U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ENERGY EDUCATION AND WORKFORCE DEVELOPMENT

Primary Science of Energy

Teacher Guide

(42 Activities)

Grades: K-4

Topic: Energy Basics

Owner: NEED

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

PRIMARY

SCIENCE OF ENERGY

Teacher Guide

Hands-on explorations that introduce scientific measurement using simple tools with an emphasis on the basic concepts of energy: motion, heat, light, sound, and growth.

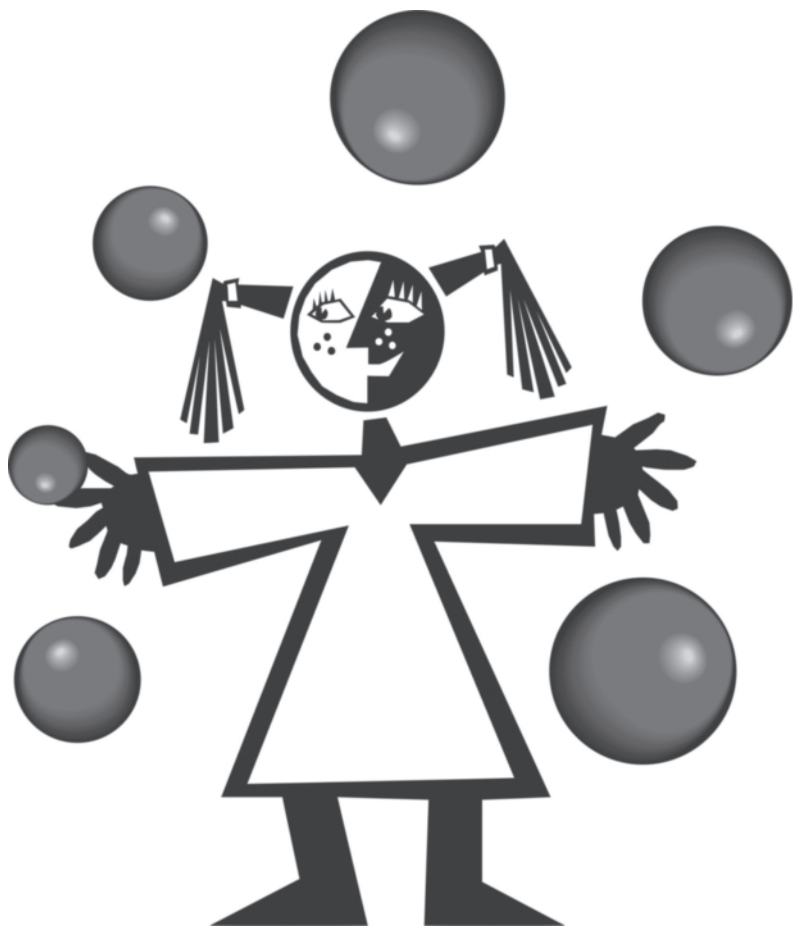
SCIENCE OF ENERGY

GRADE LEVEL

Primary

SUBJECT AREAS

Science
Social Studies
Math
Language Arts



NEED 2006-2007

Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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Putting Energy into Education

Correlations to National Science Standards

UNIFYING CONCEPTS AND PROCESSES

1. Systems, Order, and Organization

a. The goal of this standard is to think and analyze in terms of systems, which will help students keep track of mass, energy, objects, organisms, and events referred to in the content standards.

b. Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Students can develop an understanding of order–or regularities—in systems, and by extension, the universe; then they can develop understanding of basic laws, theories, and models that explain the world.

c. Prediction is the use of knowledge to identify and explain observations, or changes, in advance. The use of mathematics, especially probability, allows for greater or lesser certainty of prediction.

d. Order—the behavior of units of matter, objects, organisms, or events in the universe—can be described statistically.

e. Probability is the relative certainty (or uncertainty) that individuals can assign to selected events happening (or not happening) in a specified time or space.

f. Types and levels of organization provide useful ways of thinking about the world.

2. Evidence, Models, and Explanation

a. Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

b. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have an explanatory power. Models help scientists and engineers understand how things work.

c. Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. As students develop and as they understand more scientific concepts and processes, their explanations should become more sophisticated.

3. Change, Constancy, and Measurement

a. Although most things are in the process of change, some properties of objects and processes are characterized by constancy; for example, the speed of light, the charge of an electron, and the total mass plus energy of the universe.

b. Energy can be transferred and matter can be changed. Nevertheless, when measured, the sum of energy and matter in systems, and by extension in the universe, remains the same.

c. Changes can occur in the properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes in systems can be quantified and measured. Mathematics is essential for accurately measuring change.

d. Different systems of measurement are used for different purposes. An important part of measurement is knowing when to use which system.

