KEY CONCEPT

17.2 The Sun supplies the atmosphere's energy.

Sunshine State STANDARDS

SC.B.1.3.1: The student identifies forms of energy and explains that they can be measured and compared.

SC.B.2.3.1: The student knows that most events in the universe (e.g., weather changes, moving cars, and the transfer of a nervous impulse in the human body) involve some form of energy transfer and that these changes almost always increase the total disorder of the system and its surroundings, reducing the amount of useful energy.

BEFORE, you learned

- The atmosphere supports and protects life
- The atmosphere contains a mixture of gases
- The atmosphere is affected by natural processes

NOW, you will learn

- How solar energy heats Earth's surface and atmosphere
- How the atmosphere moves heat energy around
- About the layers of the atmosphere

THINK ABOUT

Can you feel sunlight?

If you have been on a hot beach, you have felt energy from sunlight. Perhaps you felt sunlight warming your skin or hot sand underneath your feet. It is easy to notice the energy of sunlight when it makes the ground or your skin warm. Where else does the energy from sunlight go?

FCAT VOCABULARY

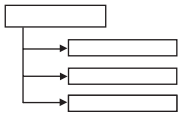
radiation p. 619
conduction p. 620
convection p. 621

Energy from the Sun heats the atmosphere.

It may seem hard to believe, but almost all the energy around you comes from the Sun. That means that food energy, fires, and even the warmth of your own body can be traced back to energy from the Sun. A lot of this energy reaches Earth in a form you can see—visible light.

Two main things happen to the sunlight that reaches Earth. Some is reflected, or sent in a new direction. You see most of the objects around you by reflected light. The sand in the picture above looks light in color because it reflects much of the sunlight that hits it. Some of the sunlight that reaches Earth's surface is absorbed. The energy from this light heats the substance that absorbs it. The sand can become warm or even hot as it absorbs some of the sunlight that hits it. Some objects, such as the striped shirts above, have bright parts that reflect more light and dark parts that absorb more light.

SUPPORTING MAIN IDEAS
Write the blue heading into your notes to begin a new chart. Add supporting details.



CHECK YOUR READING What two things happen to the sunlight that reaches Earth?

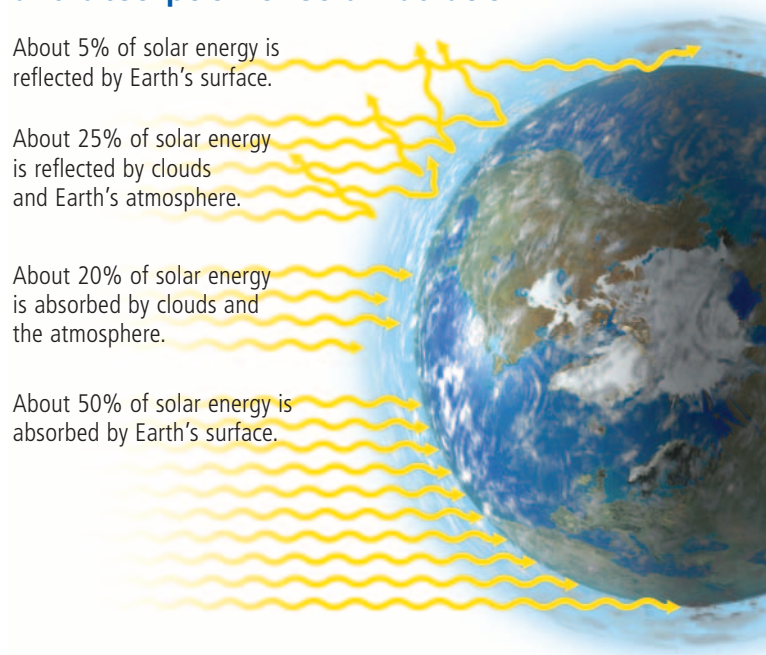
The light that you can see is one type of radiation. **Radiation** (RAY-dee-AY-shuhn) is energy that travels across distances in the form of certain types of waves. Visible light and other types of radiation can be absorbed or reflected.

The diagram shows the average amounts of solar radiation, or radiation from the Sun, that are absorbed and reflected by Earth's atmosphere, clouds, and surface. Each arrow in the diagram represents 5 percent of the solar radiation that reaches Earth. As you can see, about 30 percent of the solar energy that reaches Earth is reflected. Clouds and snow-covered ground are white, so they reflect a lot of the radiation that hits them. Air also reflects some radiation. The energy of the reflected radiation goes back into outer space.

