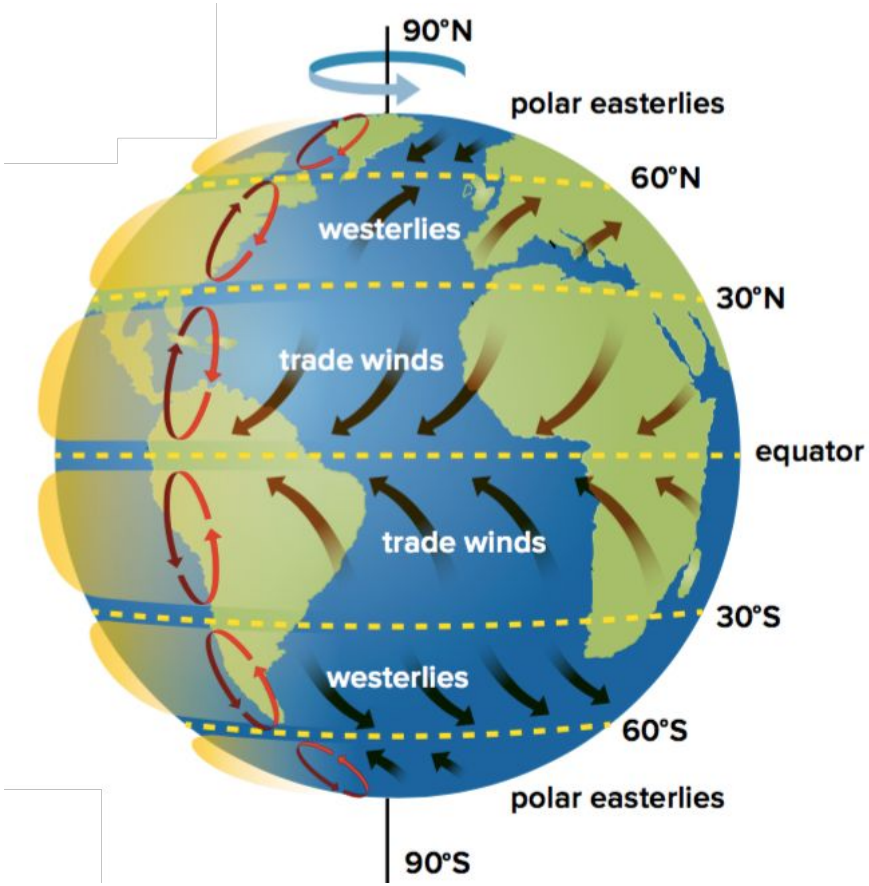


Figure 4.9: The directions of Earth's wind systems vary with the latitudes in which they occur.

Global Wind Systems: Westerlies

Westerlies:

- Move from west to east
- Steady winds that move much of the weather across North America

