

The Earth's Four Spheres

Earth is unique in the solar system: it is the only planet currently known to support life. The capacity to do so is due to the interactions among its four spheres: the atmosphere, the geosphere, the hydrosphere, and the biosphere, which is the realm of all living things. Energy moves back and forth among the spheres within the Earth system.

The Atmosphere

The gaseous envelope surrounding Earth is called the atmosphere. Composed of a mixture of gases, the atmosphere provides living things with oxygen and carbon dioxide. Other gases in the atmosphere absorb and alter rays from the Sun, blocking potentially harmful radiation. Changing amounts of water vapour in the atmosphere result in areas of high or low humidity and influence the formation of clouds. Varying areas of atmospheric pressure cause winds. Storms occur when water vapour, air pressure, and energy interact.

The Geosphere

Earth itself—the rocks, mountains, beaches, and all other physical features of the planet—makes up the geosphere. The geosphere includes the hydrosphere as well as the ocean basins and the rock layers beneath your feet, even those that you cannot see. These layers include the crust and the upper mantle, which together make up the lithosphere, as well as the lower mantle and Earth's core.

Mineral resources, such as iron and copper, are mined from the geosphere. The stone and concrete used in building materials are also a product of the geosphere. Cities and homes are perched on the geosphere—in some places, more precariously than in others.

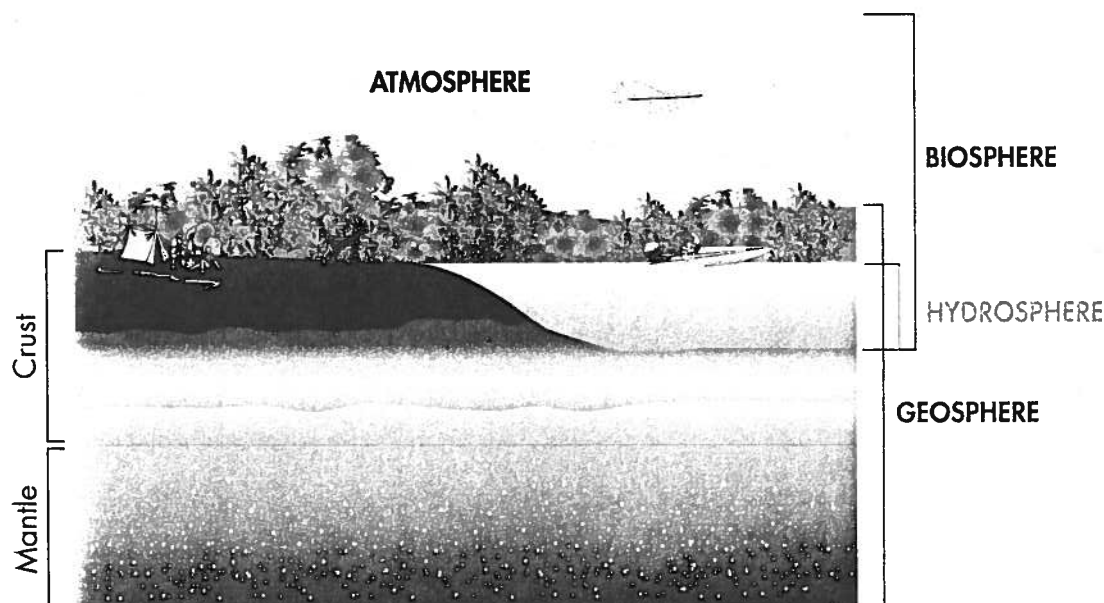


Figure 1.4.3 The four spheres. In what ways are humans interacting with each sphere in this image?

Interaction Among the Spheres

The four spheres of the Earth system are constantly moving, changing, and interacting. The wind blows. Rocks form, break down, and form again. Animals and plants live, grow, die, and decompose. Water moves from the rivers to the sea. These actions do not occur in isolation. The four spheres are interacting every day, all around you. Here are two of many possible examples:

- Volcanoes (geosphere) erupt, sending ash and gases into the air (atmosphere) and lava and ash down onto surrounding forests and fields and human habitations (biosphere).
- Humans (biosphere) drill wells into Earth's crust (geosphere) to draw out groundwater (hydrosphere) for drinking and irrigation of crops (biosphere).

