INTEGRATE Life Science

Effects of UV Light on Algae Algae are organisms that use sunlight to make their own food. This process releases oxygen to Earth's atmosphere. Some scientists suggest that growth is reduced when algae are exposed to ultraviolet radiation. Infer what might happen to the oxygen level of the atmosphere if increased ultraviolet radiation damages some algae.

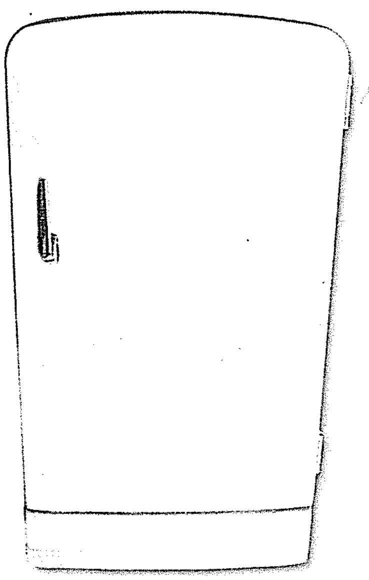
The Ozone Layer

Within the stratosphere, about 19 km to 48 km above your head, lies an atmospheric layer called the **ozone layer.** Ozone is made of oxygen. Although you cannot see the ozone layer, your life depends on it.

The oxygen you breathe has two atoms per molecule, but an ozone molecule is made up of three oxygen atoms bound together. The ozone layer contains a high concentration of ozone and shields you from the Sun's harmful energy. Ozone absorbs most of the ultraviolet radiation that enters the atmosphere. **Ultraviolet radiation** is one of the many types of energy that come to Earth from the Sun. Too much exposure to ultraviolet radiation can damage your skin and cause cancer.

CFCs Evidence exists that some air pollutants are destroying the ozone layer. Blame has fallen on **chlorofluorocarbons** (CFCs), chemical compounds used in some refrigerators, air conditioners, and aerosol sprays, and in the production of some foam packaging. CFCs can enter the atmosphere if these appliances leak or if they and other products containing CFCs are improperly discarded.

Recall that an ozone molecule is made of three oxygen atoms bonded together. Chlorofluorocarbon molecules, shown in **Figure 9,** destroy ozone. When a chlorine atom from a chlorofluorocarbon molecule comes near a molecule of ozone, the ozone molecule breaks apart. One of the oxygen atoms combines with the chlorine atom, and the rest form a regular, two-atom molecule. These compounds don't absorb ultraviolet radiation the way ozone can. In addition, the original chlorine atom can continue to break apart thousands of ozone molecules. The result is that more ultraviolet radiation reaches Earth's surface.