PRIMARY STANDARD A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Ask a question about objects, organisms, and events in the environment.

b. Plan and conduct a simple investigation.

c. Employ simple equipment and tools to gather data and extend the senses.

d. Use data to construct a reasonable explanation.

e. Communicate investigations and explanations.

2. Understandings about Scientific Inquiry

c. Simple instruments such as magnifiers, thermometers, and rulers provide more information than using only senses.

PRIMARY STANDARD B: PHYSICAL SCIENCE

1. Properties of Objects and Materials

a. Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools such as rulers, balances, and thermometers.

b. Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials.

c. Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.

2. Position and Motion of Objects

a. The position of an object can be described by locating it relative to another object or the background.

b. An object's motion can be described by tracing and measuring its position over time.

c. The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

3. Light, Heat, Electricity, and Magnetism

a. Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object.

b. Heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another. Heat can move from one object to another by conduction.

PRIMARY STANDARD E: SCIENCE AND TECHNOLOGY

2. Understandings about Science and Technology

a. People have always had questions about their world. Science is one way of answering questions and explaining the natural world.

b. People have always had problems and invented tools and techniques to solve problems. Trying to determine the effects of solutions helps people avoid some new problems.

e. Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

Overview

TOPIC	DESCRIPTION	ACTIVITIES	TIME	PAGE
What Is Energy?	Students learn what energy does and are introduced to common forms of energy.	1-3	20 minutes	8
The Energy Within	Students explore how our bodies use energy.	4	10 minutes	9
All Living Things Get Energy From Food	Students learn how our bodies get energy from food.	5-6	30 minutes	9
Growing Plants	Experiment to show that plants get their energy from sunlight.	Optional Activity 1	varies (long term)	10
The Energy Around You	Students discuss the ways that people use energy in their lives.	Supplemental Activity 1	30 minutes	10
Our Senses	Students learn about the five senses and how we use them.	7	15 minutes	10
Simple Tools	Students use simple tools to measure length and mass using English and metric systems.	8-9	40 minutes	11
Exploring Motion	Students use simple tools to learn more about objects and explore motion as a form of energy.	10-20	4 hours and 10 minutes	11
States of Matter	Students learn about the states of matter.	21	15 minutes	15
Solids and Liquids	Students measure volume using the metric system and explore properties of solids.	22-25	1 hour and 5 minutes	16
Heat Is Energy	Students measure the temperature of liquids and explore the properties of heat.	26-29	1 hour and 20 minutes	17
Light Is Energy	Students learn that light is a form of energy that can be converted into other forms of energy and explore properties of light.	30-36	2 hours and 40 minutes	18
Sound Is Energy	Students learn that sound is a form of energy, explore properties of sound, and make instruments.	37-41	1 hour and 30 minutes	21

Teacher Guide

HANDS-ON EXPLORATIONS, TEACHER DEMONSTRATIONS AND STUDENT WORKSHEETS INTRODUCE PRIMARY STUDENTS TO THE BASIC CONCEPTS OF SCIENCE AND ENERGY.

Students use their senses and simple scientific tools—rulers, tape measures, thermometers, balances, and volumetric containers—to develop a basic understanding of the scientific method and energy through hands-on explorations. *NOTE: These activities are designed for K–4 students. Many require reading skills. For younger students with limited reading skills, it is suggested that the teacher have an aide, parent helper, or upper elementary student at the center for center-based activities.*

CONCEPTS

- Energy is part of everything that occurs. Energy makes change. Energy is the ability to do work (change).
- Energy is evidenced by heat, light, motion, sound, growth, and electricity.
- Living things need energy to survive. Living things get energy from the food they eat. The energy for living things comes from the sun.
- Our bodies use energy for many things, such as growing, moving, seeing, hearing, feeling, pumping blood, digesting food, thinking, breathing, and eliminating wastes.
- We can learn about things such as energy by using our five senses.
- Simple tools can help us learn more about our world and energy.
- Different substances have different characteristics and behave in different ways.
- We can sort substances according to like and different characteristics.
- Matter exists in three basic states—solid, liquid, and gas.

TIME

Two–six weeks depending on skill level of the students and the amount of time each day allotted to the unit.

