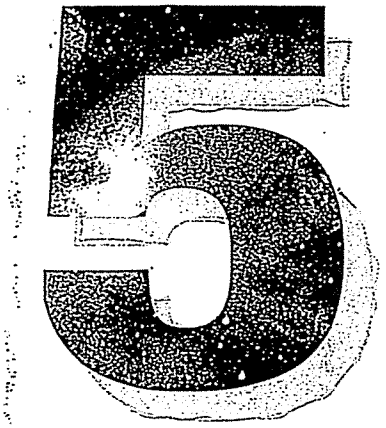
Energy: Forms and Changes



Guide for Reading

After you read the following sections, you will be able to

5–1 Nature of Energy

- Identify five forms of energy.

5–2 Kinetic and Potential Energy

- Compare kinetic energy and potential energy.
- Relate kinetic energy to mass and velocity.

5–3 Energy Conversions

- Describe different types of energy conversions.

5–4 Conservation of Energy

- Explain what Einstein said about the relationship between matter and energy.

5–5 Physics and Energy

- Relate the law of conservation of energy to motion and machines.

Within the large, cold clouds of gas and dust, small particles begin to clump together. Their own gravitational force and the pressure from nearby stars cause these small clumps to form a single large mass. Like a monstrous vacuum cleaner, gravitational force attracts more and more particles of dust and gas. The gravitational force becomes so enormous that the bits of matter falling faster and faster to the center begin to heat up. The internal temperature reaches 15 million degrees. Subatomic particles called protons collide with one another at tremendous speeds. The normal electromagnetic force of repulsion between protons is overcome by the force of particle collisions. The protons fuse together to form helium. During this process, part of the matter is transformed into energy. A star is born!

What is energy? How can energy from our sun be changed into useful energy on the Earth? Is the total energy in the universe constant? As you read further, you will find answers to these questions.

Journal *Activity*

You and Your World Think about the last time you were awakened by a violent thunderstorm. Were you frightened or excited? Did you pay more attention to the lightning or to the thunder? What did you think might happen? In your journal, explore the ideas and feelings you had on this occasion. Include any questions you have about thunderstorms.

The formation of the Orion Nebula is evidence of the interaction of matter and energy.

Guide for Reading

Focus on these questions as you read.

- *What is energy?*
- *What are the different forms of energy?*

5–1 Nature of Energy

On July 4, 1054, the sudden appearance of a new star was recorded by the Chinese. The star shone so brightly that it could be seen even during the day. After 23 days, the distant star began to disappear. What the Chinese had observed was an exploding star, or supernova. The energy released by a supernova is capable of destroying a nearby solar system in just a few hours. A supernova is one of the greatest concentrations of energy in the universe.

A supernova is a very dramatic example of energy release. But not all forms of energy are quite that dramatic. In fact, you live in an ocean of **energy.** Energy is all around you. You can hear energy as sound, you can see it as light, and you can feel it as wind. You use energy when you hit a tennis ball, compress a spring, lift a grocery bag. Living organisms need energy for growth and movement. Energy is involved when a bird flies, a bomb explodes, rain falls from the sky, and electricity flows in a wire.