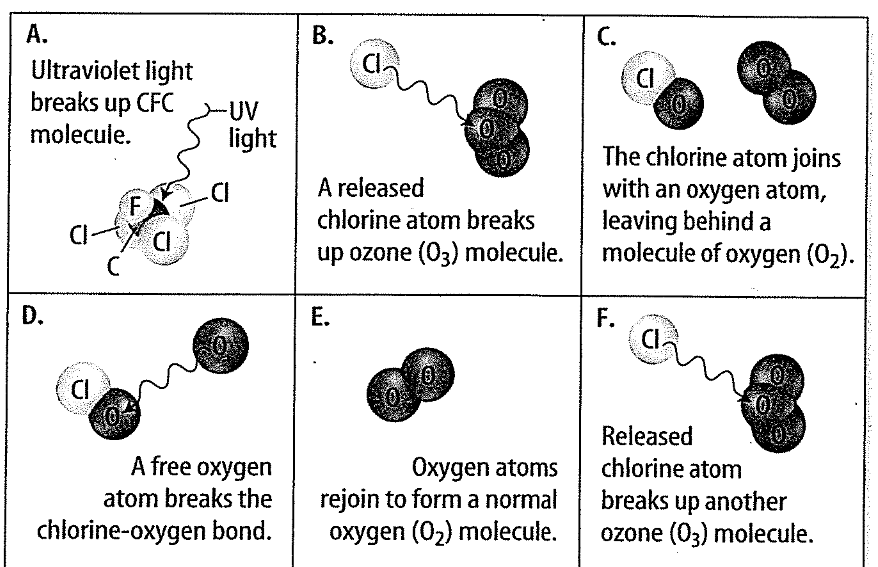
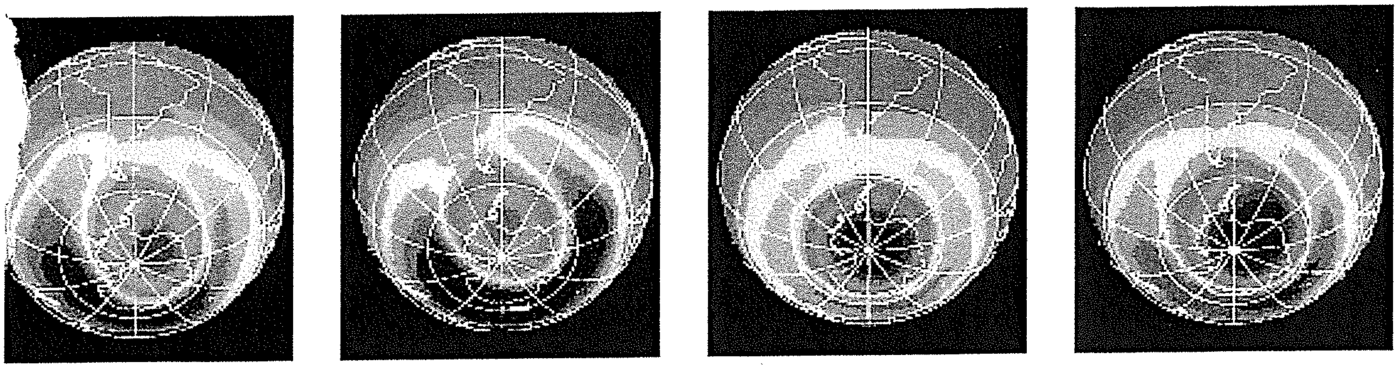


Figure 9 Chlorofluorocarbon (CFC) molecules once were used in refrigerators and air conditioners. Each CFC molecule has three chlorine atoms. One atom of chlorine can destroy approximately 100,000 ozone molecules.



October 1980 | October 1988 | October 1990 | September 1999

INTEGRATE Health

The Ozone Hole The destruction of ozone molecules by CFCs seems to cause a seasonal reduction in ozone over Antarctica called the ozone hole. Every year beginning in late August or early September the amount of ozone in the atmosphere over Antarctica begins to decrease. By October, the ozone concentration reaches its lowest values and then begins to increase again. By December, the ozone hole disappears. **Figure 10** shows how the ozone hole over Antarctica has changed. In the mid-1990s, many governments banned the production and use of CFCs. Since then, the concentration of CFCs in the atmosphere has started to decrease.

Figure 10 These images of Antarctica were produced using data from a NASA satellite. The lowest values of ozone concentration are shown in dark blue and purple. These data show that the size of the seasonal ozone hole over Antarctica has grown larger over time.

section 1 review

Summary

Layers of the Atmosphere

- The atmosphere is a mixture of gases, solids, and liquids.
- The atmosphere has five layers—troposphere, stratosphere, mesosphere, thermosphere, and exosphere.
- The ionosphere is made up of electrically charged particles.

Atmospheric Pressure and Temperature

- Atmospheric pressure decreases with distance from Earth.
- Because some layers absorb the Sun's energy more easily than others, the various layers have different temperatures.

Ozone Layer

- The ozone layer absorbs most UV light.
- Chlorofluorocarbons (CFCs) break down the ozone layer.