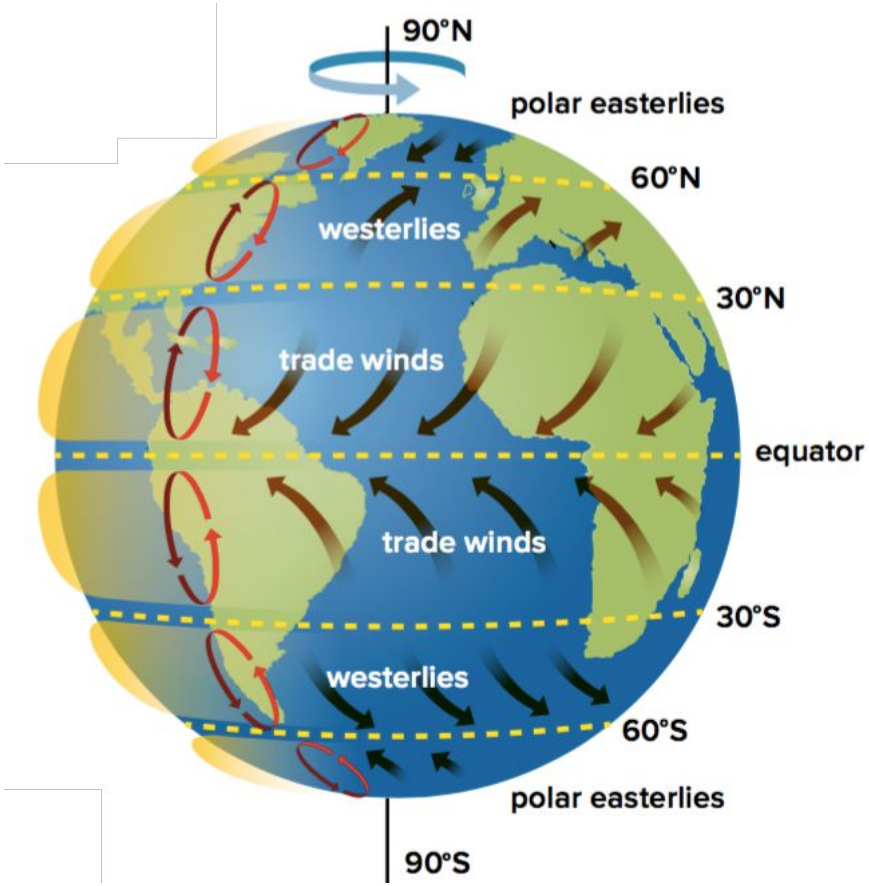


Figure 4.9: The directions of Earth's wind systems vary with the latitudes in which they occur.

Global Wind Systems: Polar Easterlies

Polar easterlies:

- From from east to west
- Move cold air from polar regions back toward equator

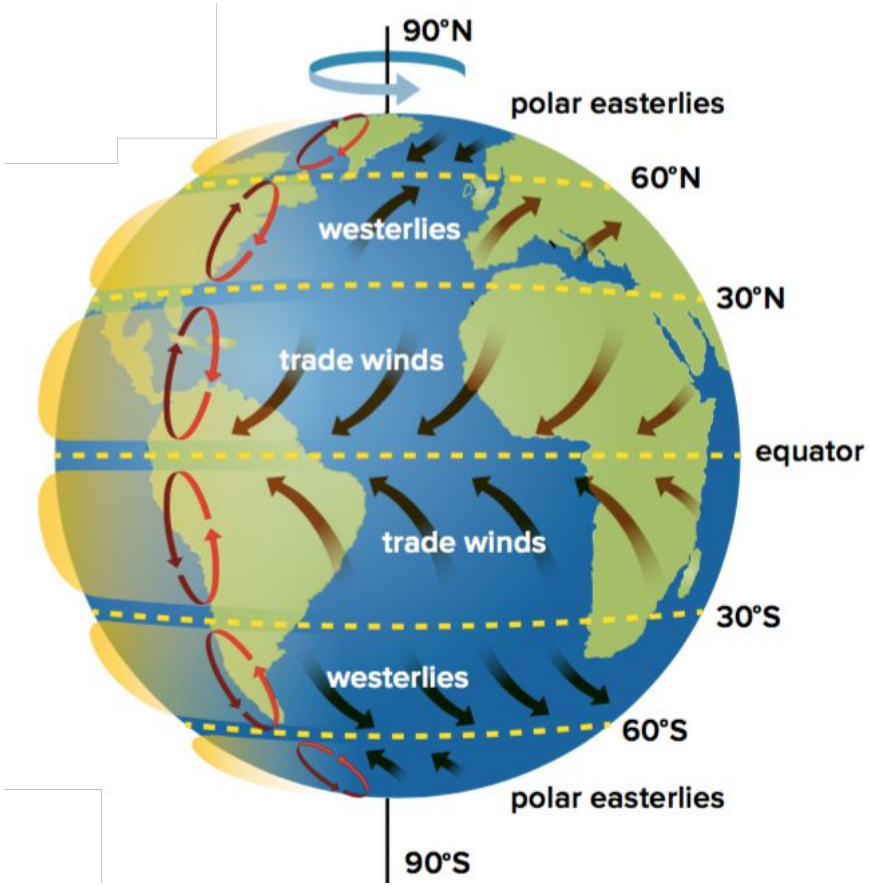


Figure 4.9: The directions of Earth's wind systems vary with the latitudes in which they occur.

