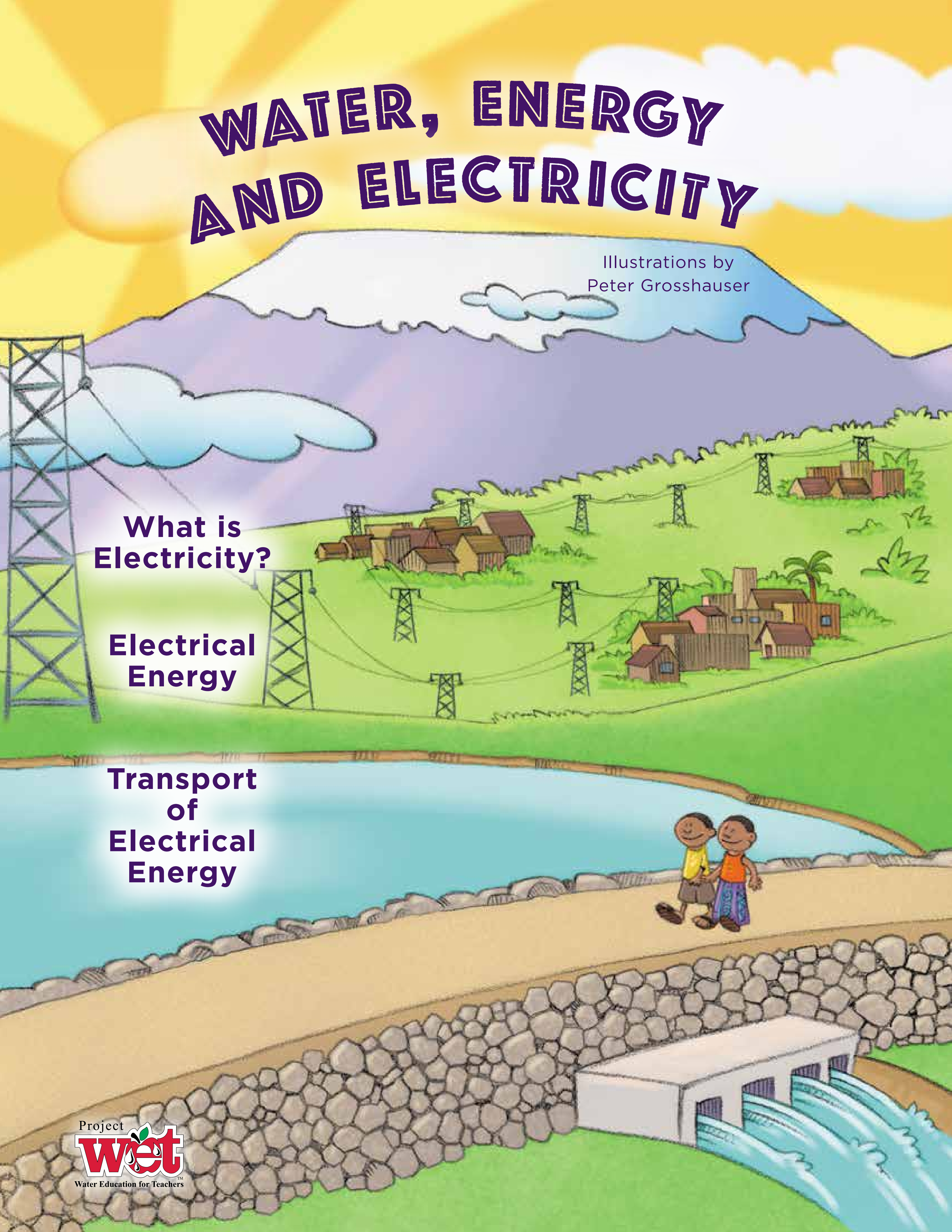
WATER, ENERGY AND ELECTRICITY

Illustrations by
Peter Grosshauser



What is Electricity?