Self Check

1. **Describe** How did oxygen come to make up 21 percent of Earth's present atmosphere?
2. **Infer** While hiking in the mountains, you notice that it is harder to breathe as you climb higher. Explain.
3. **State** some effects of a thinning ozone layer.
4. **Think Critically** Explain why, during the day, the radio only receives AM stations from a nearby city, while at night, you're able to hear a distant city's stations.

Applying Skills

5. **Interpret Scientific Illustrations** Using **Figure 2,** determine the total percentage of nitrogen and oxygen in the atmosphere. What is the total percentage of argon and carbon dioxide?
6. **Communicate** The names of the atmospheric layers end with the suffix *-sphere,* a word that means "ball." Find out what *tropo-, meso-, thermo-,* and *exo-* mean. Write their meanings in your Science Journal and explain if the layers are appropriately named.

Energy Transfer in the Atmosphere

section 2

Energy from the Sun

The Sun provides most of Earth's energy. This energy drives winds and ocean currents and allows plants to grow and produce food, providing nutrition for many animals. When Earth receives energy from the Sun, three different things can happen to that energy, as shown in **Figure 11.** Some energy is reflected back into space by clouds, particles, and Earth's surface. Some is absorbed by the atmosphere or by land and water on Earth's surface.

Heat

Heat is energy that flows from an object with a higher temperature to an object with a lower temperature. Energy from the Sun reaches Earth's surface and heats it. Heat then is transferred through the atmosphere in three ways—radiation, conduction, and convection, as shown in **Figure 12.**

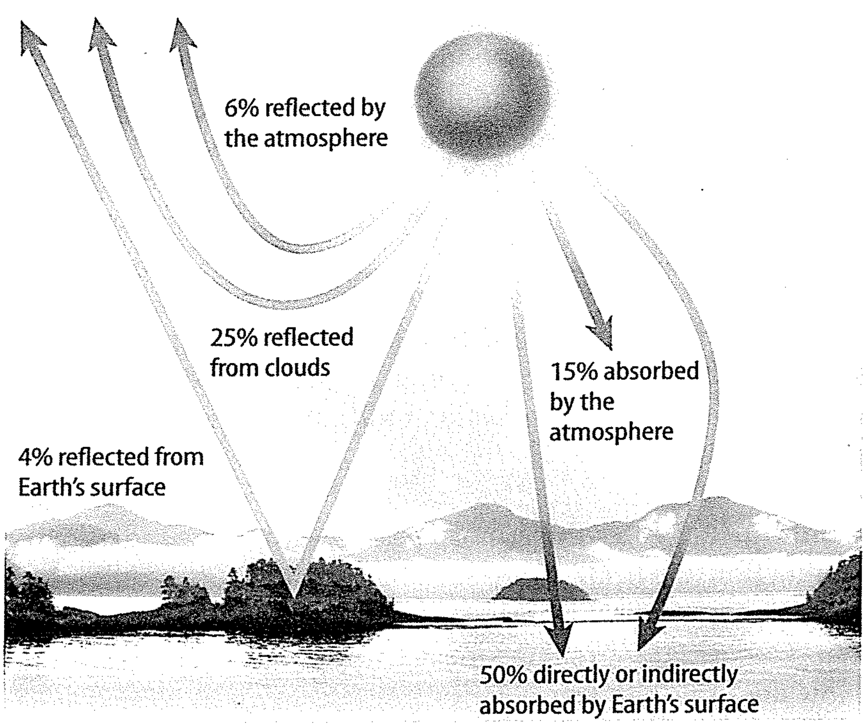


Figure 11 The Sun is the source of energy for Earth's atmosphere. Thirty-five percent of incoming solar radiation is reflected back into space.
Infer *how much is absorbed by Earth's surface and atmosphere.*

as you read

What You'll Learn

- **Describe** what happens to the energy Earth receives from the Sun.
- **Compare and contrast** radiation, conduction, and convection.
- **Explain** the water cycle and its effect on weather patterns and climate.

