8. How do the wavelength and the frequency of a wave determine its energy?
9. What does ROYGBIV stand for?
10. Which color of visible light has the shortest wavelength?
11. Which color of visible light has the highest frequency?
12. How can electromagnetic waves carry information? Give some examples.
13. How do microwaves cook our food?
14. What are some ways we protect our bodies from ultraviolet radiation?
15. How are X-rays used to help people?
16. Why do doctors cover patients with a lead blanket when they take X-rays?
17. What is the Aurora Borealis?
18. What causes the northern lights to appear in the sky?

## Follow-up Discussion

Research indicates that students will retain their previous misconceptions about a topic, in preference to new information, until they actively recognize and correct their own errors. Therefore, it is important to have your students re-examine the facts/beliefs they put on their "Everything We Think We Know About…" list. It might also be helpful to review the list by marking each entry with a "+" or "-" to show which facts were correct and which were incorrect.

Thought-provoking discussions provide a good way to assess the overall depth of student understanding. The following are some suggested discussion topics.

- Distinguish the parts of the electromagnetic spectrum by wavelength, source and use.
- Discuss how the windows in microwave ovens are made and try to explain why.

## Follow-up Activities

- Have students create electromagnets using long nails, coils of bell wire and batteries. They can deduce the relationship between numbers of coils and magnetic ability through experimentation. Have them graph the data, showing numbers of coils vs. number of paper clips attracted by the electromagnet.
- Have students create a large chart identifying the position of each type of radiation in the electromagnetic spectrum according to its wavelength, frequency and use.
- In small groups, have students discover how prisms resolve light into its rainbow components and how these colors can be recombined to create white light.

## Suggested Internet Resources

Periodically, Internet Resources are updated on our Web site at www.LibraryVideo.com ***(Continued)***



TEACHER'S GUIDE

- **amazing-space.stsci.edu/light/makewaves-frames.html**
  This Web site enables students to measure the wavelength and frequency of waves with different energy levels. Brainteasers and interesting facts about light are also provided.
- **ippex.pppl.gov/ippex/module_4/intro.html**
  This site provides an interactive module on electricity and magnetism. Students learn about charged particles, attraction and repulsion and the role of electricity and magnetism in everyday life.
- **cse.ssl.berkeley.edu/light/light_tour.html**
  The Center for Science Education at the Berkeley Space Science Laboratory sponsors this Web site that explores the mysteries of light. Information is offered about the nature of light, wavelengths and the electromagnetic spectrum.

## Suggested Print Resources

- Friedhoffer, Robert. *Magnetism and Electricity.* Franklin Watts, Danbury, CT; 1992.
- Shepherd, Donna Walsh. *Auroras: Light Shows in the Night Sky.* Franklin Watts, Danbury, CT; 1995.
- Skurzynski, Floria. *Waves: The Electromagnetic Universe.* The National Geographic Society, 1996.
- Souza, D.M. *Northern Lights.* Carolrhoda Books, Minneapolis, MN; 1994.

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**TITLES**

- **ELECTROMAGNETIC ENERGY**
- **ENERGY: POTENTIAL & KINETIC**
- **ENERGY RESOURCES: USE & CONSERVATION**
- **HEAT & CHEMICAL ENERGY**
- **MECHANICAL ENERGY**
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TEACHER'S GUIDE

ENERGY IN ACTION™

# Electromagnetic Energy

## Grades 5–8

Students in grade 5-8 classrooms possess a wide range of background knowledge. Student response to this video program is sure to be varied, so the teachers at these grades need all the help they can get! This guide has been designed to help the 5-8 science teacher by providing a brief synopsis of the program, previewing and follow-up questions, activities, vocabulary and additional resources.

**Before Viewing:** Extensive research tells how important it is for the teacher to discover what the students know — or think they know — about a topic, before actually starting a new unit. Therefore, after prompting discussion with the pre-viewing questions, lead your class to create an "Everything We Think We Know About…" list. You may also wish to preview key vocabulary words, and have students raise additional questions they hope will be answered.