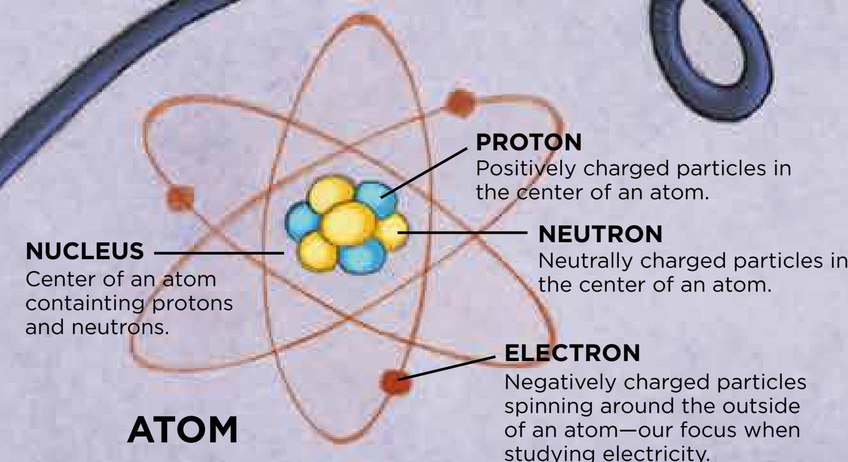
Electrical Energy

Transport of Electrical Energy

Project WET
Water Education for Teachers™

WHAT IS ELECTRICITY?

Have you ever turned on a light in a dark room? Or charged a mobile phone? What do you need to get texting again? Electricity! When another type of energy (light, motion, chemical or heat) is transformed into electrical energy, we call this **electricity**. It's easy to see that electricity powers a light and charges your phone, but to understand what electricity is we need to look more closely.



ATOMS AND YOU

Atoms are tiny particles that make up everything we see, and even things we can't see! Atoms make up your body, food, the chair you sit on and even the air you breathe. Atoms are so tiny several million of them could fit across the head of a pin. If we could see inside a single atom we would see that it is made up of even smaller parts: **neutrons** and **protons** in a **nucleus** at the center, and **electrons** spinning around its outer edges. To learn about electricity we will focus on electrons.

FEEL THE ELECTRICITY

In this activity you and several friends will demonstrate how energy passing among electrons is faster than electrons traveling from atom to atom.

- Form a line (Line 1) side-by-side facing the same direction, holding hands with people on either side. Each person represents an atom. Form a second line (Line 2) next to the first with the same number of people.
- The person at one end of each line represents the switch. The person at the other end of each line represents the light.
- When ready, the leader yells "on" and the person in Line 1 representing the switch immediately squeezes the hand of the person next to him. As soon as that person feels the squeeze, they squeeze the hand of the next person and so on. When the person representing the light feels the squeeze, they should immediately raise their hand. The squeeze represents electrical energy travelling among atoms that don't move much.
- In the second line when the leader yells "on", the person representing the switch immediately changes places with the person next to him/her. He/she immediately changes places with the next person down the line and so on until he/she reaches the other end of the line. At that point the person acting as the light in Line 2 immediately raises his or her hand. This represents electrons moving from atom to atom.

Which method was faster?

Note: It is important to wash your hands with soap and water after this activity!