Discussion Questions

1. Explain why Earth receives more direct energy at lower latitudes than at higher latitudes

2. Write a summary about how the global wind systems move thermal energy around Earth.

Concept 3: Ocean currents also redistribute thermal energy around Earth.

Ocean currents also move thermal energy around Earth

- Surface currents are created by wind
- Five major sets of surface currents (one in each main ocean basin)
  - Warm currents: move heat (warm water from the equator) toward the poles (higher, colder latitudes)
  - Cold currents: bring cold water from colder, higher latitudes to tropical regions

Ocean Currents (Surface Currents)

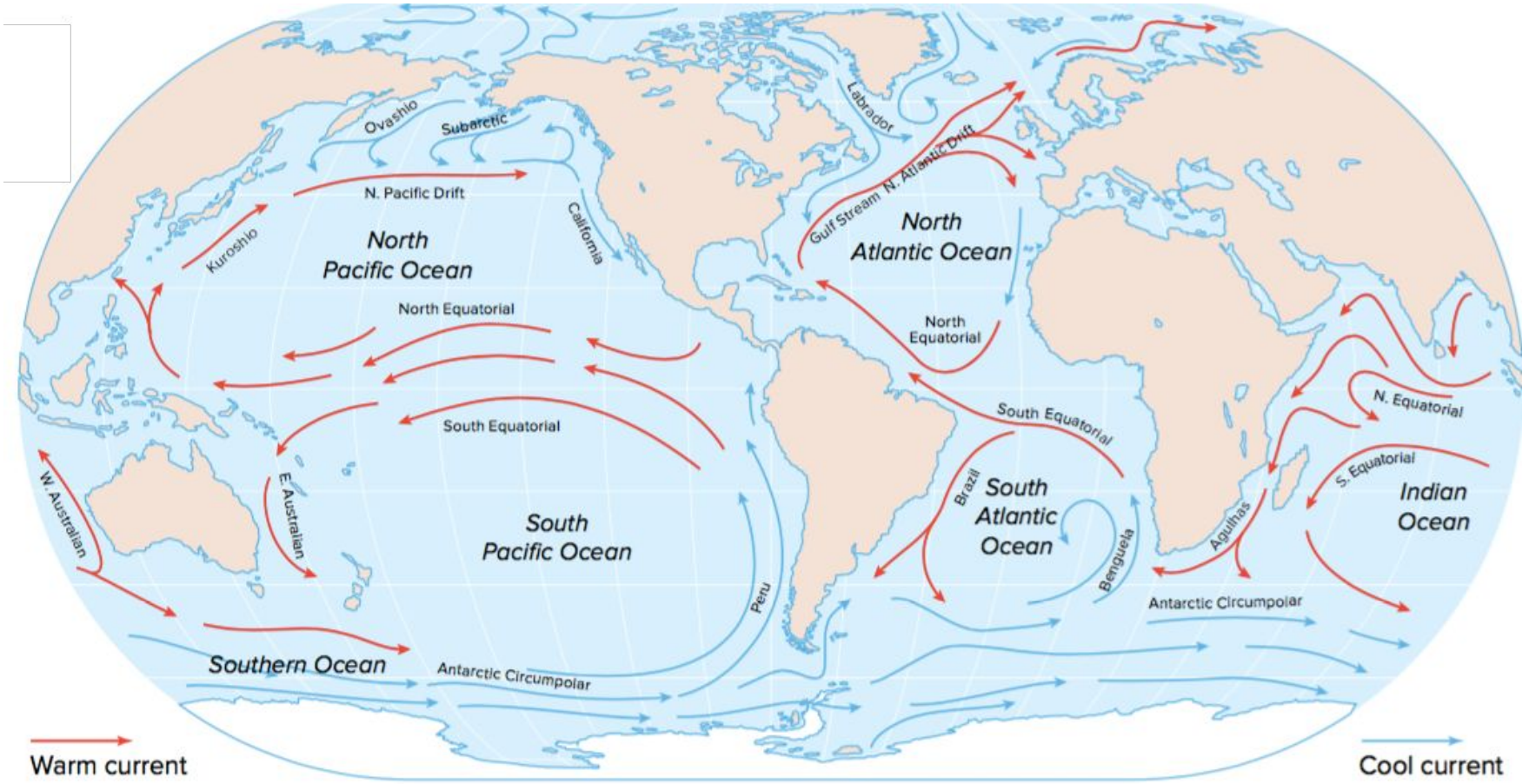


Figure 4.10: Surface currents circulate in predictable patterns in each ocean basin. The red arrows represent warm water currents and the blue arrows represent cold water currents.

