

## Section 1

# The Earth System

**Key Concept** Earth is a complex system made up of many smaller systems through which matter and energy are continuously cycled.

### What You Will Learn

- Energy and matter flow through Earth's four spheres: the geosphere, atmosphere, hydrosphere, and biosphere.
- Energy flows through the atmosphere and hydrosphere mostly by convection.

### Why It Matters

The continuous cycling of matter and energy through Earth's system makes life on Earth possible.

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Next time that you are outside, look up at the sky and down at the ground. What do they have in common? They are always changing. Some changes on Earth happen slowly, and others happen quickly. Some changes are driven by energy from inside Earth. Others are driven by energy from the sun. All of these changes are part of Earth's system.

### Earth: An Overview

Earth is the third planet from our sun. Of all of the planets in our solar system, Earth is the only planet known to have abundant liquid water on its surface. As **Figure 1** shows, water covers about 71% of Earth's surface. This water is called the *global ocean*. The global ocean is part of Earth's hydrosphere. The *hydrosphere* is the portion of Earth that is water. The three other major spheres of Earth are the biosphere, atmosphere, and geosphere. The *biosphere* is the part of Earth where life exists. The *atmosphere* is a mixture of gases that surround Earth. The *geosphere* is the mostly solid, rocky part of Earth.



**Figure 1** The view from space shows that water covers most of Earth's surface.

Energy and matter are cycled through and between the spheres. These four spheres make up the Earth system. The cycling of matter and energy in the Earth system makes life on Earth possible.

## **Geosphere**

The geosphere is the solid rock of Earth. The geosphere can be divided into layers, as **Figure 2** shows. These layers are based on chemical composition and physical properties.

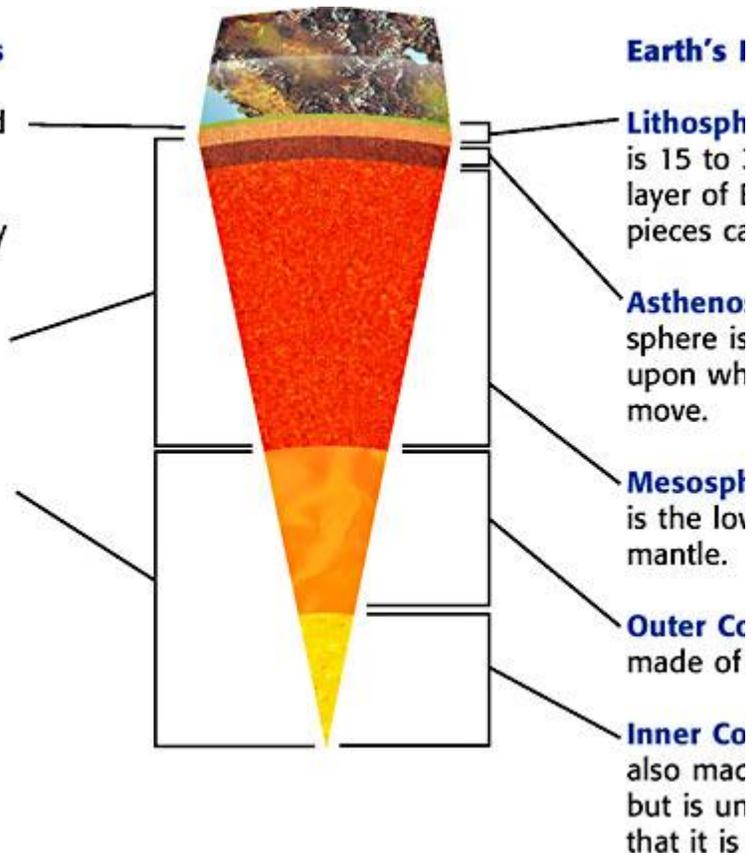
**Figure 2 The Layers of Earth**

## Earth's Compositional Layers

**Crust** The crust is the thin and solid outermost compositional layer of Earth. The crust is 5 to 70 km thick and is made mostly of silicate minerals.