**After Viewing:** Have your students share video excerpts that fascinated or surprised them, then challenge your students to prove or disprove the accuracy of the facts they put on their "Everything We Think We Know About…" list. Discuss what else they learned and use the follow-up questions and activities to inspire further discussion. Encourage students to research the topic further with the Internet and reading resources provided.

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## Program Summary

What do radios, microwave ovens and X-ray machines have in common? They all use different forms of electromagnetic energy to do work. Cosmic rays from space and visible light are also part of the family of energy waves known as the electromagnetic spectrum. Just as its name suggests, electromagnetic energy involves the forces of electricity and magnetism, as well as the movement of charged particles carried in waves. Scientist James Maxwell was the first to discover that these two forces are both parts of electromagnetism.

The electromagnetic spectrum ranges from high-energy gamma rays with very short wavelengths to low-energy radio waves with very long wavelengths. Because all forms of electromagnetic energy travel at the same speed — the speed of light — their different wavelengths give them different frequencies, and the higher the frequency, the greater the energy. Radio waves, which have the longest wavelength (as long as a soccer field) and the lowest energy level, are transmitted by radio and television stations, and can be used to communicate. Microwave energy has wavelengths that range from the size of a baseball to as small as a dot. In microwave ovens, the energy heats up the molecules of water in the food, thereby cooking the food. Microwaves are also used in radar instruments to help weather forecasters track storms.

From low-frequency radio waves and microwaves, the spectrum proceeds up the scale to infrared waves, visible light, ultraviolet rays, X-rays and finally the form with the greatest electromagnetic energy, high-frequency gamma rays. Of the entire spectrum, human eyes can only see the band in the middle of the spectrum called visible light. Visible light includes all the colors of the rainbow, from the color with the longest wavelength, red, to the color with the shortest wavelength, violet. The order of visible colors is easily remembered using the acronym ROYGBIV (red, orange, yellow, green, blue, indigo and violet). Immediately below red light on the electromagnetic spectrum are infrared waves, which are also known as heat waves. Most of the sun's radiation comes to Earth as infrared waves. Above violet light on the spectrum are ultraviolet waves (UV), which are the harmful rays from the sun that cause sunburn. Just as sunscreen protects your skin, sunglasses can protect your eyes from those harmful rays. Right above ultraviolet rays in the spectrum are X-rays, which have a wavelength smaller than a molecule and a high frequency. High-energy X-rays can pass right through the soft tissues of our bodies, but not as easily through our bones. That's why doctors can use X-rays to check out our skeletons for broken bones. Gamma rays are the most powerful form of electromagnetic energy, with a wavelength shorter than one ten trillionth of a meter. All of the planets and stars naturally emit electromagnetic energy and can be studied using special telescopes built to receive energy of specific wavelengths, from radio waves to gamma rays.

## Vocabulary

The following words are included for teacher reference or for use with students. They are listed in the order in which they appear in the video.

**matter** — Any substance that takes up space. Matter is made of small particles called atoms, and can be in the form of a solid, liquid, gas or plasma.

**energy** — The ability to make things happen or to do work.

***(Continued)***



**work** — To move or change something. Doing work takes energy.

**electromagnetic energy** — The energy that is associated with the movement of charged particles. All forms of electromagnetic energy are carried in waves.

**electricity** — The flow of charged particles.

**magnetism** — A natural force of attraction or repulsion of magnetic materials.

**electromagnetism** — The relationship between charged particles and the forces they create; electrical currents create a magnetic field, and changing magnetic fields can create an electrical field.

**attract** — To pull together. When opposite magnetic poles are put near each other, attraction occurs.

**repel** — To push away. When two similar magnetic poles are near each other, they repel one another.

**James Clerk Maxwell** — (1831–1879) The 19th-century mathematician who was the first to realize that electricity and magnetism are both part of what we now call electromagnetic energy. He correctly believed that light waves are also a form of electromagnetic energy.