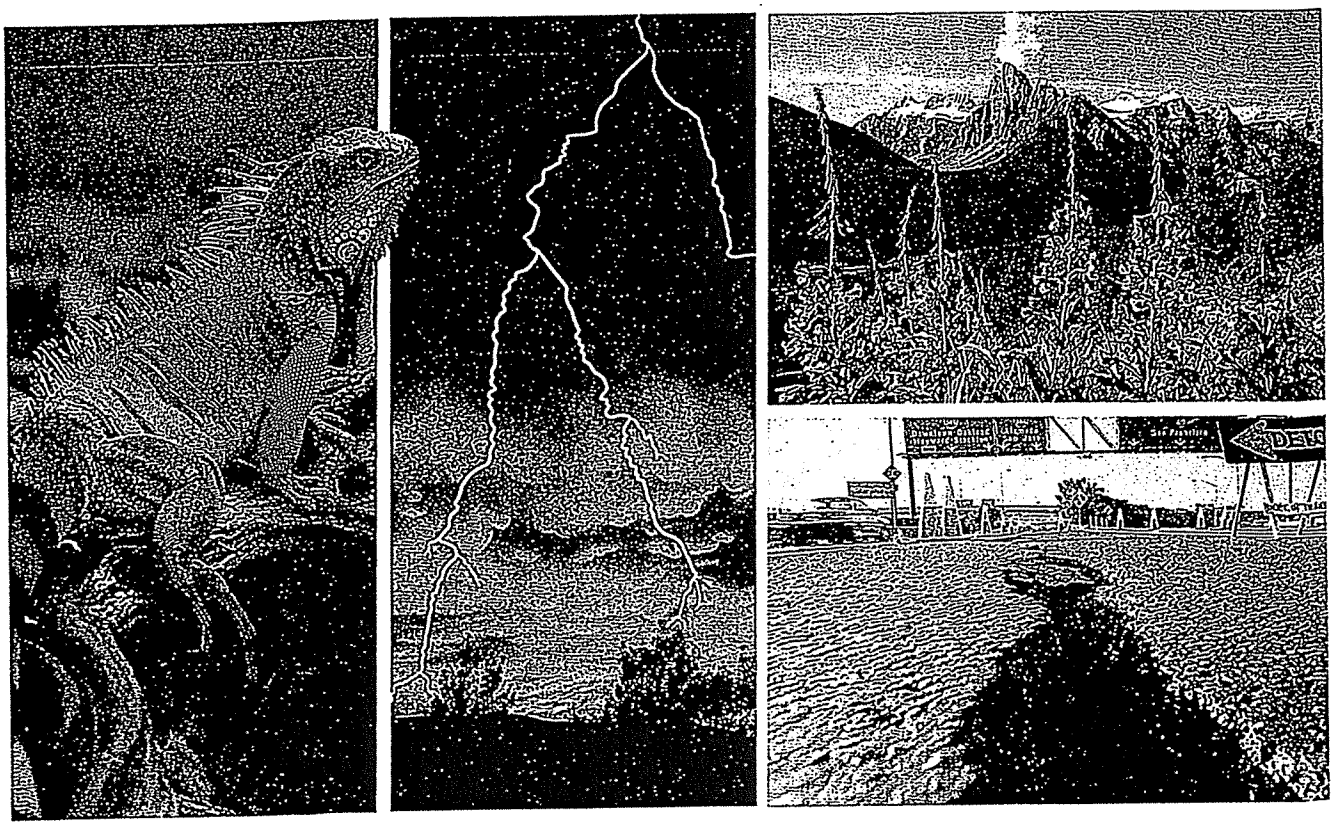


Figure 5–1 *Energy is all around you, continually shaping and reshaping the Earth and maintaining all the life that exists upon it.*

What is energy that it can be involved in so many different activities? **Energy can be defined as the ability to do work.**

If an object or organism does work (exerts a force over a distance to move an object), the object or organism uses energy. You use energy when you swim in a race. Electric charges in a current use energy as they move along a wire. A car uses energy to carry passengers from one place to another. Because of the direct connection between work and energy, energy is measured in the same unit as work. Energy is measured in joules (J).

In addition to using energy to do work, objects can gain energy because work is being done on them. If work is done on an object, energy is given to the object. When you kick a football, you give some of your energy to the football to make it move. When you throw a bowling ball, you give it energy. When that bowling ball hits the pins, it loses some of its energy to the pins, causing them to fall down.

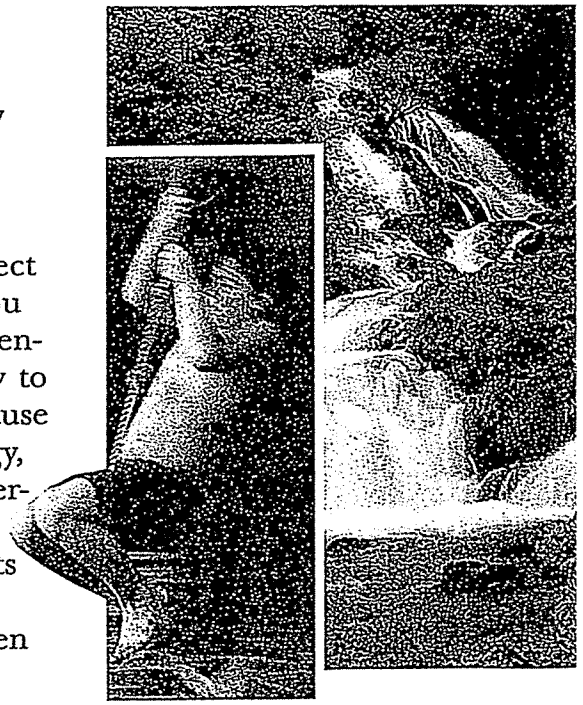


Figure 5–2 *Although he may not realize it, this young boy has energy simply because he is in motion. The same is true of the cascading waterfall.*

Forms of Energy

Energy appears in many forms. **The five main forms of energy are mechanical, heat, chemical, electromagnetic, and nuclear.** It may surprise you to learn that your body is an "energy factory" that stores and converts various forms of energy. After reading about each form of energy, see if you can describe how your energy factory works.