**Mantle** The mantle is 2,900 km thick. The mantle is slightly denser than the crust.

**Core** The core has a radius of 3,400 km. This layer, which contains iron and nickel, is about twice as dense as the mantle.



## The Compositional Layers

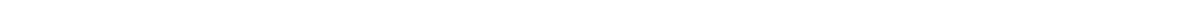
Earth can be divided into three layers based on chemical composition. The **crust** is the thin, outermost layer of Earth. It is made up largely of silicon, oxygen, and aluminum. The **mantle** is the hot layer of rock between Earth's crust and core. It is made of denser silicate minerals. The mantle has less aluminum and more magnesium than the crust does. The central part of Earth is the **core**. It is made of iron and nickel.

## The Physical Layers

Earth can also be divided into five layers based on physical properties. The *lithosphere* is Earth's cold, brittle, outermost layer. It is divided into pieces called *tectonic plates*. These plates move slowly on the *asthenosphere*, which is solid but flows like putty. The *mesosphere*—the solid, lower layer of the mantle—lies below the asthenosphere. The *outer core* is made of liquid iron and nickel. At Earth's center is the *inner core*. The inner core is also made of the metals iron and nickel, but it is solid. Because the core is made of these metals, it is very dense.

**Standards Check** List and describe the compositional and physical

layers of Earth's geosphere.



## The Atmosphere

The atmosphere is a mixture of invisible gases that surround Earth. The atmosphere extends outward to about 500 km from the surface of Earth. But most of the atmospheric gases lie within 8 to 12 km of Earth's surface. Earth's atmosphere is made up of four layers.

### Layers in the Atmosphere

The *troposphere* is the atmospheric layer in which we live. It extends outward to about 12 km from Earth's surface. Weather phenomena, such as the clouds shown in **Figure 3**, usually occur in the troposphere. The *stratosphere* is the layer directly above the troposphere. Temperatures in the stratosphere increase with altitude. Above the stratosphere is the *mesosphere*, which is the coldest layer of the atmosphere. Above the mesosphere is the *thermosphere*, which is the uppermost layer of the atmosphere. Like temperatures in the stratosphere, temperatures in the thermosphere increase with altitude.



**Figure 3** Clouds, such as these over the Sierra Nevada range are usually found in the lowest atmospheric layer, the troposphere.

### **Energy Flow in the Atmosphere**

The sun radiates the main source of energy that reaches Earth's surface. Solar radiation heats Earth's surface unevenly. This uneven heating causes the air in the atmosphere to move. For example, cold air is denser than warm air. So, cold air in the atmosphere sinks. As the cold air sinks, it forces warm, less-dense air out of the way. This movement of air distributes energy throughout the atmosphere. The transfer of energy, especially heat, due to the movement of matter, such as air, is called convection.

