Section 1: The Science of Energy[1]

What Is Energy?

Energy is the ability to do work or the ability to make a change. Everything that happens in the world involves the exchange of energy in some way or involves a change of some kind. The total amount of energy in the universe remains the same. When we use energy, we do not use it up, but we convert one form into other forms. Usually the conversion of energy produces some heat, which is considered the lowest form of energy since it dissipates into the surroundings and is difficult to capture and use again. Energy can be categorized in many ways such as by what it does, by forms it takes, by the changes it makes, and by the effects we can see or feel or measure.

Energy does a lot of things, and we recognize energy in the following ways:

- **LIGHT:** the movement of energy in transverse waves or rays produces light.
- **HEAT:** the movement of atoms and molecules within substances produces heat.
- **SOUND:** the back-and-forth vibration of substances in longitudinal waves produces sound.
- **MOTION:** energy produces motion.
- **GROWTH:** energy is required for cells to reproduce. Chemical energy is stored in the bonds of nutrients.
- **ELECTRICITY:** the movement of electrons from atom to atom provides energy to run technology.

SECTION 1: Activities

Energy within Our Bodies

Our bodies use energy to regulate temperature; breathe (take in oxygen and remove carbon dioxide); ingest and digest food; distribute nutrients; pump blood; and to send signals to tell our bodies how to make sounds and what to do, see, move, feel, taste, hear, smell, and think.

All Living Things Get Energy from Food

All living things get their energy form nutrients produced by plants. All of the energy in nutrients originally came from the sun. Plants absorb the sun's radiant energy (i.e., light) and transform it into chemical energy through the process of photosynthesis. The plants use some of the energy to grow and store the rest in their cells. When we eat plants or animals that eat plants, we use some of the stored chemical energy and store some in our cells.

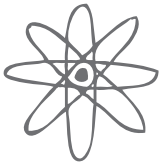
The Energy around You

Not only do our bodies use energy, we also use energy every day to do work or accomplish tasks. We use energy in many ways—to wake us up, cook and cool our food, give us light, keep us warm, entertain us, teach us, and move us from one place to another.

Heat Is Energy

All substances contain heat, which is the internal energy in substances. We can use thermometers to measure the temperature (the average amount of heat energy) of substances. Thermometers measure temperature using different scales. In the United States, we use the Fahrenheit scale in our daily lives and the Celsius scale for scientific measurements.

Heat Is the Motion of Molecules



The heat in substances is called kinetic energy, or the energy of motion. Heat is the motion of the molecules in a substance, not the motion of the substance itself. Even though we can't see them, the molecules in substances are never still. They are always moving. That motion is the kinetic energy called heat.

Molecules Vibrate, Spin, and Move

The molecules in solids—like rocks, wood, or ice—cannot move much at all. They are held in one position and cannot flow through the substance. They do move back and forth in their positions. They vibrate. The more heat they have, the faster they vibrate. The liquids and gases are called fluids. The molecules in fluid move more freely than in solids. They flow through the fluids. The more heat fluids have, the faster their molecules move.

What happens when you heat an ice cube? Ice is a solid. A solid has a definite shape. Its molecules vibrate in one position. When you add heat, the molecules vibrate faster and faster. They push against each other with more force. Finally, they break the bonds that hold them in one position. They become a liquid—water. The molecules begin to move and spin. They are still bonded together, but not so tightly. A liquid flows to take the shape of its container. It has a definite volume but can take any shape. Volume is the amount of space a fluid occupies. If you add more heat energy to the molecules, they move faster and faster. They crash into each other and move away. Finally, they break the bonds that hold them together. They become a gas—steam. A gas does not have a definite shape or volume. It spreads out and fills whatever space it occupies.

Heat Seeks Balance

Everything in nature seeks balance. Heat seeks balance, too. Heat flows from hotter places to colder places and from hotter substances to colder substances. What happens if you pour hot water into a tub of cold water? The molecules of hot water have more energy. They move fast. They crash into the colder molecules and give them some of their energy. The molecules of hot water slow down. The molecules of cold water move more quickly. The cold water gets warmer. The hot water gets cooler. Soon all of the water is the same temperature. All of the water molecules are moving at the same speed. The heat in the water is in balance.

Heat Energy Moves

Heat is always on the move. It moves to seek balance. Heat moves by conduction in solids. In a hot object, the molecules vibrate fast. The molecules in a cold object vibrate more slowly. If you touch a hot object to a cold object, the molecules in the hot object push against the molecules in the cold object. The fast molecules give up some energy. The molecules in the cold object gain some energy. They vibrate faster. When the energy is in balance, all the molecules vibrate at the same speed.

Conductors and Insulators

In some materials, heat flows easily from molecule to molecule. These materials are called conductors. They conduct, or move, heat energy well. Materials that don't conduct heat well are called insulators. The molecules in good conductors are close together. There is very little space between them. When they vibrate, they push against the molecules near them. The energy flows between them easily. The molecules in insulators are not so close together. It is harder for energy to flow from one molecule to another in insulators.