HOW ELECTRONS MOVE

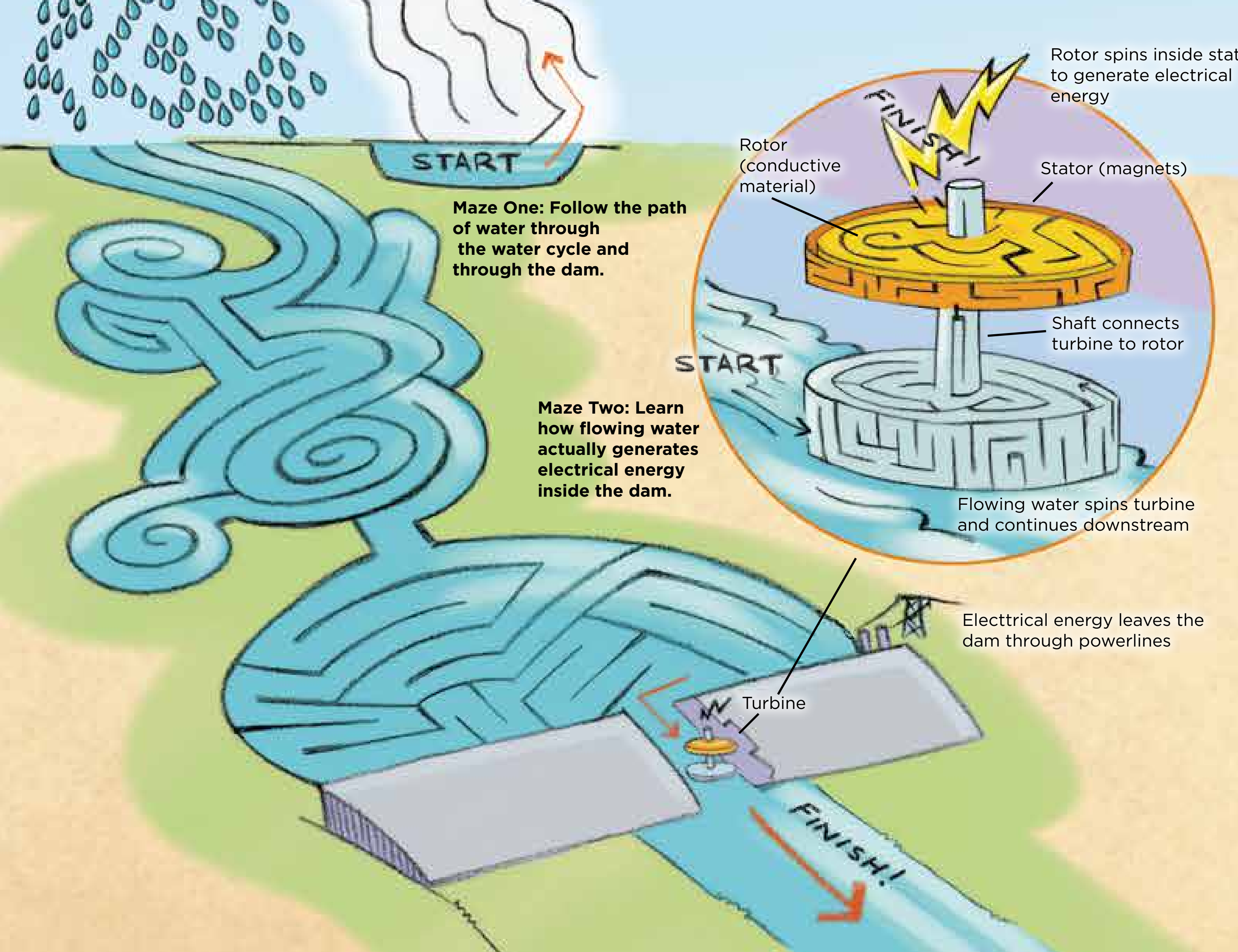
Every material is made of atoms which are packed closely together in a small space, and every atom has electrons. Electrons vibrate and spin around atoms and have the ability to travel from one atom to another. Electrons travel slowly (slower than a minute hand on a clock moves) and electron travel is not the reason a light turns on quickly after a switch is flipped. Instead, electrical energy passes among the atoms toward the light bulb much more quickly than electrons can travel. On the next page we will learn about energy and where it comes from.

CONDUCTION

Although all materials are made of atoms, the electrons around the atoms in some materials pass electrical energy more quickly than others. These materials are called **conductors**. Copper and other metals are good conductors. Materials that are not good conductors are called **insulators**. Insulators do not allow electrons to pass energy efficiently. If you could see inside the cord for a light or mobile phone you would see that the inside is metal (likely copper) and the outside is plastic. Why?

WHERE DOES ELECTRICAL ENERGY COME FROM?

Electrical energy passes among atoms along the conductor to light a light bulb. But what is energy? Where does the electrical energy in an outlet come from?



HOW DO TURBINES GENERATE ELECTRICITY?

Turbines generate electrical energy because the motion energy from water, wind, or steam rotates a conductor (such as copper wire)—which is full of electrons—near magnets. Magnets produce an invisible **magnetic field**—the area around a magnet to which the magnet's forces extend. The electrons in the conductor produce an **electric field** in the area where their forces extend. When electrons move through a magnetic field, electric and magnetic forces transform motion energy into waves of **electromagnetic energy**. We call this generating electricity.

SOME SOURCES OF ENERGY

These major sources of energy can be transformed to generate electrical energy.