**Standards Check** Explain how energy is distributed in the atmosphere.

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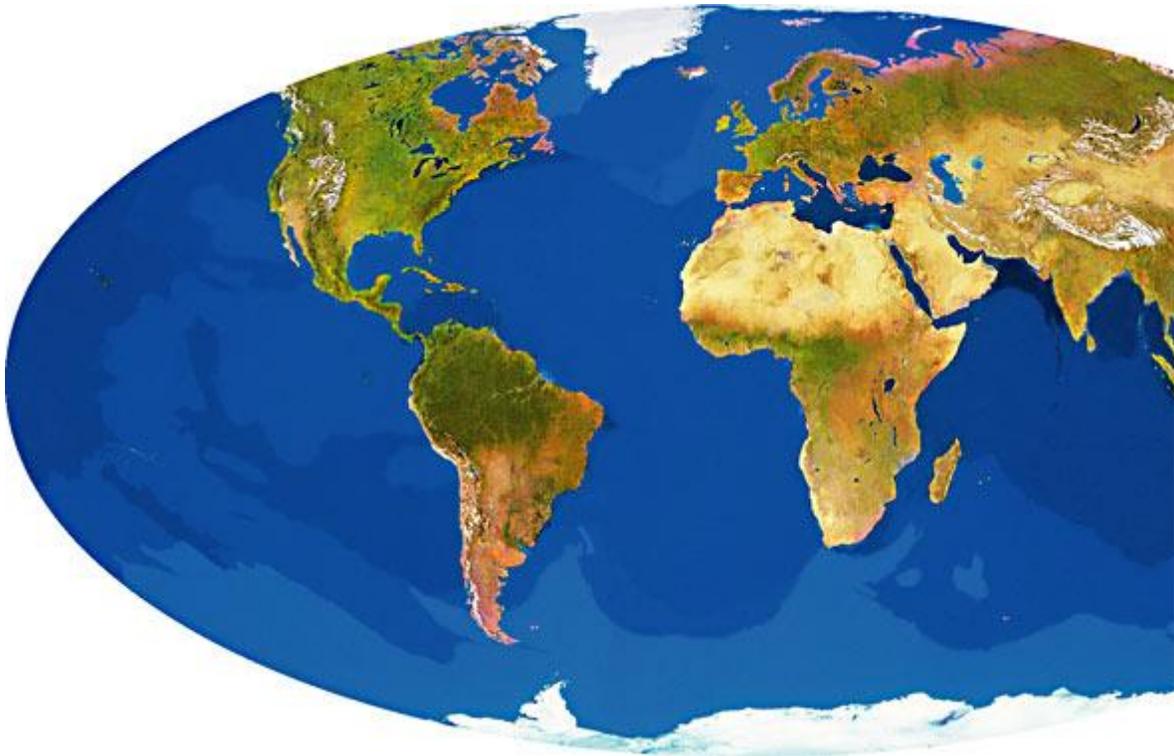
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## The Hydrosphere

Earth's hydrosphere is made up of the water in, on, and surrounding Earth. The hydrosphere includes the water in the oceans, lakes, rivers, glaciers, and polar icecaps. Clouds, rain, and snow are also parts of the hydrosphere. Even water that is in rock deep underground is part of the hydrosphere.

## The Global Ocean

As **Figure 4** shows, most of the water on Earth is in the global ocean. The global ocean covers a surface area of about 335 million square kilometers. It holds more than 97% of all of the water on Earth. However, ocean water contains salt. Therefore, the water cannot be used as drinking water.



**Figure 4** Most of Earth's surface, about 71%, is covered by water.

## Energy Flow in the Ocean

The sun's energy heats ocean water unevenly. Thus, the temperature of the water varies. The temperature of ocean water ranges from warm at the equator to near freezing at the poles. The temperature of ocean water also decreases with depth. Differences in temperature cause differences in density. The salt in ocean water also affects the density of ocean water. Differences in the density of ocean water cause the

water to move by convection. This movement of matter caused by differences in density is called a **convection current**. Convection currents distribute energy in the ocean.