Why It's Important

The Sun provides energy to Earth's atmosphere, allowing life to exist.

Review Vocabulary

evaporation: when a liquid changes to a gas at a temperature below the liquid's boiling point

New Vocabulary

- radiation
- conduction
- convection
- hydrosphere
- condensation

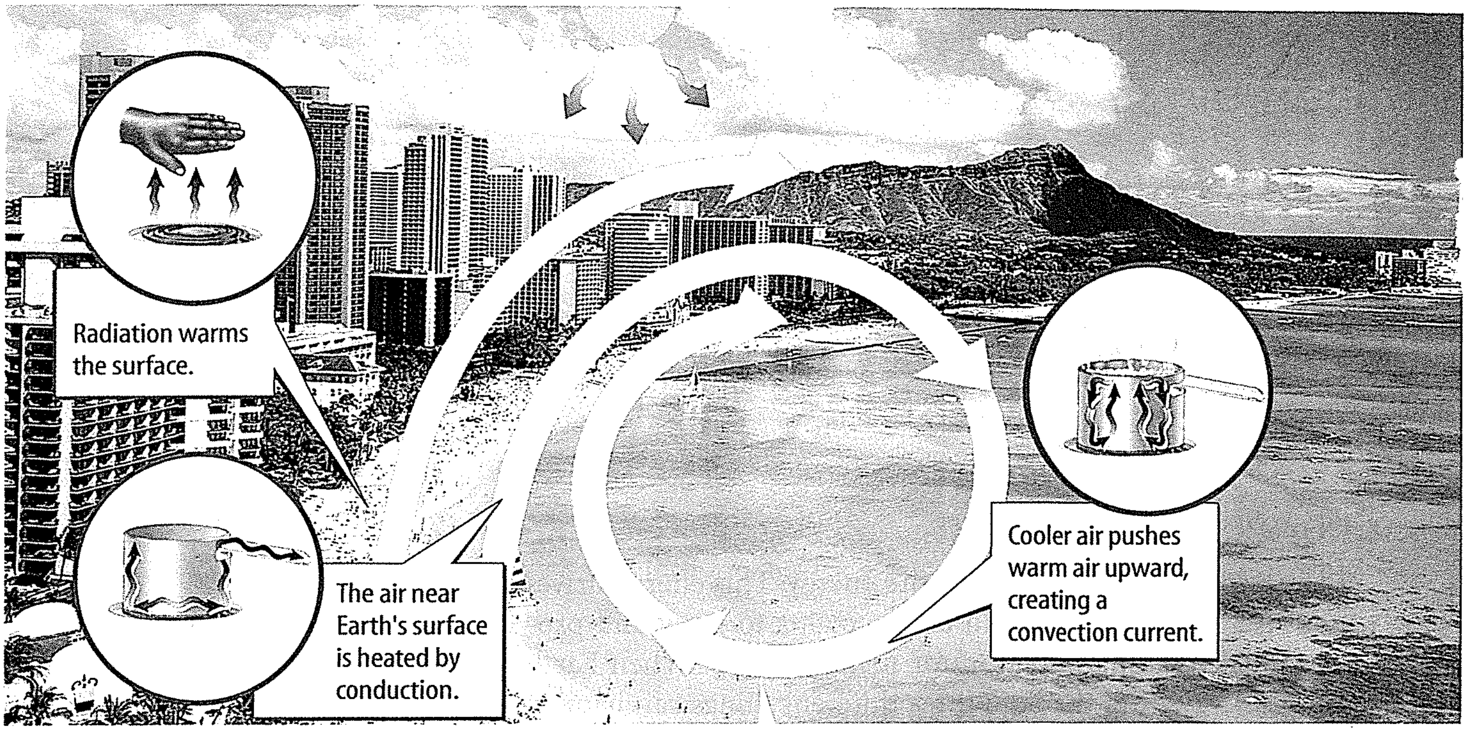


Figure 12 Heat is transferred within Earth's atmosphere by radiation, conduction, and convection.