Great Ocean Conveyer Belt: A System of Deep-Water Currents

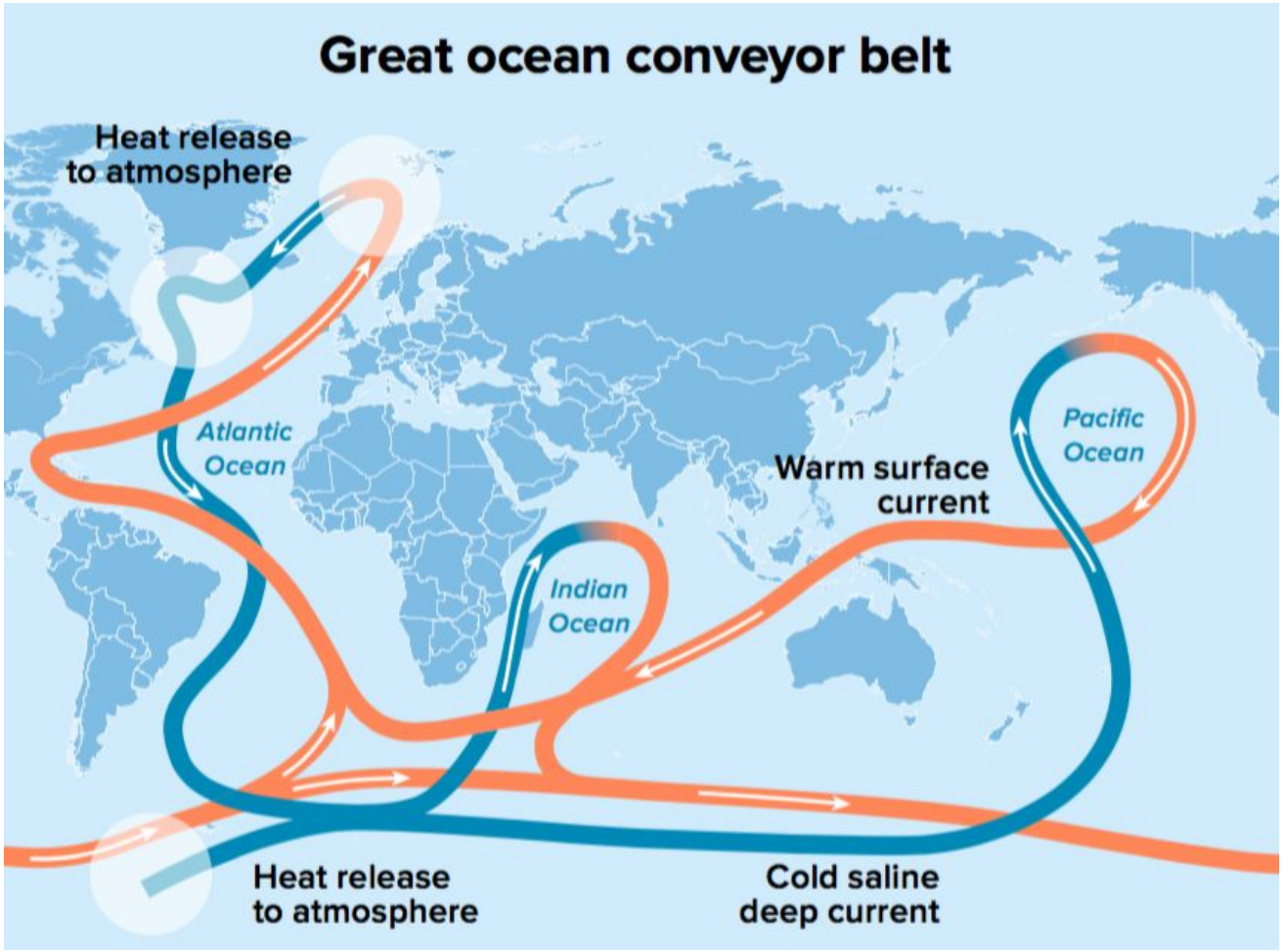
The *great ocean conveyer belt* is a massive system of deep-water currents that moves deep water, thermal energy, and nutrients around Earth.