PROCEDURE

Step One—Preparation

- Familiarize yourself with the **Teacher** and **Student Guides**, and with the equipment in the kit.
- Make a day-by-day schedule for the unit according to the skill level of your students, the time you can allot to the activities each day, and the activities you want to conduct. Each activity is explained in detail beginning on the next page, with the materials needed and estimated time for completion.
- Make transparencies of the masters you want to use on pages 24-32.
- Collect the materials that are not included in the kit, listed on page 23.
- Label the five large plastic balls A - E with a permanent marker, in any order. Label the small plastic ball with a P and the metal ball with an M. Label the Happy/Sad balls H and S with white-out. The H ball will bounce.

What Is Energy?

Energy is the ability to do work, the ability to make a change. Everything that happens in the world involves the exchange of energy in some way, 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; 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—by the forms it takes, by what it does, by the changes it makes, and by the effects we can see or feel or measure.

What Energy Does: Energy is recognized in the following ways (see pages 34-37):

- Energy is light; energy produces light; the movement of energy in transverse waves or rays; radiant energy.
- Energy is heat; energy produces heat; the movement of atoms and molecules within substances; thermal energy.
- Energy is sound; energy produces sound; the back-and-forth vibration of substances in longitudinal waves.
- Energy is motion; energy produces motion; kinetic energy.
- Energy is growth; energy is required for cells to reproduce; chemical energy stored in the bonds of nutrients.
- Energy is electricity to run technology; the movement of electrons from atom to atom.

Forms of Energy: Energy is recognized in many forms, all of which are potential or kinetic (see page 33 for detailed explanation):

- Thermal Energy (Heat)
- Mechanical Energy (Motion)
- Chemical Energy
- Electrical Energy (Electricity, Lightning)
- Nuclear Energy
- Radiant Energy (Light, X-rays)
- Sound (Motion)

ACTIVITIES 1, 2 & 3: WHAT IS ENERGY? (20 MINUTES)

Objective: To learn what energy does: heat, light, motion, sound, growth, electricity.

- Introduce energy as the topic of discussion and have students brainstorm to make a list of the things energy does. Write the ideas on the board.
- Distribute the Student Guides to the students and have them write their names on the covers.
- **Go to ACTIVITY 1 of the Student Guide**. Discuss the things energy does and lead the students to categorize the list on the board according to the pictures. Many of the things listed will fall into more than one category.

  A television, for example, produces sound, light, heat, and motion, all powered by electricity.

- **Go to ACTIVITY 2 of the Student Guide**. Discuss each picture with students, explaining the additional things energy does in each picture, for example:

  The sun produces light and other rays we can't see. The sun's energy produces heat when it touches things on or near Earth.

  The lightbulb produces light and heat.

  The matches produce light, heat and motion, as well as some sound.

  The flashlight produces light and some heat, powered by electricity from batteries.

- **Go to ACTIVITY 3 of the Student Guide**. Have students lead the discussion of the pictures and the things energy does.

The Energy Within

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

ACTIVITY 4: BODIES USE ENERGY (10 MINUTES)

Objective: To learn how our bodies use energy.

- Have students close their eyes, stay very quiet, and hold very still. Tell them to think of ways their bodies are using energy.
- **Go to ACTIVITY 4 of the Student Guide**. As a group, or individually, have students label or explain each of the numbers. Review with students. See answers on page 38.
- Measure and graph student height and weight once a month throughout the year to show growth.

All Living Things Get Energy From Food

All living things get their energy from nutrients produced by plants. All of the energy in nutrients originally came from the sun. Plants absorb the sun's radiant (light) energy 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 chemical energy in food is measured in calories. The packaging for many foods lists the number of calories—the amount of energy—that the food contains per serving.

ACTIVITIES 5 & 6: FOOD HAS ENERGY FROM THE SUN (30 MINUTES)

MATERIALS NEEDED: Various food packages with nutrition information.

Objective: To learn how our bodies get the energy they need.

- Discuss how living things get the energy they need to survive, grow, and do the things they do from the food that they eat.
- **Go to ACTIVITY 5 in the Student Guide**. Have the students complete the worksheet by drawing lines from the consumers to the foods that they eat. Review. See answers on page 38.
- Discuss how all of the energy in food originally came from the sun.

- **Go to ACTIVITY 6 in the Student Guide**. Have the students complete the worksheet by drawing arrows from the sun through the food chain to the boy. Review. See answers on page 38.
- Sing the **Food Chain Song** with the students found on page 23 of the **Teacher Guide**. Have the students draw pictures illustrating the song.
- Show the students several food packages with the number of calories indicated and explain that calories are a measure of the amount of energy in the foods.