The other 70 percent of solar radiation that reaches Earth is absorbed. Most of this energy is absorbed by oceans, landforms, and living things. The absorbed energy heats Earth's surface. In the same way, energy that is absorbed by gas molecules, clouds, and dust particles heats the atmosphere.

Solar Radiation

Arrows show the average global reflection and absorption of solar radiation.



The atmosphere is much smaller than shown.

INVESTIGATE Solar Radiation

How does reflection affect temperature?

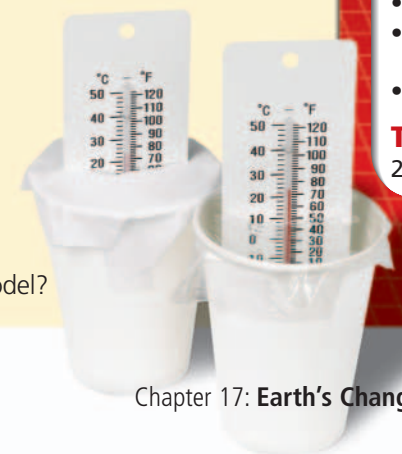
SKILL FOCUS
Measuring

MATERIALS
- 2 cups
- plastic wrap
- white paper
- tape
- 2 short thermometers
- watch

TIME
25 minutes

PROCEDURE

1. Cover the top of one cup with plastic wrap. Cover the second cup with paper. Secure the plastic wrap and paper with tape.
2. Poke a small slit in each cup's cover. Insert a thermometer through each slit.
3. Place the cups in direct sunlight. Record their temperature every minute for 15 minutes.



WHAT DO YOU THINK?

- How did the temperature change inside each cup?
- How did the coverings contribute to these changes?

CHALLENGE What does the paper represent in this model?

The atmosphere moves energy.

If you walk along a sunny beach, you may be comfortably warm except for the burning-hot soles of your feet. The sand may be much hotter than the air. The sand absorbs solar energy all day and stores it in one place. The air also absorbs solar energy but moves it around and spreads it out. Radiation, conduction, and convection are processes that move energy from place to place.

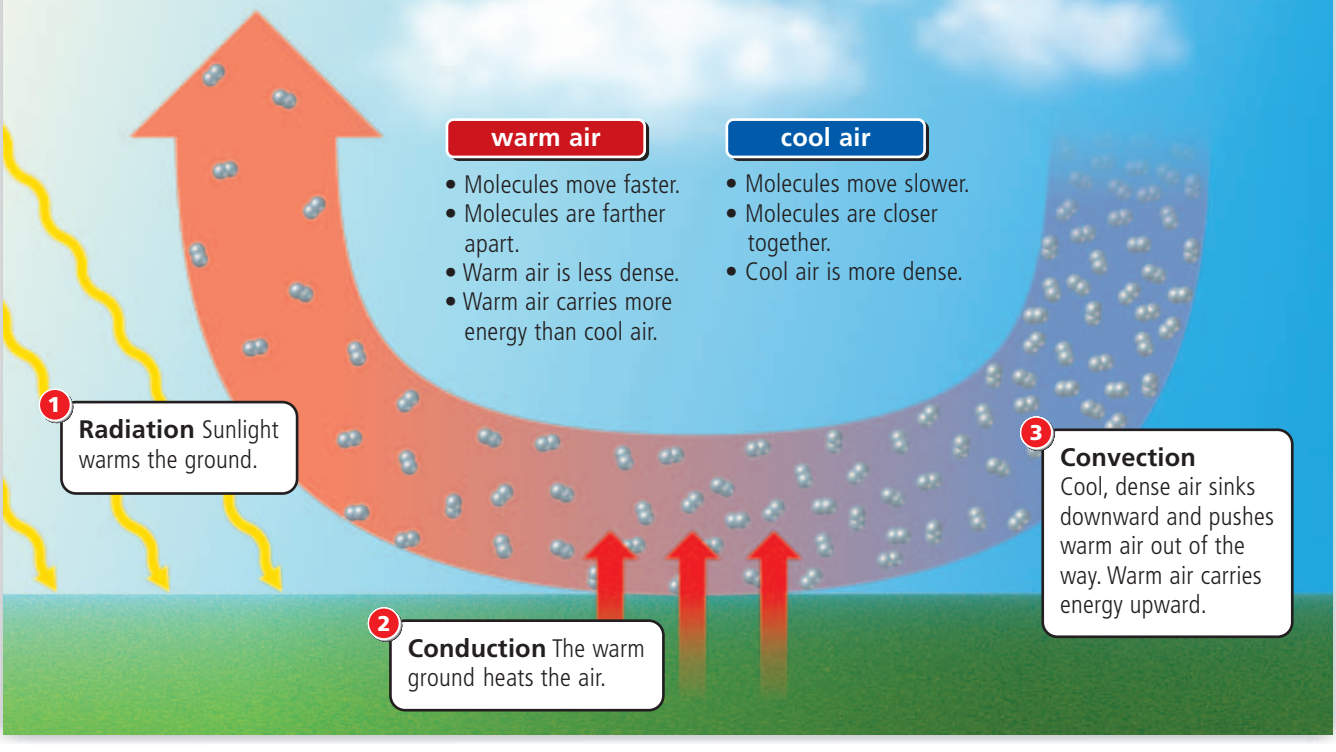
Radiation You have already read that solar radiation warms a sandy beach. You may be surprised to learn that radiation also transfers energy from the sand to the air. Earth's surface gives off a type of invisible radiation, called infrared radiation, that can be absorbed by certain gases. The energy from the radiation warms the air. The air also gives off infrared radiation. You will read more about this cycle of radiation in Section 17.3.