SUN	captured with solar panel
WATER	moving water, hot water, stored water and steam all spin turbines to generate electricity
FOSSIL FUELS	oil, coal, natural gas—mined from the ground, burned to provide energy for cars, and burned to heat water creating steam to spin turbines
WIND	the power of wind spins turbines to generate electricity
NUCLEAR	heat energy is released through the process of splitting atoms which heats water, making steam to spin turbines
BIOMASS OR CHEMICAL	(e.g., food, wood, agricultural waste, garbage, etc.) is burned to release heat energy and create steam to spin turbines
OTHER	scientists and engineers are working to identify new energy sources

Humans have identified energy sources to generate electrical energy to power the tools we use. The sun is the source of solar energy. Solar energy travels to earth as invisible waves. You can feel the energy from those waves as warmth on your skin on a sunny day, and some we see as sunlight. Humans capture energy from the sun, and other sources, to use it. You can't light a light bulb by plugging the cord into the sun, a rushing river or a log—so to use these sources their energy must be converted to another form. Energy is often changed, or transformed, from one form to another to become usable to humans. For example, energy from the sun is transformed into chemical energy in the form of a banana, and into motion energy for your body when you eat it. To capture the sun's energy directly, engineers have designed solar panels, which convert solar energy waves into electrical energy. Energy from the sun also powers major processes on earth—such as water and air movement. The sun's energy is indirectly responsible for other sources of energy, like water, wind and even fossil fuels. Usable energy is generated from water (flowing, or as steam) and wind by taking advantage of the power of movement (water and wind's motion energy). Moving water, wind, or pressure from steam spins a **turbine**—a large rotor, which generates electrical energy (see sidebar for more information). Turbines don't create energy, they transform one type of energy into another.

TRANSPORT OF ELECTRICAL ENERGY

We've learned that energy from a variety of sources can be transformed into electrical energy for our use. However, once electrical energy is generated from another energy source, it still needs to travel from where it was generated to where it will be used. We build conductive powerlines so electrical energy can travel from where it was generated to our school and home to pump water, grind flour, turn on a light or charge your mobile phone.

LIGHTS ON!

We now have an idea how energy (directly or indirectly) from the sun can be captured, transformed, and transported to an outlet in our home or school. We also understand how electrical energy is passed among electrons of a conductive material, from one location to another. So how does that lightbulb go from dark to lit, or your mobile phone charge? The answer is **circuits**. Circuits create a closed loop of conductive material through which electrical energy is passed among electrons. When a light bulb is added into a circuit the electrical energy passes through a coil inside the bulb called a **filament**, where it is transformed into heat and light energy. When you plug the cord from your light into an outlet you add electrical energy to the circuit. You may have to flip a switch to complete the circuit and turn the light on!

ENERGY WAVES: THE ELECTROMAGNETIC SPECTRUM

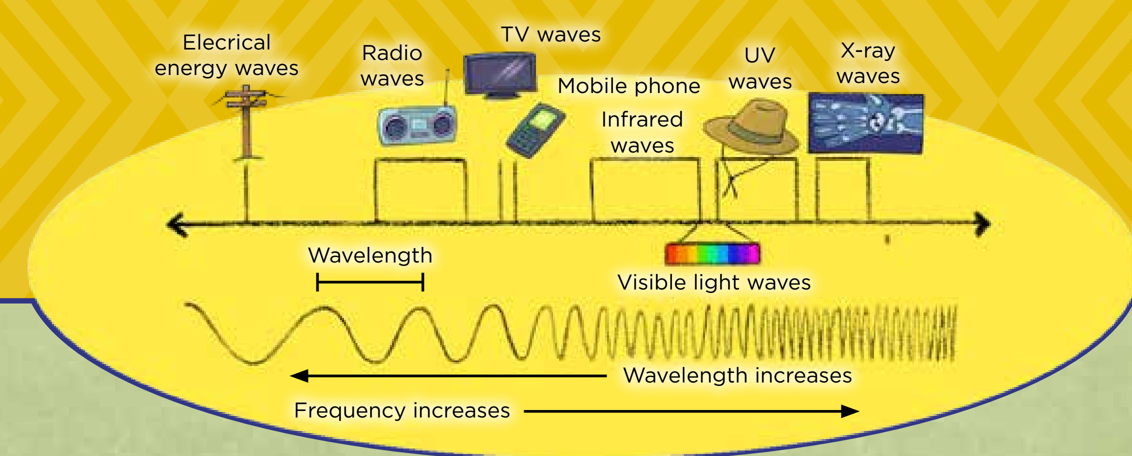
Different kinds of electromagnetic energy from the sun travel to Earth in the form of electromagnetic waves. Some electromagnetic waves do not need a substance to travel through (like water or sound waves do)—they can even travel through the vacuum of space. We call these different kinds of electromagnetic waves the **electromagnetic spectrum** (see diagram below). They range in wavelength, frequency and the energy they carry (for example, the waves of electrical energy that travel through powerlines have a much longer wavelength and a much lower frequency than the ultraviolet light waves that warm your skin from the sun).