Heat and Temperature

Heat and temperature are different things. Two cups of boiling water would have twice as much heat as one cup of water, but the water would be at the same temperature. A giant iceberg would have more heat energy than a cup of boiling water, even though its temperature is lower. Heat is the total amount of kinetic energy in a substance. Temperature is a measure of the average kinetic energy of the molecules in a substance. Temperature is also called a measure of the hotness or coldness of a substance. Think about a pan in a hot oven. The pan is too hot to touch, but the air in the oven is not too hot to touch because the pan has more heat energy than the air, even though it is the same temperature.

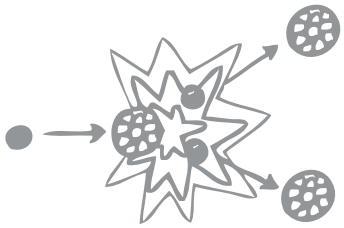
Measuring Temperature

We use thermometers to measure temperature. In the United States, we use the Fahrenheit (°F) scale in our daily lives. Scientists usually use the Celsius (°C) scale, as do people in most other countries. On the Fahrenheit scale, the boiling point of water is 212 °F. The freezing point of water is 32 °F. On the Celsius scale, the boiling point of water is 100 °C. The freezing point of water is 0 °C.

Solids, Liquids, and Gases

The molecules in solids have strong bonds. They are held tightly in one position. They cannot move around. They can only vibrate. When heat energy is added, the molecules vibrate faster. They push against each other with more energy. The space between them gets a little bigger, but they are still held in position.

The molecules in liquids are also held together but not in one position. They are free to spin and move around each other. When heat energy is added to a liquid, the liquid expands more than a solid. The binds that hold molecules in a liquid together are not as strong as solid bonds, so liquid molecules can push away from each other.



There is a lot of space between molecules of gases. The bonds that hold them together are very weak. When heat energy is added to gases, the gas expands a lot. Sometimes molecules of gas break the bonds completely and float away from each other.

Light Is Energy

Light is a form of radiant energy, or electromagnetic energy, which moves in transverse waves. The radiant energy we use to see, called visible light, is only a small part of the radiant energy in the universe. Although we cannot see light energy, we can see and feel its effect when the light waves encounter our bodies or other objects. When light waves encounter objects, they are reflected, refracted, and/or absorbed. Dark objects tend to absorb light and light objects tend to reflect light. When light energy is absorbed, some of that energy is converted into heat.

Light Is Energy in Waves

Light is energy that travels in waves. All the energy we get from the sun travels in waves. Some of that energy is in light waves we can see. The light we can see is called visible light. Some light is in waves we can't see. We can't see infrared waves, but they can warm us when they touch our skin. We can't see ultraviolet light waves, but they can burn our skin. Some waves of energy, like radio waves, are very long. Radio waves can be a mile long. Other waves are very short, like light waves and x-rays. There are about 50,000 light waves in an inch.

Visible Light

The wave energy we see is made of many colors. Every color has a different wavelength. The longest wavelengths are reds. The medium wavelengths are yellows. The shortest wavelengths are violets. All of the colors mixed together make white light. We measure waves by the distance from the top, or crest, of one wave to the top of the next. This distance is called its wavelength. The shorter the wavelength, the more energy the wave has.

Light waves travel in straight lines. When light waves hit something, three things can happen. The light can travel through a substance and bend (or be refracted). Light passing though transparent substances like hot water is bent. Light waves can enter a substance and be absorbed. Plants absorb some light waves and convert them into sugars. Light waves can also bounce off a substance (or be reflected). A mirror reflects light waves. Many substances absorb some light waves and reflect others.

Light Waves Can Be Absorbed

Light waves can also enter a substance and change into other forms of energy. The light energy can be absorbed by the substance. When we are in the sun, some of the light waves enter our skin and turn into heat. Our bodies absorb some of the light waves. Most substances reflect some light waves and absorb others. That's why we see colors!

Visible light is made of every color. Every color has a different wavelength. When a substance absorbs all wavelengths of visible light, the substance looks black. No light waves are reflected to reach our eyes. The light waves, which are waves of energy, enter the substance. The substance changes the light energy to other forms of energy. When a substance reflects all wavelengths of visible light, the substance looks white.

Seeing Colors

We see many colors because most substances absorb some wavelengths of light and reflect others. We see the colors that are reflected by the substances. A rose looks red because it is reflecting the red light waves and absorbing the oranges, yellows, blues, greens, and violets. A blue bird looks blue because it is reflecting the blue light waves and absorbing the others. The dirt looks brown because it is reflecting several light waves that together look brown and absorbing other light waves.

Using Light Energy

We use light energy everyday to see. We use it in many other ways, too. The leaves reflect green light waves and absorb others. The energy they absorb is used by the plants to make sugars through a process called photosynthesis. The sugars feed the plants and the plants we eat give energy to us. All the energy we get to move and grow come from plants.

We can use the energy in light to make heat in many ways. We can color things black to absorb the light waves. We can use mirrors to reflect many light waves onto an object that absorbs them and turns them into heat. We can use this heat to warm houses and water or to cook food. We can also use light energy to make electricity. Solar cells can absorb light waves and turn the energy into electricity.

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1 Text for *The Science of Energy* was adopted from the National Energy Education Development.