LESSON 3

Energy Transformations and Conservation

UNLOCK THE BIG ?

- How Are Different Forms of Energy Related?
- What Is the Law of Conservation of Energy?

Science Day at the Amusement Park

During science days at Great America Amusement Park™ in Santa Clara, California, the park becomes a giant laboratory! Here is how one investigation might work. You choose a ride like the Drop Tower, which drops you 68 meters in less than four seconds, or the Fire Fall, which contains a series of vertical twists and turns. You observe how your speed and height change during the ride. Then you use your observations to learn about transformations between potential and kinetic energy.

FIELD TRIP

Write your answer to the question below.

How do you think energy is transformed in the Drop Tower?

PLANET DIARY Go to **Planet Diary** to learn more about energy transformations.

Lab zone® Do the Inquiry Warm-Up *What Would Make a Card Jump?*

How Are Different Forms of Energy Related?

What does flowing water have to do with electricity? In a hydroelectric power plant, the mechanical energy of moving water is transformed into electrical energy. **All forms of energy can be transformed into other forms of energy.** A change from one form of energy to another is called an **energy transformation.** Some energy changes involve single transformations, while others involve many transformations.

Vocabulary

- energy transformation
- law of conservation of energy

Skills

- Reading: Identify Supporting Evidence
- Inquiry: Infer

Single Transformations Sometimes, one form of energy needs to be transformed into another to get work done. For example, a toaster transforms electrical energy to thermal energy to toast your bread. A cell phone transforms electrical energy to electromagnetic energy that travels to other phones.

Your body transforms the chemical energy in food to the mechanical energy you need to move your muscles. Chemical energy in food is also transformed to the thermal energy your body uses to maintain its temperature.

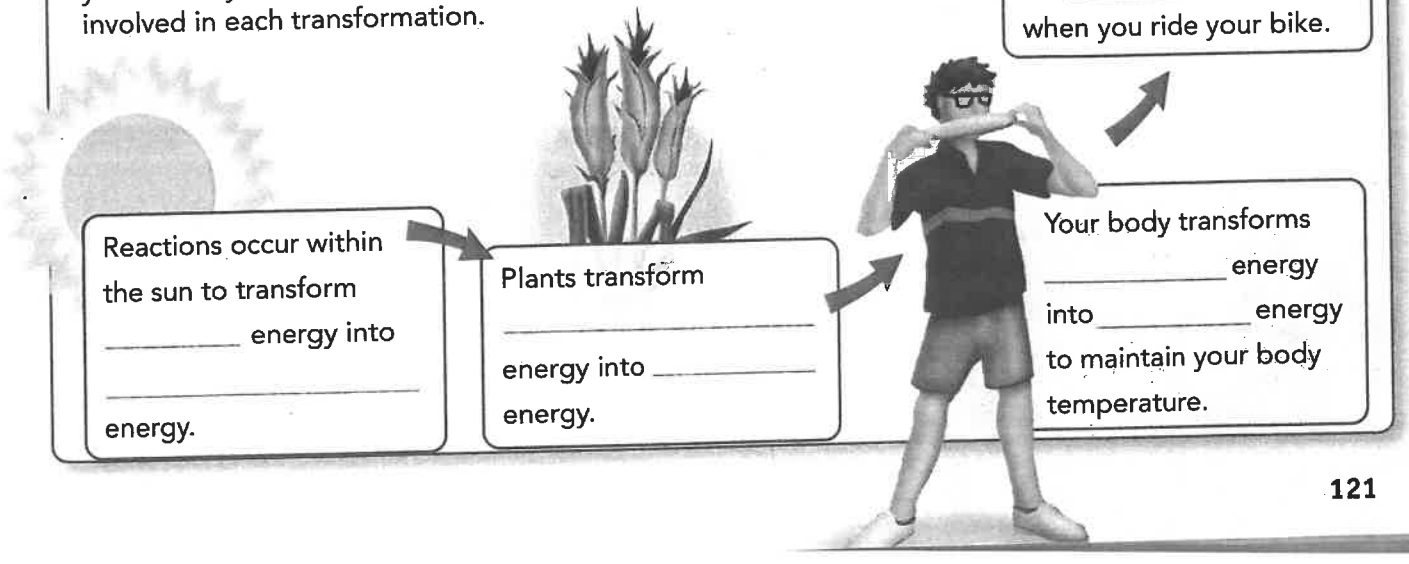
Multiple Transformations Often, a series of energy transformations is needed to do work. For example, the mechanical energy used to strike a match is transformed first to thermal energy. The thermal energy causes the particles in the match to release stored chemical energy, which is transformed to more thermal energy and to the electromagnetic energy you see as light.