OPTIONAL ACTIVITY: GROWING PLANTS WITH AND WITHOUT SUNLIGHT

MATERIALS NEEDED: Seeds and planters or small plants.

Objective: To learn that plants get their energy from the sun in the form of light.

- Have students germinate seeds or grow small plants with and without sunlight to demonstrate that plants get the energy they need to live and grow from the sun.

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.

SUPPLEMENTAL ACTIVITY: USING ENERGY TO DO WORK (30 MINUTES)

MATERIALS NEEDED: See Today in Energy activity booklet included in the kit for materials and preparation of this activity.

Objective: To learn ways that people use energy in their lives.

- Have the students make a list of all the ways they use energy every day, either as a group or individually. Discuss.
- Conduct the ***Today in Energy*** activity with the students.

Our Senses

Living creatures use all of their senses to survive and to learn more about their world. Scientists use their senses to learn new things about the world and the things in the world. Whenever we use our senses there is a transformation of energy. Our eyes see because reflected light energy stimulates cells at the back of our eyes, sending electrical messages to our brains. Our ears hear because vibrating air molecules make our eardrums and small bones in our ears vibrate, sending electrical signals to our brains. Our noses and tongues respond to chemical reactions. Our skin feels changes in heat and motion.

ACTIVITY 7: THE FIVE SENSES (15 MINUTES)

Objective: To learn about the five senses and how we use them.

- **Go to ACTIVITY 7 of the Student Guide**. Discuss the five senses and how people use their senses to learn about the world. Discuss the difficulties people encounter when they don't have the use of all of their senses. Discuss how energy is transformed whenever we use our senses.

Simple Tools

People use tools to expand their senses and learn more about the world and about energy. Measuring tools give scientists and others ways to compare and categorize things in the world. We can measure the size of objects and the distance they move with rulers and tape measures. We can measure the mass of objects and substances with balances. We can measure the volume of liquids with beakers and graduated cylinders. We can measure the temperature of substances with thermometers. There are many scales for measurements. Scientists use the metric scale. People in the United States often use other scales. It is important to understand and be able to use several scales of measurement.

ACTIVITY 8: MEASURING LENGTH (10 MINUTES)

MATERIALS NEEDED: New pencils, new crayons.

Objective: To learn how to measure length in English and metric measurement.

- Use Transparency 1 (page 24) to show students how length is measured in inches and centimeters.
- **Go to ACTIVITY 8 of the Student Guide**. Have students practice measuring the length of objects in inches and centimeters. Tell them to draw a line completely through the ruler on the worksheet, then record the length of the objects in both centimeters and inches.

ACTIVITY 9: MEASURING MASS (30 MINUTES)

MATERIALS FROM KIT: Balance with masses.

MATERIALS NEEDED: 20 crayons.

Objective: To learn how to measure mass using a balance.

- Use Transparency 2 (page 25) and the balance itself to show students the parts of a balance and to explain how a balance works.
- Use Transparency 3 (page 26) and the masses themselves to show students the various masses in the balance drawer. Explain that a gram is a measure of mass used by scientists.
- **Go to ACTIVITY 9 of the Student Guide**. Have the students in groups of five practice using the balance by finding the mass of 1, 5, 10, and 20 crayons as shown on the worksheet. Each student should record the number of each mass used in the column on the right. *(Answers will vary.)*

Using Our Senses and Simple Tools to Explore Motion

We can use our senses and simple tools to learn about objects and their motion. With our eyes, we can observe color, shape, patterns, texture, finish, etc. With our hands we can feel shape, temperature, texture, hardness, weight, etc. See page 34 for a detailed explanation of the scientific concepts of motion.

ACTIVITY 10: FIVE BALLS: OBSERVING AND MEASURING SIZE (30 MINUTES)

MATERIALS FROM KIT: Balls A, B, C, D, E, 5 rulers, 5 measuring tapes.

Objective: To use our senses and simple tools to learn more about objects.

- Set up a center with the five similar plastic balls (labeled A, B, C, D, E), five rulers and five tape measures.

- **Go to ACTIVITY 10 in the Student Guide**. Explain the worksheet to the students. Under the **I See** section, the students should describe the balls just using their eyes. They should touch the balls to complete the **I Feel** section. Demonstrate how to measure the circumference of the balls using the tape measure and the diameter of the balls using the ruler. It is helpful in measuring the diameter to place the ruler against a wall, and the ball in the groove of the ruler touching the wall.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the results, comparing and contrasting the characteristics of the five balls.