MECHANICAL ENERGY Matter that is in motion has energy. The energy associated with motion is called **mechanical energy.** Water in a waterfall has a great amount of mechanical energy. So does wind. An automobile traveling at 95 km/hr has mechanical energy. A jet plane cruising at 700 km/hr has even more! When you walk, ride a bike, or hit a ball, you use mechanical energy. Sound is a type of mechanical energy. Even the blood flowing through your blood vessels has mechanical energy.

HEAT ENERGY All matter is made up of tiny particles called atoms that are constantly moving. The internal motion of the atoms is called **heat energy.** The faster the particles move, the more heat energy is produced. Rub your hands together for several

ACTIVITY DOING

Energy in the News

1. Make five columns on a sheet of paper.

2. Write one of the following headings at the top of each column: Mechanical Energy, Heat Energy, Chemical Energy, Electromagnetic Energy, and Nuclear Energy.

3. Read through a newspaper and place a check mark in the appropriate column every time a particular form of energy is mentioned.

What form of energy is most often mentioned? Would this form of energy always be the most discussed?

Figure 5–3 *Lots of delicious foods to eat have an added benefit. They are a source of energy. What type of energy is stored in food?*

seconds. Did you feel heat? Using the friction between your hands, you converted mechanical energy (energy of motion) into heat energy! Heat energy usually results from friction. Heat energy causes changes in the temperature and phase (solid, liquid, gas) of any form of matter. For example, it is heat energy that causes your ice cream cone to melt and drip down your hand.

CHEMICAL ENERGY Energy is required to bond atoms together. This energy is called **chemical energy.** Often, when bonds are broken, this chemical energy is released. The fuel in a rocket engine has stored chemical energy. When the fuel is burned, chemical energy is released and converted into heat energy. When you start a fire in a charcoal grill, you are releasing chemical energy. When you digest food, bonds are broken to release energy for your body to store and use. When you play field hockey or lacrosse, you are using the chemical energy stored in your muscles that you obtained from food.

ELECTROMAGNETIC ENERGY Moving electric charges have the ability to do work because they have **electromagnetic energy.** Power lines carry electromagnetic energy into your home in the form of electricity. Electric motors are driven by electromagnetic energy. Light is another form of electromagnetic energy. Each color of light—red, orange, yellow, green, blue, violet—represents a different amount of electromagnetic energy. Electromagnetic energy is also carried by X-rays, radio waves, and laser light.

NUCLEAR ENERGY The nucleus, or center, of an atom is the source of **nuclear energy.** When the nucleus splits, nuclear energy is released in the form of heat energy and light energy. Nuclear energy is also released when lightweight nuclei collide at high speeds and fuse (join). The sun's energy is produced from a nuclear fusion reaction in which hydrogen nuclei fuse to form helium nuclei. Nuclear energy is the most concentrated form of energy.

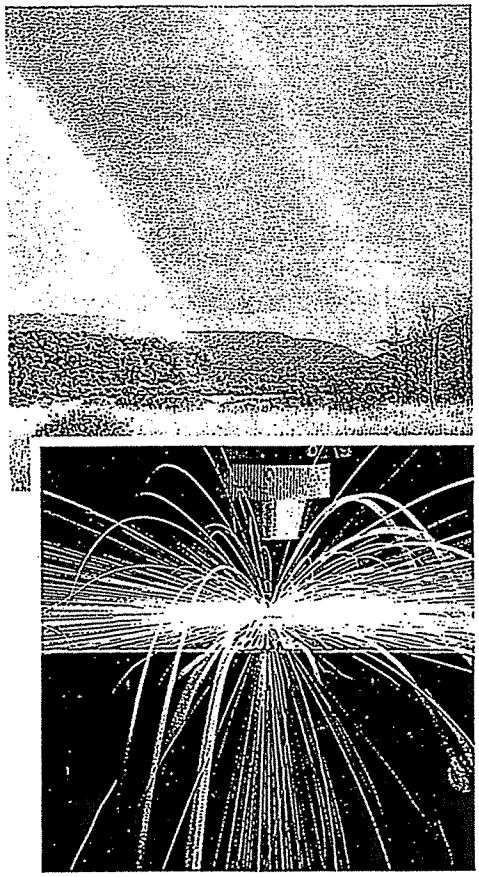


Figure 5–4 *Light, whether seen as a beautiful rainbow or used as laser beams, is an important part of everyday life. No matter how it is used, light is a form of energy. What form of energy is light?*