In a car engine, another series of energy conversions occurs. Electrical energy produces a spark. The thermal energy of the spark releases chemical energy in the fuel. The fuel expands as it is broken down into smaller particles. The expansion of the fuel produces pressure on parts of the car. The increased pressure eventually causes the wheels to turn, transforming chemical energy into mechanical energy.

Identify Supporting Evidence
Underline the energy transformation that must occur for you to talk on your cell phone.

apply it!

A series of energy transformations must occur for you to ride your bike. Write the forms of energy involved in each transformation.



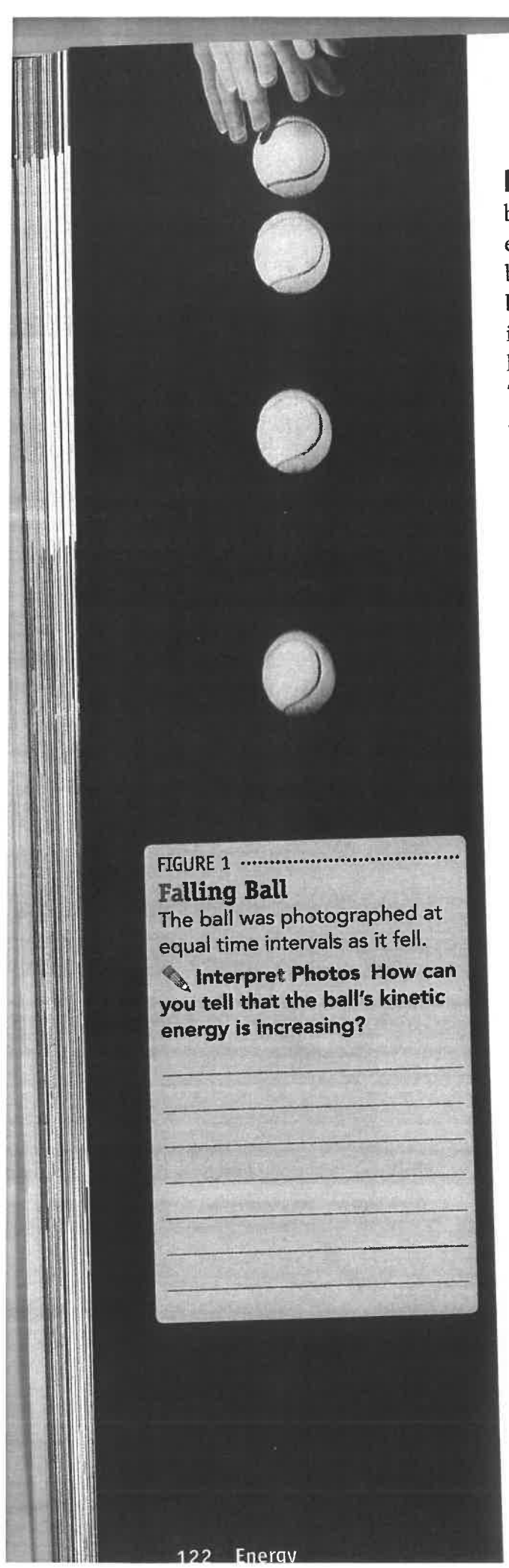


FIGURE 1
Falling Ball
The ball was photographed at equal time intervals as it fell.

Interpret Photos How can you tell that the ball's kinetic energy is increasing?