**wavelength** — Measurement of the distance between two consecutive high or two consecutive low points on a wave.

**frequency** — Measurement of the number of waves that pass an established point in a given amount of time. Waves with higher frequency have more energy than waves with lower frequency.

**electromagnetic spectrum** — The full range of electromagnetic waves that includes visible light, arranged in order of wavelength and frequency from radio waves to gamma rays. All electromagnetic energy travels at the speed of light.

**speed of light** — The speed at which electromagnetic energy travels in a vacuum; it is defined as 299,792,458 meters/second (186,000 miles/second).

**radio waves** — The longest waves in the electromagnetic spectrum. These low-energy waves are used to carry information.

**microwaves** — Waves in the electromagnetic spectrum that range from the size of a baseball to the size of a dot. In a microwave oven, microwaves penetrate the food, transferring their energy to molecules of water in the food, which heat up and cook the food. Microwaves are also used by meteorologists to track storms.

**infrared waves** — Electromagnetic radiation at wavelengths longer than the red end of visible light and shorter than microwaves (roughly between 1 and 100 microns). These waves in the electromagnetic spectrum are about the size of a single cell. Much of the sun's radiation comes to Earth in the form of infrared waves. These waves are too long for humans to see.

**visible light waves** — Waves in the electromagnetic spectrum that humans can see. Visible light consists of waves of different lengths. Visible light waves are the range of wavelengths of visible light that comprises white light and can be identified by the human eye; these colors are red, orange, yellow, green, blue, indigo and violet.

**ROYGBIV** — An acronym created from the first letters of the colors of visible light, arranged in order from the longest wavelength to the shortest (red, orange, yellow, green, blue, indigo and violet).

***(Continued)***



**ultraviolet waves (UV)** — Waves in the electromagnetic spectrum that are too short for humans to see. Ultraviolet rays from the sun are what cause sunburn.

**X-rays** — Waves in the electromagnetic spectrum that can be smaller than a molecule. Because they do not penetrate bones well, safe levels of X-rays are used to identify broken bones.

**gamma rays** — The shortest (less than one hundred billionth of a centimeter) and most energetic of the waves in the electromagnetic spectrum. Gamma rays are generated by radioactive atoms and nuclear explosions.

**Hubble Space Telescope** — The telescope named for astronomer Edwin Hubble that has orbited the Earth since 1990, helping scientists explore the solar system by observing distant, high-energy electromagnetic radiation.

**solar flare** — The explosive, outward burst of plasma from the sun's surface, which sends energy through space, causing the Aurora Borealis and Australis on Earth.

**Northern Lights** — (Aurora Borealis) Changing light patterns observed in the sky near the Earth's north pole that are caused by high-energy particles from the sun coming in contact with Earth's magnetic field. In the southern hemisphere, this phenomenon is known as the Aurora Australis.

**plasma** — The super-heated matter which makes up much of the sun. Plasma is the fourth state of matter.

## Pre-viewing Discussion

Before students generate their list of "Everything We Think We Know About…" for this topic, stimulate and focus their thinking by raising these questions so that their list will better reflect the key ideas in this show:

- What color is sunlight?
- How does light travel?
- What is electromagnetic energy?
- What causes magnetic fields?

After the class has completed their "Everything We Think We Know About…" list, ask them what other questions they have that they hope will be answered during this program. Have students listen closely to learn if everything on their class list is accurate and to hear if any of their own questions are answered.

## Focus Questions

1. How are energy and work related?
2. What kind of energy comes from the sun?
3. How are electricity and magnetism related?
4. Who was James Clerk Maxwell?
5. What is the electromagnetic spectrum? How are its parts arranged?
6. What is a wavelength?
7. What is meant by the frequency of a wave?

***(Continued)***