Radiation Sitting on the beach, you feel the Sun's warmth on your face. How can you feel the Sun's heat even though you aren't in direct contact with it? Energy from the Sun reaches Earth in the form of radiant energy, or radiation. **Radiation** is energy that is transferred in the form of rays or waves. Earth radiates some of the energy it absorbs from the Sun back toward space. Radiant energy from the Sun warms your face.

Reading Check *How does the Sun warm your skin?*

Conduction If you walk barefoot on a hot beach, your feet heat up because of conduction. **Conduction** is the transfer of energy that occurs when molecules bump into one another. Molecules are always in motion, but molecules in warmer objects move faster than molecules in cooler objects. When objects are in contact, energy is transferred from warmer objects to cooler objects.

Radiation from the Sun heated the beach sand, but direct contact with the sand warmed your feet. In a similar way, Earth's surface conducts energy directly to the atmosphere. As air moves over warm land or water, molecules in air are heated by direct contact.

Convection After the atmosphere is warmed by radiation or conduction, the heat is transferred by a third process called convection. **Convection** is the transfer of heat by the flow of material. Convection circulates heat throughout the atmosphere. How does this happen?

INTEGRATE Physics

Specific Heat Specific heat is the amount of heat required to raise the temperature of one kilogram of a substance one degree Celsius. Substances with high specific heat absorb a lot of heat for a small increase in temperature. Land warms faster than water does. Infer whether soil or water has a higher specific heat value.

When air is warmed, the molecules in it move apart and the air becomes less dense. Air pressure decreases because fewer molecules are in the same space. In cold air, molecules move closer together. The air becomes more dense and air pressure increases. Cooler, denser air sinks while warmer, less dense air rises, forming a convection current. As **Figure 12** shows, radiation, conduction, and convection together distribute the Sun's heat throughout Earth's atmosphere.

The Water Cycle

Hydrosphere is a term that describes all the waters of Earth. The constant cycling of water within the atmosphere and the hydrosphere, as shown in **Figure 13,** plays an important role in determining weather patterns and climate types.

Energy from the Sun causes water to change from a liquid to a gas by a process called evaporation. Water that evaporates from lakes, streams, and oceans enters Earth's atmosphere. If water vapor in the atmosphere cools enough, it changes back into a liquid. This process of water vapor changing to a liquid is called **condensation.**

Clouds form when condensation occurs high in the atmosphere. Clouds are made up of tiny water droplets that can collide to form larger drops. As the drops grow, they fall to Earth as precipitation. This completes the water cycle within the hydrosphere. Classification of world climates is commonly based on annual and monthly averages of temperature and precipitation that are strongly affected by the water cycle.

Mini LAB

Modeling Heat Transfer

Procedure

1. Cover the outside of an empty **soup can,** with **black construction paper.**
2. Fill the can with **cold water** and feel it with your fingers.
3. Place the can in sunlight for 1 h, then pour the water over your fingers.

Analysis

1. Does the water in the can feel warmer or cooler after placing the can in sunlight?
2. What types of heat transfer did you model?