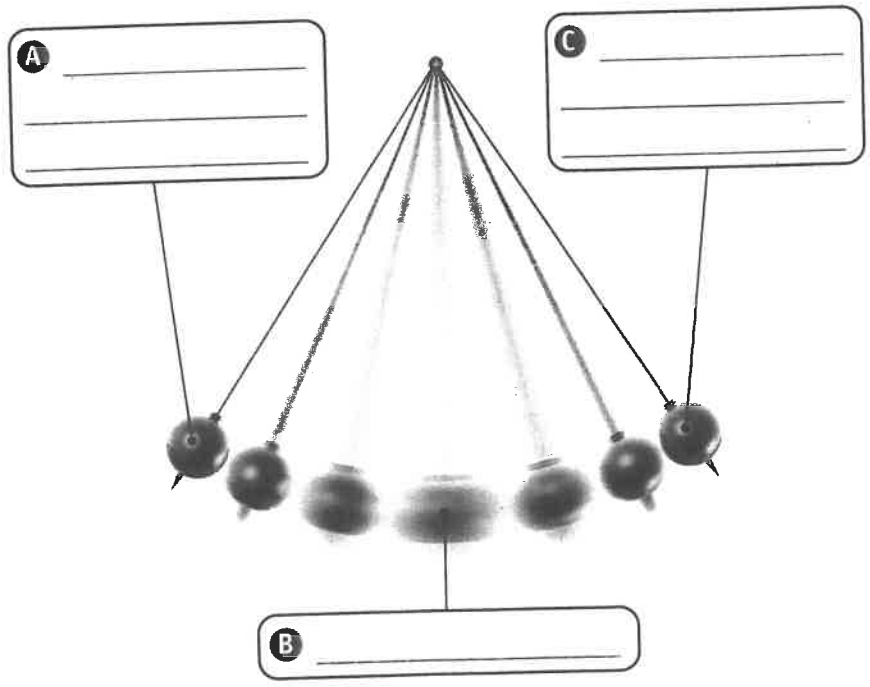
Kinetic and Potential Energy

The transformation between potential and kinetic energy is one of the most common energy transformations. For example, when you stretch a rubber band, you give it elastic potential energy. If you let it go, the rubber band flies across the room. When the rubber band is moving, it has kinetic energy. The potential energy of the stretched rubber has transformed to the kinetic energy of the moving rubber band. Transformations between kinetic and potential energy can also occur in any object that rises or falls. A falling object, a pendulum, and a pole vault are all examples of these transformations.

Falling Object A transformation between potential and kinetic energy occurs in the ball in **Figure 1**. As the height of the ball decreases, it loses potential energy. At the same time, its kinetic energy increases because its speed increases. Its potential energy is transformed into kinetic energy.

Pendulum A pendulum like the one in **Figure 2** swings back and forth. At the highest point in its swing, the pendulum has no movement. As it swings downward, it speeds up. The pendulum is at its greatest speed at the bottom of its swing. As the pendulum swings to the other side, its height increases and its speed decreases. At the top of its swing, it comes to a stop again.

FIGURE 2
INTERACTIVE ART **Pendulum**
A continuous transformation between potential and kinetic energy occurs in a pendulum. **Interpret Diagrams Label the type of energy the pendulum has at positions A, B, and C.**



Pole Vault The pole-vaulter in Figure 3 starts out by running forward. When the pole-vaulter plants the pole to jump, his speed decreases and the pole bends. As the pole straightens out, the pole-vaulter is lifted high into the air. Once he is over the bar, the pole-vaulter's speed increases as he falls toward the safety cushion.