ACTIVITY 11: FIVE BALLS: MEASURING MASS (30 MINUTES)

MATERIALS FROM KIT: Balls A-E, balance, masses.

Objective: To learn more about objects by determining their mass.

- Set up a center with five plastic balls A-E and the balance with weights.
- **Go to ACTIVITY 11 in the Student Guide**. Explain the worksheet to the students. The students should number the balls from heaviest to lightest in the prediction column on the left, write the actual masses of the balls in the square on the right side of the balance, then number the results in the results column on the right.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class.

ACTIVITY 12: FIVE BALLS: SINK OR FLOAT (20 MINUTES)

MATERIALS FROM KIT: Balls A-E, plastic container.
MATERIALS NEEDED: Water.

Objective: To learn more about objects by determining if they sink or float.

- Set up a center with five plastic balls A-E and a plastic container with 300 ml of water.
- **Go to ACTIVITY 12 in the Student Guide**. Explain the worksheet to the students. The students should predict if the balls will sink or float, conduct the experiment and record the results, then draw on the pictures of the containers at the bottom of the page how far each of the floating balls sank into the water. Make sure the students carefully place the balls into the containers rather than dropping them. Check the foam ball after each group to squeeze out any water.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class.

ACTIVITY 13: FIVE BALLS: MEASURING BOUNCE (20 MINUTES)

MATERIALS FROM KIT: Balls A-E, 5 rulers.

Objective: To learn more about objects by measuring how high they bounce.

- Set up a center with five plastic balls A-E and five rulers.
- **Go to ACTIVITY 13 in the Student Guide**. Explain the worksheet to the students. The students should predict how the balls will bounce, numbering them from 1-5 with 1 as the highest. Demonstrate how to hold the ruler upright and drop the ball from the top of the ruler, having a helper measure how high the ball bounces. The students should record the height of the bounce in both centimeters and inches, then number the balls in the column on the right.

- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class.

ACTIVITY 14: FIVE BALLS: MEASURING SOUND (20 MINUTES)

MATERIALS FROM KIT: Balls A-E, 5 rulers.

Objective: To learn more about objects by comparing the sound they make when dropped.

- Set up a center with five plastic balls A-E, and five rulers.
- **Go to ACTIVITY 14 in the Student Guide**. Explain the worksheet to the students. The students should predict the loudness of the balls when they bounce, numbering the balls from 1-5 with the loudest ball as 1. Explain that there are sound meters that can scientifically measure the loudness of sound, but that they are using a more subjective test and that there may be disagreements within the group. Give them suggestions such as conducting several trials, determining the softest sound first, or comparing two balls at a time.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class. Discuss the difficulty of subjective testing compared to objective measurable testing. Discuss how the potential energy of the balls held in the air is transformed into kinetic (motion) energy as the balls fall (see page 34). When the balls hit the table, some of the motion energy is transformed into sound.

ACTIVITY 15: FIVE BALLS: MEASURING ROLL (20 MINUTES)

MATERIALS FROM KIT: Balls A-E, 5 rulers, 5 tape measures.

MATERIALS NEEDED: 5 thin books of identical thickness.

Objective: To learn more about objects by measuring how far they roll.

- Set up a center with five plastic balls A-E, five rulers, five measuring tapes, and five thin books.
- **Go to ACTIVITY 15 in the Student Guide**. Explain the worksheet to the students. The students should predict how the balls will roll, numbering the balls from 1-5 with the ball rolling the farthest as 1. Demonstrate how to make a ramp with the rulers and books. (It is suggested that this activity be conducted on carpet so the balls don't roll too far.) The students should record the distance each ball rolls in centimeters and inches, then number the result data in the right column.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class. Explain that gravity is the force giving the balls energy to move and that friction is the force slowing down the balls. Discuss why there might be more friction between some of the balls and the carpet than with others (see page 34).

ACTIVITY 16: HAPPY/SAD BALLS: OBSERVING & MEASURING (30 MINUTES)

MATERIALS FROM KIT: Balls H & S, 2 rulers, 2 tape measures, balance, bowl.

MATERIALS NEEDED: Water.

Objective: To learn about similar objects by observing and measuring characteristics.

- Set up a center with the happy/sad balls labeled H and S, two rulers, two measuring tapes, balance with masses, and a 400 ml beaker with 300 ml of water.
- **Go to ACTIVITY 16 in the Student Guide**. Explain the worksheet to the students.

- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the class, comparing and contrasting the characteristics of the balls. *(The balls are made of different materials. The only difference the students should be able to notice at this point is that the sad ball is slightly heavier.)*

ACTIVITIES 17 & 18: HAPPY/SAD BALLS: ROLLING & BOUNCING (30 MINUTES)

MATERIALS FROM KIT: Balls H & S, 2 rulers, 2 tape measures.

MATERIALS NEEDED: 2 thin books.

Objective: To learn about and measure the motion of similar balls and graph the results.

- Set up a center with the happy/sad balls labeled H and S, two rulers, two measuring tapes, and two thin books.
- **Go to ACTIVITY 17 in the Student Guide**. Explain the worksheet to the students. Explain how repeated trials can give more reliable results.
- Have the students in groups of five go to the center and complete the worksheet.
- **Go to ACTIVITY 18 in the Student Guide**. Have the students graph the results from Activity 17.
- Review the worksheets with the class, comparing and contrasting the characteristics of the balls. Note that more of the energy in the sad ball is converted into sound.

ACTIVITY 19: TEACHER DEMONSTRATION: HAPPY/SAD BALLS: HEAT & BOUNCING (20 MINUTES)

MATERIALS FROM KIT: H & S balls, ruler, plastic containers.

MATERIALS NEEDED: Ice water, very hot water (almost boiling), spoon or tongs.

Objective: To learn how heat energy affects the bounce of objects.

- Set up a demonstration center that all of the students can see with the balls labeled H & S, a container of very hot water, a container of ice water, a ruler, and a spoon or tongs.
- **Go to ACTIVITY 19 in the Student Guide**. Explain to the students that you will be demonstrating the experiment because of the danger of hot water. Explain that the objective of the experiment is to determine the effect of adding and taking away heat energy on the bouncing ability of the balls (see page 34).
- Holding the ruler vertically, drop each of the balls three times from the top of the ruler and measure how high they bounce. Have the students record the measurements.
- Place the balls in the container of ice water for one minute, then repeat the trial three times for each ball. Have the students record the measurements.
- Place the balls in the very hot water for two minutes. Remove the balls one at a time with the spoon or tongs. Repeat the trials with the hot balls and have the students record the measurements.
- Discuss the results with the students. Explain that the balls bounced higher when they were hot because they contained more energy and that some of the heat energy was changed into motion energy (see page 35).

ACTIVITY 20: METAL & PLASTIC BALLS: OBSERVING & MEASURING (30 MINUTES)

MATERIALS FROM KIT: M & P balls, tape measures, rulers, balance, containers.

MATERIALS NEEDED: Warm and ice water.

Objective: To compare and contrast the characteristics of plastic and metal objects.

- Set up a center with the metal and plastic balls labeled M and P, two rulers, two tape measures, the balance with masses, a 400 ml beaker with 300 ml of water, a 400 ml beaker with ice water, and a 400 ml beaker with warm water (about 100°F).
- **Go to ACTIVITY 20 in the Student Guide**. Explain the worksheet to the students.
- Have the students in groups of five go to the center and complete the worksheet.
- Review the worksheet with the students. Explain that both of the balls in the beginning are at the same temperature, as is every non-living, non-electrical object. Some substances, such as metals, conduct (or move) energy better than others. Substances, such as plastics, that don't conduct energy well are called insulators. The metal ball feels colder because it conducts the heat in your hands away from your hands. Have the students feel objects made of different materials in the classroom to see if they are conductors or insulators (see page 35).

States of Matter

Matter exists in three basic states—solids, liquids, and gases. Solids have a definite size and shape. Liquids have a definite size but take the shape of the container they are in, held in the container by the force of gravity. Gases have no definite size or shape, but they fill the space in which they are contained, because their molecules are so far apart that gravity has little effect on them. Gravity is defined as the force of attraction between objects. For a more detailed explanation, see the background information on heat on page 35.

ACTIVITY 21: TEACHER DEMONSTRATION: STATES OF MATTER (15 MINUTES)

MATERIALS NEEDED: Clear pan, heat source, ice cubes, pot holder, perfume.

Objective: To learn about the states of matter by observing ice turn to water then vapor.