VOCABULARY
Add new terms to your notebook.

Conduction Another way that sand warms the air is through conduction. When you walk barefoot on a hot beach, rapidly moving molecules in the hot sand bump against molecules in your feet. This process transfers energy to your feet, which get hot. **Conduction** is the transfer of heat energy from one substance to another by direct contact. Earth's surface transfers energy to the atmosphere by conduction, such as when hot beach sand warms the air above it. Molecules of air can

Transfer of Energy

Radiation, conduction, and convection move energy from place to place.



gain energy when they collide with molecules in grains of hot sand. The air just above the sand gets warm. Energy can also spread slowly through the air by conduction as air molecules bump into one another.

Convection Heated air can move easily from place to place. When a heated liquid or gas moves, it carries energy along with it. **Convection** is the transfer of energy from place to place by the motion of gas or liquid. When scientists talk about convection in the atmosphere, they usually mean the motion of gases up and down rather than side to side. The heat energy comes from below and is moved upward. Think once more about the beach. First, radiation from the Sun warms the sand. Second, the hot sand conducts energy to the air. Third, the warm air carries energy upward in convection. Follow this cycle of radiation, conduction, and convection in the diagram on page 620.

Moving hot air near the flames makes the mountain behind appear distorted.

CHECK YOUR READING Compare conduction and convection. How are they similar?

Differences in density produce the motion of air convection. You have read that the atmosphere is less dense at higher altitudes. At any particular altitude, however, the density of air depends mostly on its temperature. Warm air has more energy, so the molecules move faster than they do in cool air. The motion makes the molecules collide more, so they stay farther apart. When there is more space between molecules, the air is less dense.

REMINDER
Density is the amount of mass in a given volume of a substance.

Imagine a box full of warm air and another box of the same size full of cool air. If you could see air molecules, you would find more molecules—more mass—in the box of cool air. Cool, dense air is heavier, so it tends to sink and push warm, less dense air upward.

As it moves upward, warm air carries energy away from the ground. The air can cool as it rises. Eventually, the air can become cool enough—dense enough—to sink back to the ground, where it may heat up again.

VISUALIZATION CLASSZONE.COM
See radiation, conduction, and convection in action.

The atmosphere has temperature layers.

Density is not the only characteristic of the atmosphere that changes with altitude. Different parts of the atmosphere absorb and move energy in different ways. As a result, the air's temperature changes with altitude. Scientists use the patterns of these temperature changes to define four layers of the atmosphere. To explore these layers, turn the page and ride an imaginary elevator up through the atmosphere.