Try at Home

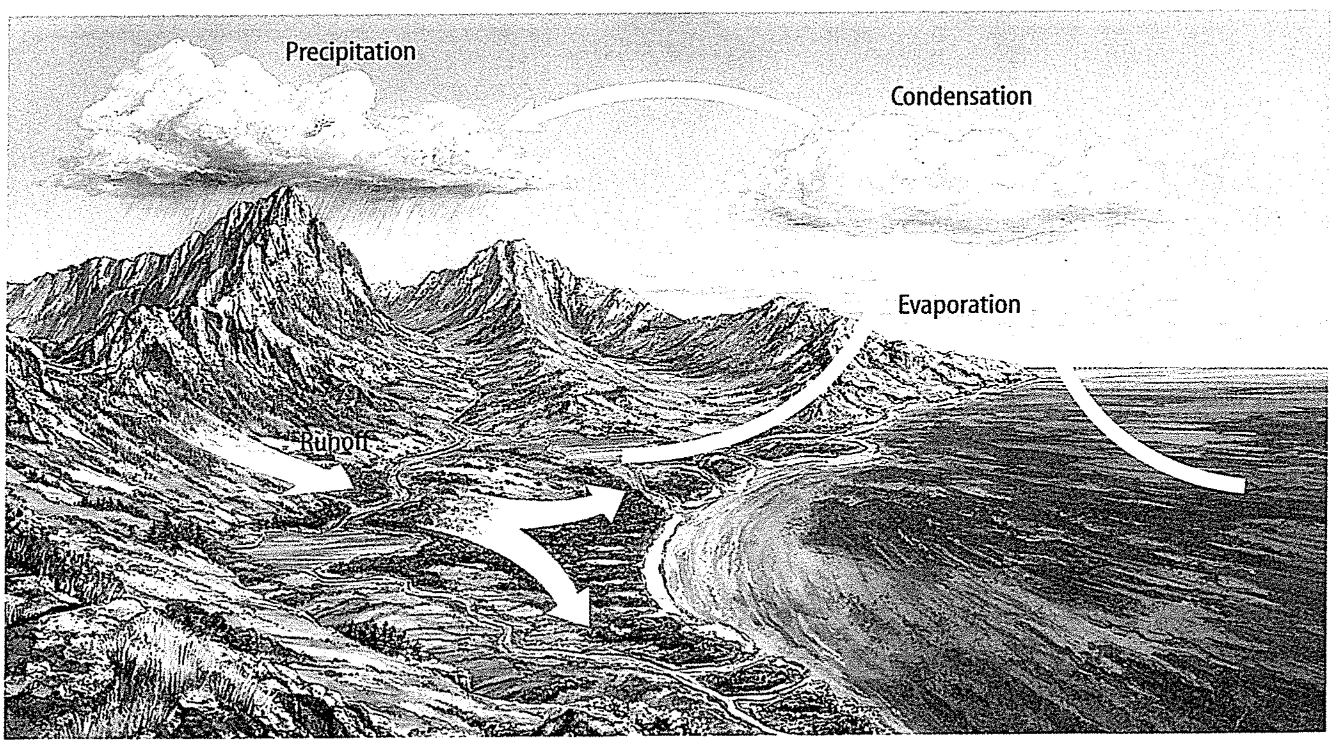
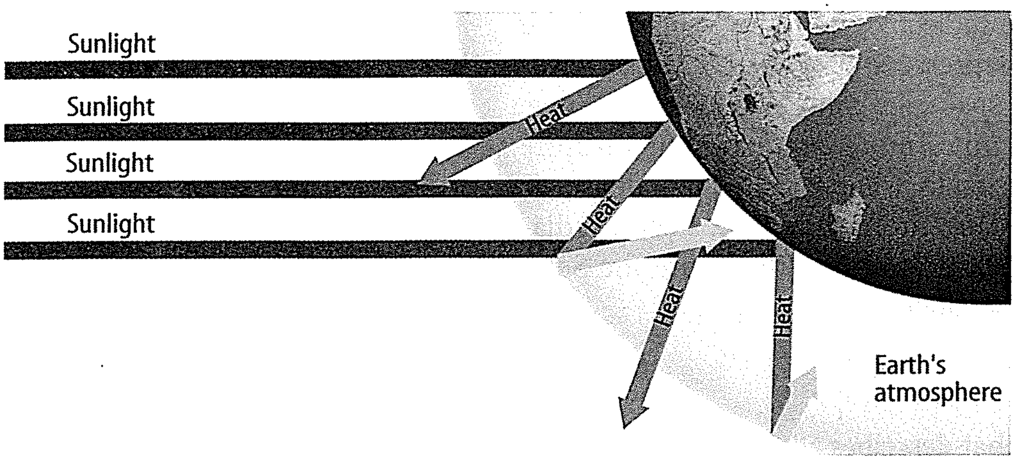


Figure 13 In the water cycle, water moves from Earth to the atmosphere and back to Earth again.