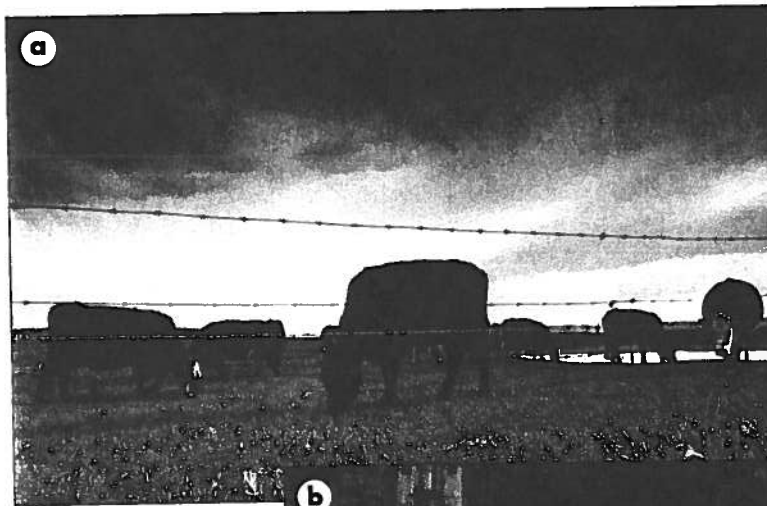
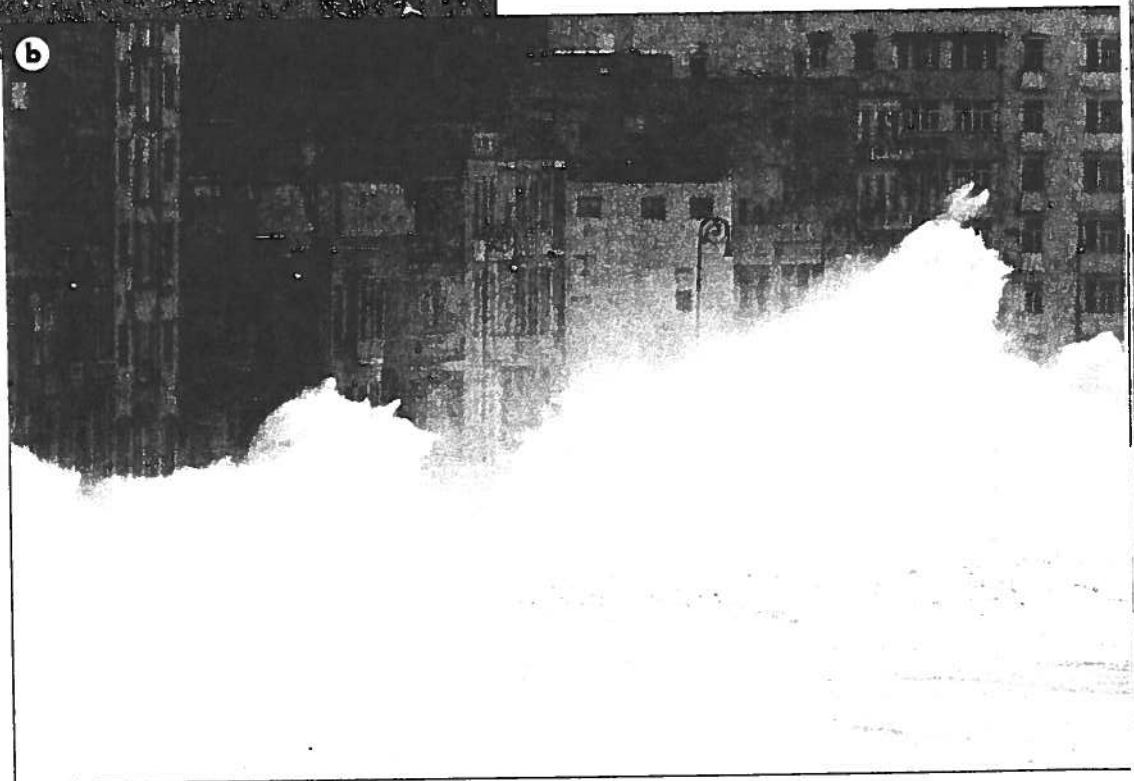


Figure 1.4.5 a) cattle grazing at an Alberta farm; b) Hurricane Wilma battering the coastal area of Cuba. Describe the interactions among the spheres that are shown in these photographs.



Although transformation happens slowly, the geosphere is ever-changing. Volcanic eruptions form new land. Mountains are uplifted and eroded. And Earth's continents are in slow but constant motion.

The Hydrosphere

The hydrosphere contains all the water in the Earth system, including the water in the oceans, lakes, rivers, and ground, as well as the water that is locked up in ice and snow at the North and South poles and in high mountains.

Most of Earth's water is salty. Only about 3 percent of the hydrosphere consists of fresh water, and approximately 70 percent of that water is frozen in the form of glacial ice. The remainder is found in groundwater or lakes, or as soil moisture, water vapour, and river water. Of all the water in the hydrosphere, only about one-half of 1 percent is usable fresh water.

All the water on Earth is continually recycled. The water you drank this morning may have irrigated a field last year or splashed up against the feet of a dinosaur standing at a river's edge millions of years ago.

The Biosphere

The interactions of the geosphere, atmosphere, and hydrosphere gave rise to the conditions that support life. This layer of Earth, and the life that exists within it, is called the **biosphere**. The biosphere includes all forms of life, from protozoa (single-celled organisms found in marine or fresh water) to jellyfish, redwood trees, and even people. Human activities within the biosphere have changed the face of the geosphere, had an impact on the oceans, and altered the atmosphere. We are living proof that one sphere can affect another.