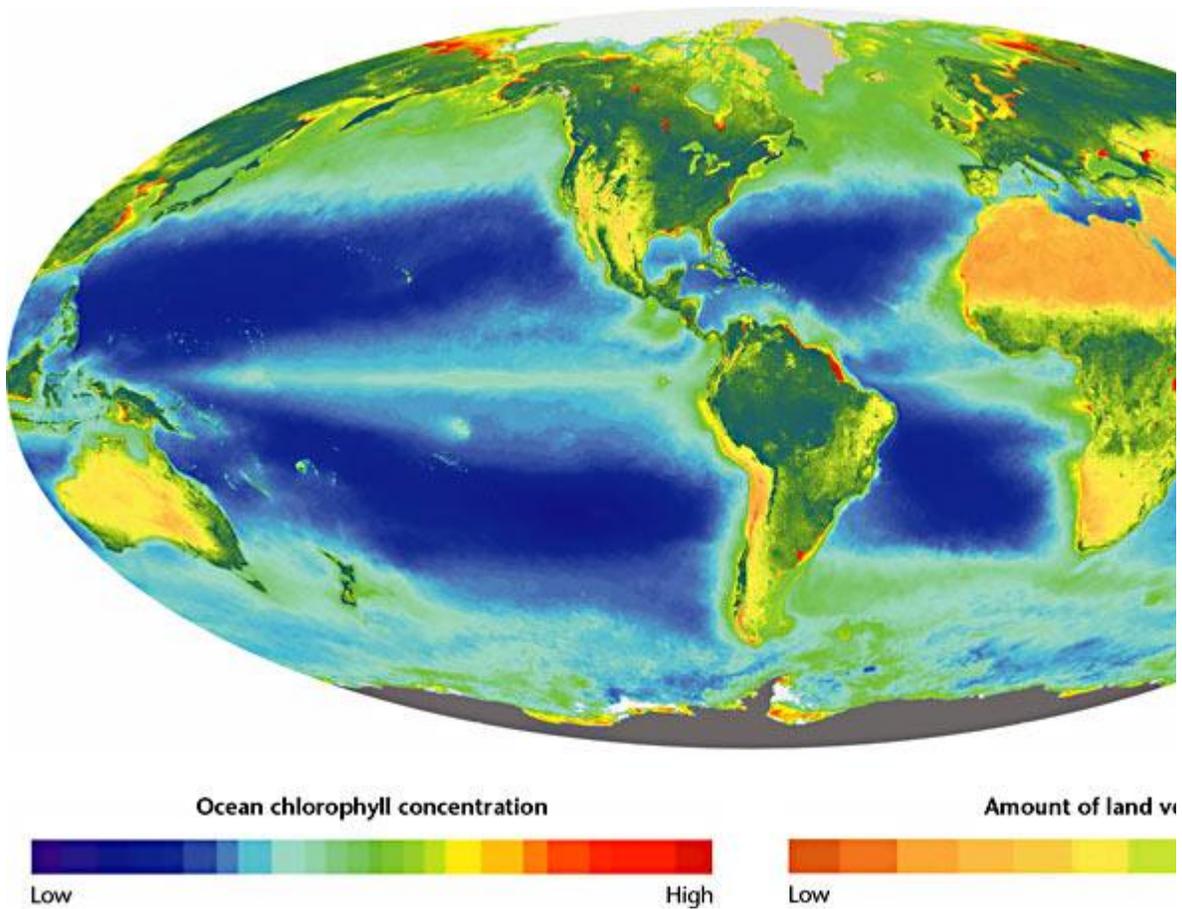
**Standards Check** Explain how energy is distributed in the ocean.

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## The Biosphere

The biosphere is made up of living organisms and the areas of Earth where life is found. The biosphere includes Earth's surface, the lower part of the atmosphere, and most of the hydrosphere. As **Figure 5** shows, plants and algae are found in the oceans as well as on land. Some organisms have even been found living deep in Earth's crust. Scientists continue to discover life in new environments. These newly found forms of life expand the known boundaries of the biosphere.



**Figure 5** The colors in this map show the relative concentrations of plant life across the surface of Earth. The red areas of the map represent lakes, bays, and wetlands where life is especially abundant.

### Factors Necessary for Life

The biosphere has certain factors that plants and animals need in order to live. Liquid water and a suitable habitat are very important for the survival of living things. Most plants and animals can also live only in environments that have moderate temperatures. You will not find a lizard living at the North Pole. The temperature is too cold!

A stable source of energy is equally important to organisms. For example, plants and algae get their energy from the sun. They use energy from the sun to produce food. Other organisms get their food by eating plants and algae.

**Standards Check** How do plants get energy?



### Energy and Matter Flow in the Biosphere

Energy enters the biosphere as sunlight. Plants change this energy into chemical energy through the process of photosynthesis. Then, the energy is passed to organisms that eat the plants. Energy and matter is also passed between organisms when they eat one another. The transfer of energy and matter does not stop when a living thing dies. Dead organisms are consumed by decomposers, such as bacteria and fungi. The decomposers break down the remains into simple materials. These materials, such as carbon dioxide, are used by plants to make food during photosynthesis.

**Standards Check** Explain how energy is transferred in the biosphere.



### Section Summary

- The four divisions of Earth are the hydrosphere, atmosphere, geosphere, and biosphere.
- The geosphere is divided into layers based on composition and physical properties.
- Convection moves energy through the atmosphere and through the hydrosphere.
- Energy in the biosphere is transferred from the sun to plants and then from one organism to another.