Movement of these currents is based on the differences between the temperature and salt content of water:

- Cold water is more dense than warm water
  - Cold water sinks and displaces the warm water
- Saltier water is more dense than less salty water
  - Saltier water sinks and displaces less salty water

Great Ocean Conveyer Belt: A System of Deep-Water Currents (continued)

Figure 4.11: The great ocean conveyor belt moves water, nutrients, and thermal energy around Earth.



Great Ocean Conveyer Belt: Movement of Nutrients

The great ocean conveyor belt also moves nutrients, such as nitrogen and phosphorus, around the ocean.

- Surface water that sinks does not have many nutrients
- After the water sinks, bacteria in deep water break down organic material and return nutrients to the water
- When the deep water returns to the surface, it has a high concentration of nutrients

Discussion Questions

1. Describe how surface currents in ocean basins redistribute heat between the equator and the poles.

2. How does the great ocean conveyor belt move heat and nutrients around Earth?

Concept 4: Solar energy enters the biosphere through photosynthesis and cellular respiration.

Table 4.4 Comparing Photosynthesis and Cellular Respiration

	Photosynthesis
1. What is it?	A series of chemical changes in which green plants capture the Sun's light energy and transform it into chemical energy that is stored in energy-rich food compounds such as sugars
2. Which living things use it?	Green plants and certain kinds of single-celled organisms
3. How is energy changed?	Light energy is changed to chemical energy
4. What substances does it use?	• carbon dioxide (CO_2) • water (H_2O)
5. What substances does it produce?	• glucose ($C_6H_{12}O_6$) • oxygen (O_2)
6. How can it be represented?	light energy + carbon dioxide + water $\longrightarrow$ glucose + oxygen light energy from the Sun + CO_2 + H_2O $\longrightarrow$ $C_6H_{12}O_6$ + O_2
7. Why is it important?	• Photosynthesis transforms the Sun's energy into a form that living things can use to survive • Photosynthesis produces the oxygen that most living things need to survive

Concept 4: Solar energy enters the biosphere through photosynthesis and cellular respiration.

Cellular Respiration	
A series of chemical changes that let living things release the energy stored in energy-rich food compounds such as sugars to fuel all life functions	**1.** What is it?
Nearly all living things on Earth	**2.** Which living things use it?
Chemical energy is changed to other forms of energy such as kinetic (motion) energy and heat	**3.** How is energy changed?
• glucose ($C_6H_{12}O_6$) • oxygen (O_2)	**4.** What substances does it use?
• carbon dioxide (CO_2) • water (H_2O)	**5.** What substances does it produce?
glucose + oxygen $\longrightarrow$ carbon dioxide + water + usable energy $C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$ + usable energy	**6.** How can it be represented?
• Cellular respiration releases the energy that living things use to survive • Cellular respiration produces the carbon dioxide that green plants need to carry out photosynthesis	**7.** Why is it important?

Photosynthesis and Cellular Respiration Balance Each Other

Photosynthesis and cellular respiration balance each other

- Each process makes the raw materials that the other processes needs to store or release energy:
  - Photosynthesis stores energy; Cellular respiration releases energy
  - Photosynthesis uses carbon dioxide and water, and produces glucose and oxygen
  - Cellular respiration uses glucose and oxygen, and produces carbon dioxide and water

Discussion Questions

1. What forms of energy are transformed during photosynthesis and cellular respiration?

2. Which substances are used and produced by photosynthesis and by cellular respiration?

Topic 4.2 Summary: What is the role of the Sun's energy in Earth's spheres?

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