OBSERVING WAVELENGTH AND FREQUENCY

For this activity you need a length of string or rope and either another person or something, such as a doorknob, onto which to tie the rope.

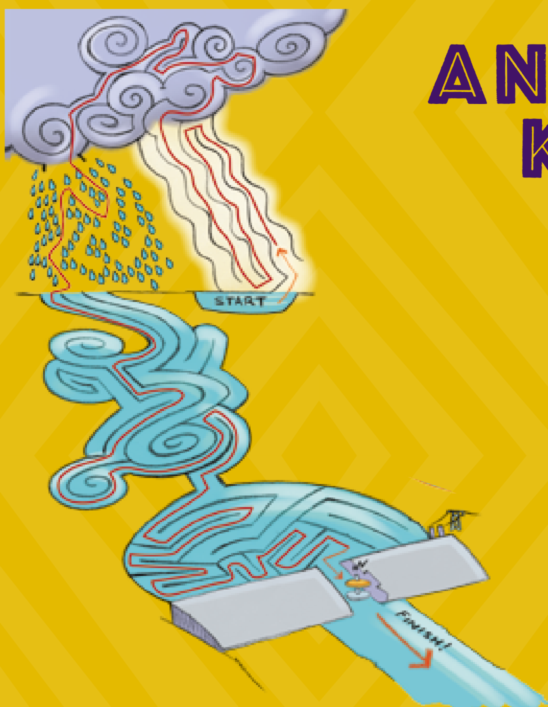
- Tie one end of the rope to a doorknob or have another person hold on to it about waist level.
- With some slack in the rope, hold the other end and move it up and down rapidly to create waves.
- You should observe wave motion along the rope as the energy from your arm moving up and down is transformed into wave motion energy that moves along the length of the rope. Energy travels in waves along the rope, the rope conducts the energy (moving up and down) but does not move from one end to the other with it—similar to how atoms pass energy through an electrical cord.
- Experiment with the relationship between **wavelength** (the distance between wave crests) and **frequency** (how fast you move your arm).

Visible light from the sun is part of the electromagnetic spectrum, but it is the only part of the spectrum we can see without the aid of technology. In addition to electrical energy, other energy waves from the electromagnetic spectrum can also be generated on Earth. For example, we generate waves to send information to radios, televisions, and mobile phones. We use other waves to cook food in a microwave oven and doctors use x-rays to see if we might have a broken bone.



AC/DC

Not all electrical energy is the same. When a turbine generates electrical energy using conductors and magnets as described on page 4, the **electrical current** (flow of electricity) that is produced is called **alternating current (AC)**. For AC current, waves of electromagnetic energy alternate from stronger to weaker as electrons in the conductor move closer and further away from the magnets in the turbine. When electromagnetic energy is released from solar panels or batteries (sources of stored—often chemical—energy) the electrical current does not alternate so it is called **direct current (DC)**. Both AC and DC provide current to charge mobile phones or power lights.



ANSWER KEY

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Water Education for Teachers™

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The Project WET Foundation envisions a world in which action-oriented education enables every child to understand and value water, ensuring a sustainable future. www.projectwet.org

PROJECT TEAM:
Megan Regnerus, Project Manager
Molly Ward, Contributing Author
Dave Dolicelek, Contributing Author

Illustrated by Peter Grosshauser
Designed by Abby McMillen, folk dog art

REVIEWERS:
Julia Nelson Beck, Morgan Close, Kristi Crawford; John Etgen, Aloyce Kimario, Dennis Nelson

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Dennis L. Nelson, President and CEO

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For more information contact:
301 N. Willson Ave.
Bozeman, MT 59715
1-406-585-2236
1-406-522-0394 (fax)
info@projectwet.org
www.projectwet.org

Scan the QR code with a smartphone to visit the Project WET website.