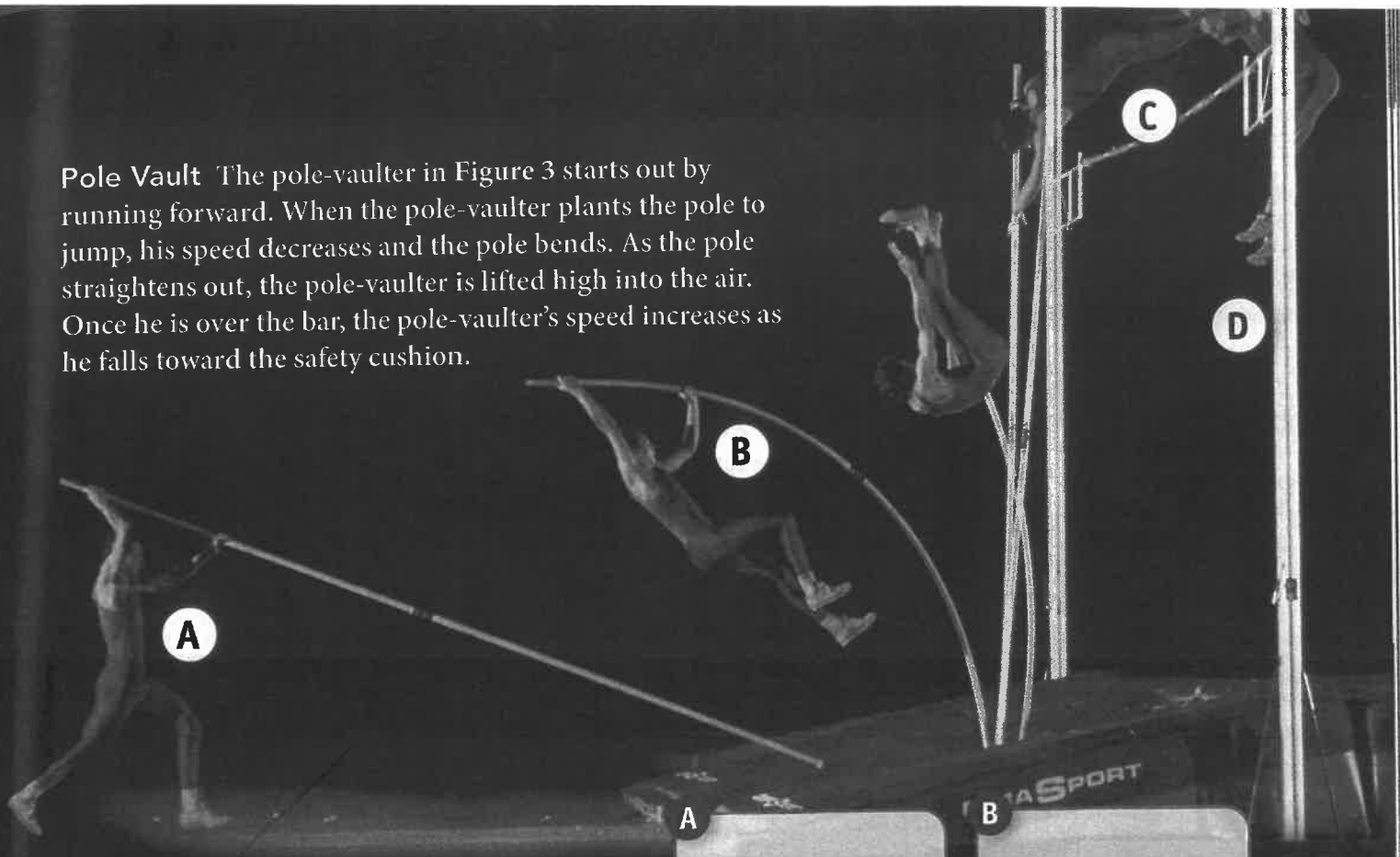


FIGURE 3

Pole Vault
Energy transformations enable this athlete to vault more than 6 meters into the air.
Sequence Identify the main forms of energy present at points A through D.

Lab zone Do the Quick Lab *Soaring Straws.*

Assess Your Understanding

1a. Define A change in one form of energy to another form of energy is called a(n) _____

b. Relate Cause and Effect When you turn on an iron, _____ energy is transformed into _____ energy.

c. Apply Concepts Describe the energy transformation that occurs in a waterfall. _____

got it?

○ **I get it!** Now I know that all forms of energy can be transformed into _____

○ I need extra help with _____

Go to **my science coach** *online for help with this subject.*

What Is the Law of Conservation of Energy?

Once you set a pendulum in motion, does it swing forever? No, it does not. Then what happens to its energy? Is the energy destroyed? Again, the answer is no. The **law of conservation of energy** states that when one form of energy is transformed to another, no energy is lost in the process. **According to the law of conservation of energy, energy cannot be created or destroyed.** The total amount of energy is the same before and after any transformation. If you add up all of the new forms of energy after a transformation, all of the original energy will be accounted for. So what happens to the energy of the pendulum once it stops moving?