- Set up a demonstration center with a clear glass heat-resistant pan, a heat source such as a hot plate or bunsen burner, several ice cubes, pot holder, and a few drops of perfume.
- **Go to ACTIVITY 21 in the Student Guide**. Explain the demonstration to the students.
- Place the ice cubes in the pan and explain that the ice cubes are solids—their shape remains the same in any container.
- Place the pan on the heat source and slowly melt the ice cubes. Explain that you are adding heat energy to the ice cubes. Remove the pan from the heat source and demonstrate how the water stays in the pan but can change its shape if the pan is tilted. The water is a liquid.
- Place a few drops of perfume in the pan and place it back on the heat source. Allow the water to boil until a noticeable amount has turned into steam, escaped the pan, and filled the room. The students all over the room should be able to smell the perfume molecules that have attached themselves to the steam, or water vapor molecules. Explain that adding energy to the water molecules made them bounce against each other with enough force to break the bonds that were holding them together (see page 35).

Solids and Liquids

We can measure some solids with regular shapes with rulers and determine the amount of space they take. Solids are measured in cubic centimeters (cc). With irregularly-shaped solids, we can determine their volume by placing them in a liquid and determining the amount of the liquid that is displaced. The volume of liquids is measured using several scales. In the United States, sometimes we use ounces, cups, pints, quarts, and gallons. Scientists use metric measurements such as milliliters and liters to measure the volume of liquids. One cubic centimeter (cc) is equal to one milliliter (ml).

ACTIVITIES 22 & 23: MEASURING LIQUIDS (20 MINUTES)

MATERIALS FROM KIT: Pitcher, 100 ml beaker, 100 ml graduated cylinder.

MATERIALS NEEDED: Water.

Objective: To learn how to measure liquids in English and metric measurements.

- o Set up a center with a pitcher of water, 100 ml beaker, 100 ml graduated cylinder.
- o Use Transparencies 4–5 (pages 27-28) to demonstrate how to measure the volume of liquids.
- o **Go to ACTIVITY 22 in the Student Guide**. Have the students complete the worksheet by coloring the pictures of the beakers to indicate the volume.
- o **Go to ACTIVITY 23 in the Student Guide**. Explain the procedure to the students. Have the students in groups of five visit the center and complete the worksheet.
- o Review the worksheet, emphasizing that liquids have definite volume, but not definite shape.

ACTIVITY 24: VOLUME OF SOLIDS (30 MINUTES)

MATERIALS FROM KIT: Clay, 400 ml beaker, pitcher.

MATERIALS NEEDED: Water.

Objective: To learn that a pliable solid has the same volume irrespective of its shape.

- o Set up a center with a pitcher of water, a lump of clay, and a 400 ml beaker.
- o **Go to ACTIVITY 24 in the Student Guide**. Explain the worksheet to the students—that they will find the volume of the piece of clay by measuring how much water is displaced (how much the water in the beaker rises when the clay is added). Explain that solids are measured in cubic centimeters and liquids in milliliters and that one cubic centimeter equals one milliliter.
- o Give the students the following instructions for the center:
  - ♦ fill the beaker with 200 ml of water, then draw a line on the top picture A to show the exact volume of water in the beaker.
  - ♦ form the clay into a ball and place in the beaker of water.
  - ♦ draw a line on the top picture B to show the volume of water in the beaker with the clay.
  - ♦ remove the clay and flatten it to fit the bottom of the beaker.
  - ♦ repeat the experiment and record the results on the bottom pictures.
  - ♦ calculate the volume of the clay in each experiment, using the formula B – A = Volume of Clay. *(Younger students may need assistance with this calculation. The important concept is that the clay contains the same amount of matter regardless of its shape.)*
- o Have the students go to the center in groups of five to complete the worksheet.

- Review the worksheet, emphasizing that the clay will have the same volume, regardless of its shape, because it has the same amount of matter. The clay is considered a solid because it retains its shape until it is changed by force.

ACTIVITY 25: TEACHER DEMONSTRATION: SOLIDS & LIQUIDS (15 MINUTES)

MATERIALS FROM KIT: balance, 2–100 ml beakers, water bottle, plastic container.
MATERIALS NEEDED: Ice cubes, hot water.

Objective: To learn that the mass of substances stays the same irrespective of state.

- Set up a demonstration center with the balance, 2–100 ml beakers, flip top bottle of water, ice cubes, bowl of hot water.
- **Go to ACTIVITY 25 in the Student Guide**. Explain the worksheet to the students––does the mass of ice change when it melts?
- Place two ice cubes into a 100 ml beaker. Have the students predict how much water the ice cubes will make when they melt by drawing a line on Picture 2.
- Place the beaker of ice into one bucket of the balance. Place the second 100 ml beaker in the other bucket. Fill this beaker with water until it balances the ice. Have the students record the volume of water in the beaker by drawing a line on Picture 4.
- Place the beaker with the ice cubes into a bowl of hot water to speed up melting. Once the ice has melted, have the students record the volume on Picture 3.
- Place the beakers back into the balance. Do they still weigh the same? Have the students compare the volumes of Pictures 3 and 4. Are they equal? How well did the students predict?