Earth's Atmosphere is Unique

On Earth, radiation from the Sun can be reflected into space, absorbed by the atmosphere, or absorbed by land and water. Once it is absorbed, heat can be transferred by radiation, conduction, or convection. Earth's atmosphere, shown in **Figure 14,** helps control how much of the Sun's radiation is absorbed or lost.

Figure 14 Earth's atmosphere creates a delicate balance between energy received and energy lost. **Infer** *What could happen if the balance is tipped toward receiving more energy than it does now?*

✔ Reading Check *What helps control how much of the Sun's radiation is absorbed on Earth?*

Why doesn't life exist on Mars or Venus? Mars is a cold, lifeless world because its atmosphere is too thin to support life or to hold much of the Sun's heat. Temperatures on the surface of Mars range from 35°C to −170°C. On the other hand, gases in Venus's dense atmosphere trap heat coming from the Sun. The temperature on the surface of Venus is 470°C. Living things would burn instantly if they were placed on Venus's surface. Life on Earth exists because the atmosphere holds just the right amount of the Sun's energy.

section 2 review

Summary

Energy From the Sun

- The Sun's radiation is either absorbed or reflected by Earth.
- Heat is transferred by radiation (waves), conduction (contact), or convection (flow).

The Water Cycle

- The water cycle affects climate.
- Water moves between the hydrosphere and the atmosphere through a continual process of evaporation and condensation.

Earth's Atmosphere is Unique

- Earth's atmosphere controls the amount of solar radiation that reaches Earth's surface.

Self Check

1. **State** how the Sun transfers energy to Earth.
2. **Contrast** the atmospheres of Earth and Mars.
3. **Describe** briefly the steps included in the water cycle.
4. **Explain** how the water cycle is related to weather patterns and climate.
5. **Think Critically** What would happen to temperatures on Earth if the Sun's heat were not distributed throughout the atmosphere?

Applying Math

6. **Solve One-Step Equations** Earth is about 150 million km from the Sun. The radiation coming from the Sun travels at 300,000 km/s. How long does it take for radiation from the Sun to reach Earth?

Science Online earth.msscience.com/self_check_quiz

section 3

Air Movement

Forming Wind

Earth is mostly rock or land, with three-fourths of its surface covered by a relatively thin layer of water, the oceans. These two areas strongly influence global wind systems. Uneven heating of Earth's surface by the Sun causes some areas to be warmer than others. Recall that warmer air expands, becoming lower in density than the colder air. This causes air pressure to be generally lower where air is heated. Wind is the movement of air from an area of higher pressure to an area of lower pressure.

Heated Air Areas of Earth receive different amounts of radiation from the Sun because Earth is curved. **Figure 15** illustrates why the equator receives more radiation than areas to the north or south. The heated air at the equator is less dense, so it is displaced by denser, colder air, creating convection currents.

This cold, denser air comes from the poles, which receive less radiation from the Sun, making air at the poles much cooler. The resulting dense, high-pressure air sinks and moves along Earth's surface. However, dense air sinking as less-dense air rises does not explain everything about wind.

as you read

What You'll Learn

- **Explain** why different latitudes on Earth receive different amounts of solar energy.
- **Describe** the Coriolis effect.
- **Explain** how land and water surfaces affect the overlying air.

Why It's Important

Wind systems determine major weather patterns on Earth.