Temperature Layers

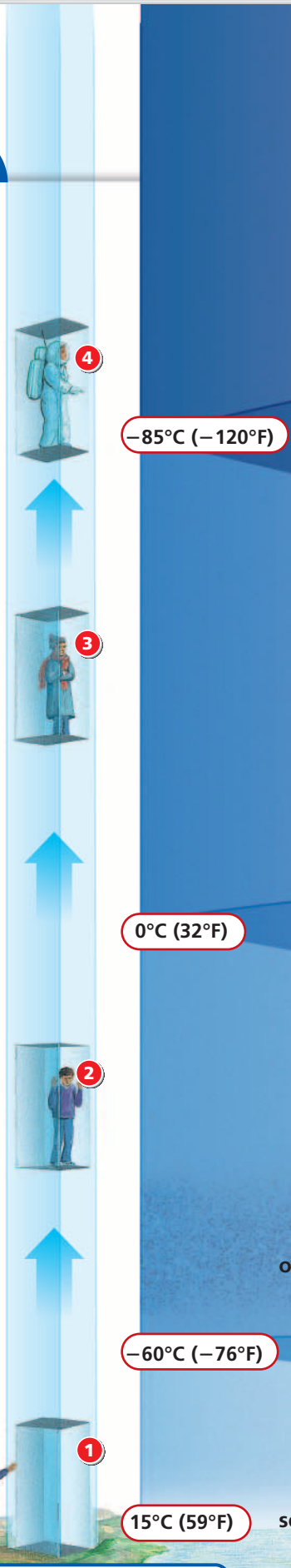
Explore the atmosphere's temperature layers by riding an imaginary elevator up from the ground.

Thermosphere
Continue through the thermosphere. The air thins out until you reach outer space.

Mesosphere
Reach the mesosphere after rising 50 km (31 mi) off the ground. You are now above 99.9% of the molecules of Earth's air.

Stratosphere
Pass through the stratosphere, which includes the ozone layer. The air gets thinner as you move up through the atmosphere.

Troposphere
Board the elevator at ground level, which is also the bottom of the troposphere.



Thermosphere

Radiation from the Sun heats the thermosphere, causing the temperature to rise as you move upward.

90 km (56 mi) and up

Mesosphere

This layer is heated from below by the stratosphere, and the temperature falls as you move upward.

50–90 km (31–56 mi)

Stratosphere

Ozone in this layer absorbs energy from the Sun and heats the stratosphere. The temperature rises as you move upward.

10–50 km (6–31 mi)

Troposphere

This layer is heated by the ground. The temperature falls as you move upward.

0–10 km (0–6 mi)

READING VISUALS How does the temperature change as you move up through the atmosphere?

1. **Troposphere** (TROH-puh-SFEER) The layer of the atmosphere nearest Earth's surface is called the troposphere because convection seems to turn the air over. This layer contains about 80 percent of the total mass of the atmosphere, including almost all of the water vapor present in the atmosphere. The troposphere is warmed from below by the ground. The temperature is highest at ground level and generally decreases about 6.5°C for each kilometer you rise.

2. **Stratosphere** (STRAT-uh-SFEER) Above the troposphere lies a clear, dry layer of the atmosphere called the stratosphere. Within the stratosphere are molecules of a gas called ozone. These molecules absorb a type of solar radiation that is harmful to life. The energy from the radiation raises the temperature of the air. The temperature increases as you rise high in the stratosphere.

3. **Mesosphere** (MEHZ-uh-SFEER) The air in the mesosphere is extremely thin. In fact, this layer contains less than 0.1 percent of the atmosphere's mass. Most meteors that enter the atmosphere burn up within the mesosphere. The mesosphere, like the troposphere, is heated from below, so the temperature in the mesosphere decreases as you rise.

4. **Thermosphere** (THUR-muh-SFEER) The thermosphere starts about 90 kilometers (56 mi) above Earth's surface. It grows less and less dense over hundreds of kilometers until it becomes outer space. The air high in this layer becomes very hot because the molecules absorb a certain type of solar radiation. However, even the hottest air in this layer would feel cold to you because the molecules are so spread out that they would not conduct much energy to your skin. The temperature in the thermosphere increases as you rise.

CHECK YOUR READING How does the temperature change in each layer of the atmosphere?

READING TIP

You can use the word parts to help you recall the temperature layers.

tropo-"turning"

strato-"spreading out"

meso-"middle"

thermo-"heat"

FLORIDA Content Review

Remember that gas molecules spread out when there is no container to hold them, as you learned in Chapter 2.

17.2 Review

KEY CONCEPTS

1. What two things happen to solar radiation that reaches Earth?
2. Describe the three processes that transport energy.
3. What characteristic do scientists use to define four layers of Earth's atmosphere?

CRITICAL THINKING

4. **Draw Conclusions** How might a thick, puffy cloud reflect a different amount of the Sun's radiation than a thin, wispy one?
5. **Apply** Jet planes fly near the top of the troposphere. Is it more important to heat or to cool the passenger cabins? Explain your reasoning.

CHALLENGE

6. **Analyze** Earth loses about the same amount of energy as it absorbs from the Sun. If it did not, Earth's temperature would increase. Does the energy move from Earth's surface and atmosphere out to space through radiation, conduction, or convection? Give your reasons.