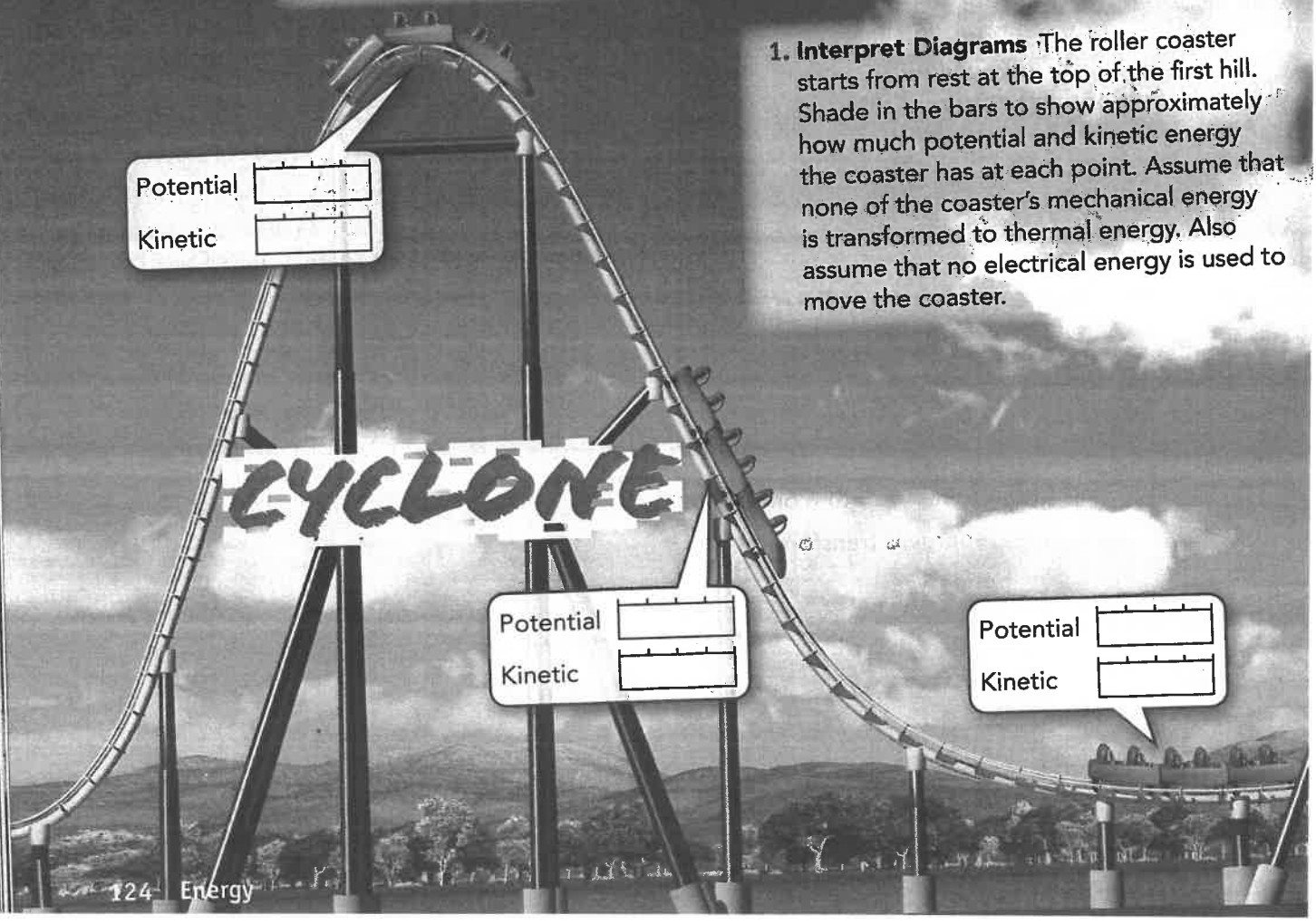
EXPLORE THE BIG ?

Conserving Energy While You Ride

How is energy conserved in a transformation?

FIGURE 4

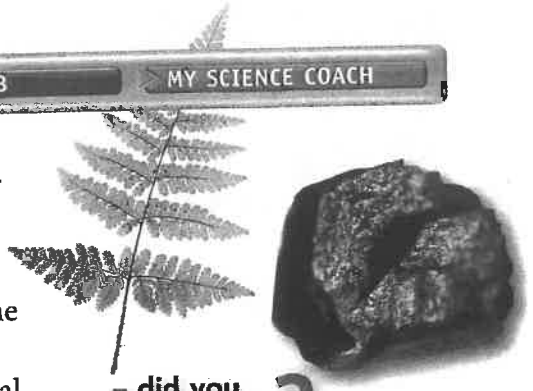
VIRTUAL LAB Transformations between potential and kinetic energy occur during a roller coaster ride. **Use what you have learned about energy transformations to answer Questions 1–3.**



1. **Interpret Diagrams** The roller coaster starts from rest at the top of the first hill. Shade in the bars to show approximately how much potential and kinetic energy the coaster has at each point. Assume that none of the coaster's mechanical energy is transformed to thermal energy. Also assume that no electrical energy is used to move the coaster.