Review Vocabulary
density: mass per unit volume

New Vocabulary
- Coriolis effect
- jet stream
- sea breeze
- land breeze

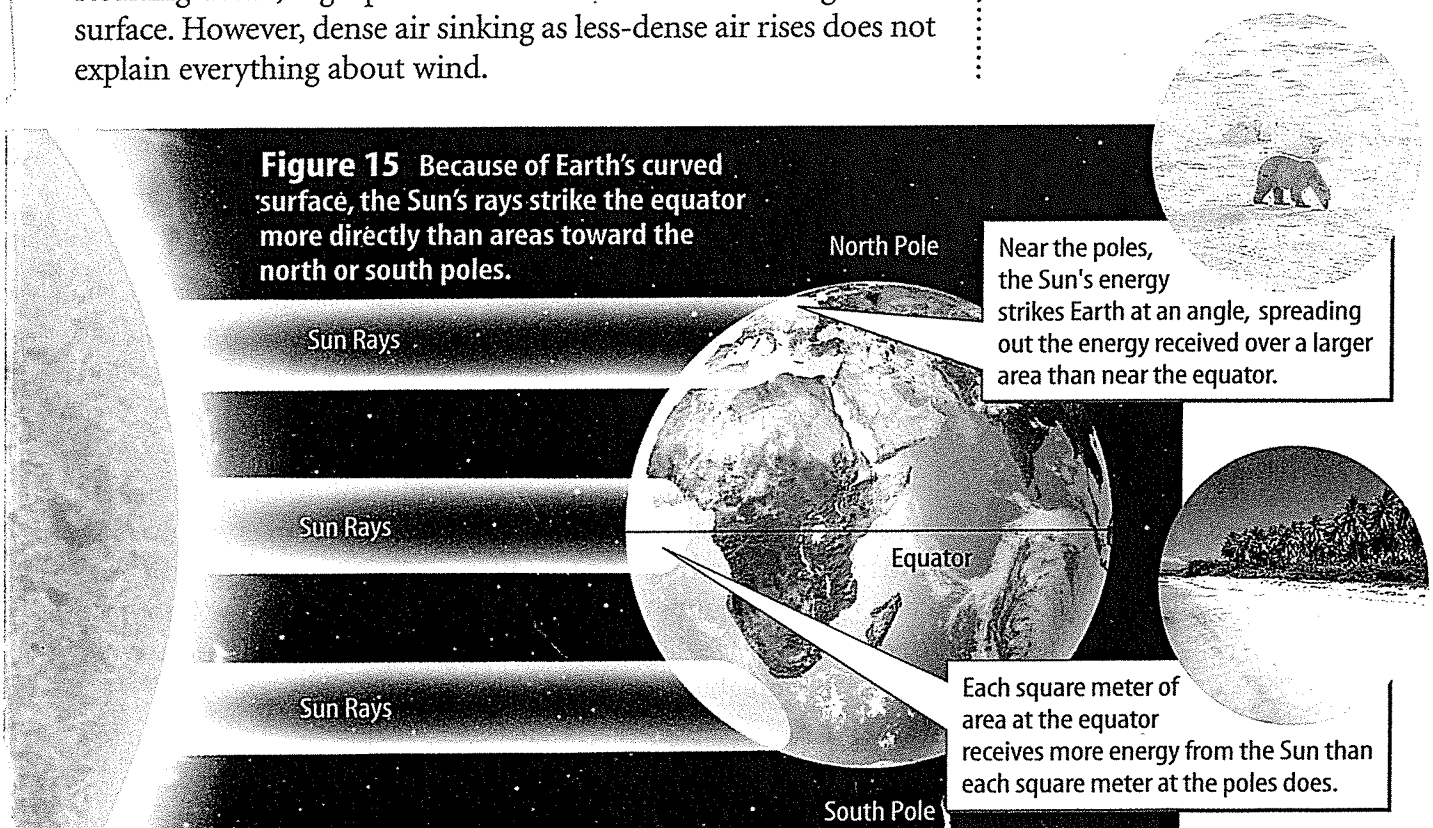


Figure 15 Because of Earth's curved surface, the Sun's rays strike the equator more directly than areas toward the north or south poles.