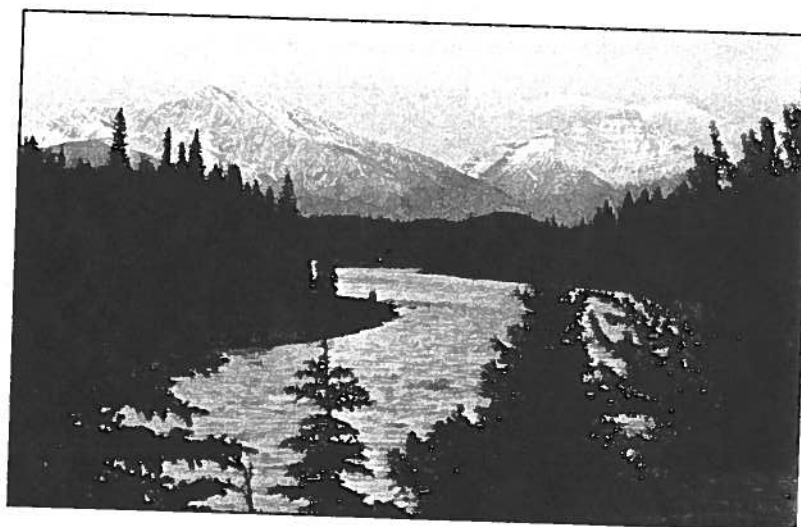


Figure 1.4.4 Identify all four spheres of the Earth system in this photograph taken in Jasper National Park, Alberta.

REVIEW AND REFLECT

1. Is the geosphere static, or does it change? Explain your answer.
2. Some people consider human beings the fifth sphere of Earth, known as the androsphere. Do you agree with this classification? Why or why not?

How Interactions Change the Spheres

Throughout history, the interactions among the spheres have changed the Earth system as well as the individual spheres themselves. An interaction can take one of many forms. It can be a single event, such as the eruption of a volcano or a flood. It can be a temporary change, such as a cold snap that kills fruit crops. Or it can be an ongoing, steady process, such as erosion.

Some changes take thousands or millions of years. Erosion illustrates the effects of the hydrosphere and the atmosphere on the geosphere. Over time, water breaks down rock, and running water and ice carry it away. Wind can transport fine grains of rock over great distances. These changes are all part of the rock cycle, which you will read about in Unit 2. Similarly, the cooling of the atmosphere that took place during the last Ice Age led to the formation of glacial ice from the liquid water on the planet. Some plants, animals, and insects died, while others adapted to the change and survived.

Interactions also cause changes on a more personal scale, especially when they involve the biosphere. Storms can damage homes and crops. Periods of high rainfall may lead to bountiful harvests, while droughts may cause crop failures. Human beings also alter the other spheres. Since the Industrial Revolution—beginning in the mid-18th century—the amount of carbon dioxide in the atmosphere has increased, a situation that has implications not only for humans, but for all life on Earth.

While Earth's four spheres can be and have been studied separately, it is important to keep in mind how they interact. Changes to one sphere have profound effects on one or more of the others. The interconnected nature of the four spheres is well illustrated by the interdependence of the species that inhabit the biosphere, as well as by the cycling of matter and energy that occurs among them. Earth's cycles will be explored in detail in the next topic.

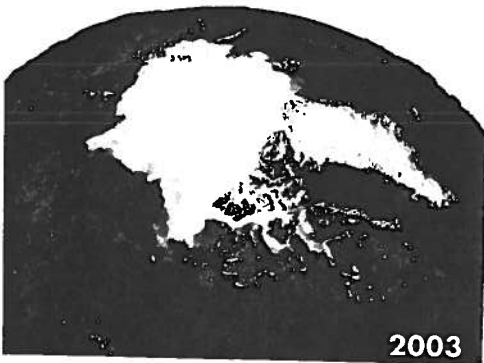
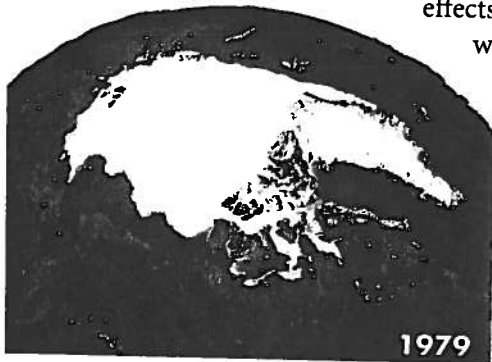


Figure 1.4.6 Satellite photos of the Arctic polar cap over a 24-year period. How might interactions among spheres be affecting this phenomenon?

REVIEW AND REFLECT

1. Describe how erosion is an example of interaction among the spheres.
2. Explain how water vapour could be considered part of the atmosphere as well as part of the hydrosphere.
3. Review Sultan bin Salman al-Saud's comment on page 37. Use systems terminology to explain the changing views of astronauts on the space shuttle *Discovery*.