As the pendulum swings, it encounters friction at the pivot of the string and from the air through which it moves. Whenever a moving object experiences friction, some of its kinetic energy is transformed into thermal energy. So the mechanical energy of the pendulum is not destroyed. It is transformed to thermal energy.

The fact that friction transforms mechanical energy to thermal energy should not surprise you. After all, you take advantage of such thermal energy when you rub your cold hands together to warm them up. Friction is also the reason why no machine is 100 percent efficient. You may recall that the output work of any real machine is always less than the input work. This reduced efficiency occurs because some mechanical energy is always transformed into thermal energy due to friction.



did you know?

When ancient animals and plants died, the chemical energy they had stored was trapped within their remains. This trapped energy is the chemical energy found in coal.

2. **Infer** Suppose you had taken thermal energy into account in Step 1. Would the total length of the shaded portion of the bars increase, decrease, or stay the same as as result?

○ Increase ○ Decrease ○ Stay the same

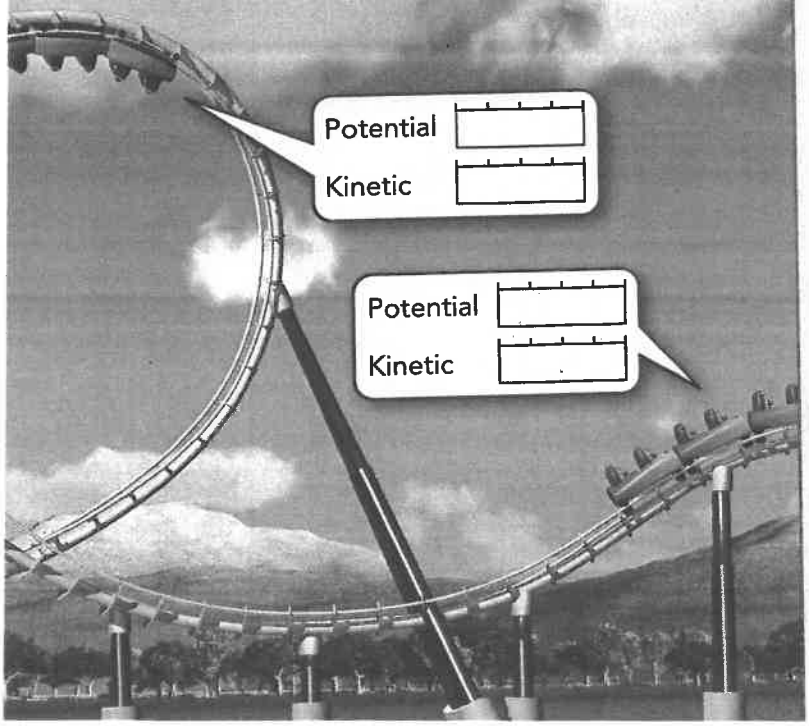
3. **CHALLENGE** Why is the first hill of a roller coaster always the tallest?

_____

_____

_____

_____



Lab zone Do the Quick Lab *Law of Conservation of Energy.*

Assess Your Understanding

2. ANSWER THE BIG Q? How is energy conserved in a transformation?

_____

_____

_____

_____

_____

got it?

○ I get it! Now I know that according to the law of conservation of energy, energy _____

_____

_____

○ I need extra help with _____

Go to **my science coach** *online for help with this subject.*

CHAPTER 4

Review and Assessment

LESSON 3 Energy Transformations and Conservation

11. As a car skids to a stop, friction transforms kinetic energy to

a. thermal energy. **b.** potential energy.

c. chemical energy. **d.** electrical energy.

12. The law of conservation of energy states that

13. Classify Describe the energy transformation that occurs in a digital clock.

14. Apply Concepts Explain why a spinning top will not remain in motion forever.

15. Infer Why does a bouncing ball rise to a lower height with each bounce?

16. Write About It An eagle flies from its perch in a tree to the ground to capture and eat its prey. Describe its energy transformations.

APPLY THE BIG IDEA How is energy conserved in a transformation?

17. The golfer in the photo is taking a swing. The golf club starts at point A and ends at point E. (1) Describe the energy transformations of the club from points A to E. (2) The kinetic energy of the club at point C is more than the potential energy of the club at point B. Does this mean that the law of conservation of energy is violated? Why or why not?