Heat is Energy

All substances contain heat, the internal energy in substances. We can measure the temperature of substances—the average amount of heat energy—using thermometers. 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. For more detailed information about heat, see page 35.

ACTIVITIES 26 & 27: USING A THERMOMETER (30 MINUTES)

MATERIALS FROM KIT: 5 thermometers.

Objective: To learn to measure temperature in Fahrenheit and Celsius.

- Set up a center with five thermometers.
- Use Transparency 6 (page 29) to demonstrate how to measure temperature with a thermometer.
- **Go to ACTIVITY 26 in the Student Guide**. Have the students color in the tubes of the pictures to indicate the temperatures given in Fahrenheit; then, determine the equivalent Celsius reading and write it in the circles of the thermometers.
- **Go to ACTIVITY 27 in the Student Guide**. Explain the worksheet to the students, demonstrating how to gently hold the thermometer bulb between the palms of their hands.
- Have the students go to the center in groups of five to complete the worksheet.
- Review the worksheet with the students.

ACTIVITY 28: MEASURING TEMPERATURE (20 MINUTES)

MATERIALS FROM KIT: 2–400 ml beakers, 2 thermometers.

MATERIALS NEEDED: Ice water, warm water.

Objective: To learn to measure liquids with a thermometer.

- o Set up a center with two thermometers, and 400 ml beakers of ice water and warm water.
- o **Go to ACTIVITY 28 in the Student Guide**. Explain the worksheet to the students.
- o Have the students go to the center in groups of five to complete the worksheet.
- o Review the worksheet with the students. *(Was the temperature of the warm water the same for the last group as for the first? What might have made it lower?)*

ACTIVITY 29: PREDICTING AND MEASURING TEMPERATURE (30 MINUTES)

MATERIALS FROM KIT: 3 beakers (2–100 ml & 1–400 ml), 2 pitchers, 2 thermometers.

MATERIALS NEEDED: Warm and cold water.

Objective: To learn to predict and measure the temperature of liquids.

- o Set up a center with 2–100 ml beakers, 1–400 ml beaker, a pitcher of cold water, a pitcher of warm water, and two thermometers.
- o **Go to ACTIVITY 29 in the Student Guide**. Explain the worksheet to the students.
- o Have the students go to the center in groups of five to complete the worksheet. *(After each group, empty the 400 ml beaker and make sure the pitchers have enough warm and cold water.)*
- o Review the worksheet with the students, emphasizing that the heat lost by the warm water equaled the heat gained by the cold water.

LIGHT IS ENERGY

Light is a form of radiant energy––electromagnetic energy that 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. For more detailed information about light, see page 36.

ACTIVITY 30: TEACHER DEMONSTRATION: LIGHT IS ENERGY (30 MINUTES)

MATERIALS FROM KIT: Radiometer, 2 thermometers.

MATERIALS NEEDED: Black and white construction paper.

Objectives: To show that light is energy.

To show that light energy can be changed into motion and heat energy.

To show that the color of objects affects the amount of light energy that is absorbed and reflected.

- o Set up a demonstration center in a sunny window with the radiometer, two thermometers, and 3” x 3” squares of black and white construction paper.
- o Place the radiometer in a bright light—either in bright sun or on an overhead projector. Have the students observe the speed of the vanes spinning. *The vanes will begin to spin as the black sides of the vanes absorb the light and become warm, while the white sides reflect the light. The air molecules near the black sides absorb heat and move with more energy, giving the black sides of the vanes a push.*
- o Reduce the amount of light energy striking the radiometer by covering a small part of it with your hand. Show the students how the radiometer spins more slowly when less light energy is striking it. *If you have a very bright flashlight, you can try holding it at different angles and at different distances from the radiometer to further demonstrate the relationship between the amount of light energy striking the radiometer and the speed of its spin.*
- o **Go to ACTIVITY 30 in the Student Guide**. Explain the demonstration to the students. Have the students predict which thermometer will record the higher temperature by numbering the pictures 1 and 2, with 1 as the hotter, in the top section of the pictures.
- o Place the thermometers in the sun. Cover the bulb of one with black paper and the other with white paper. Wait five minutes. *While waiting, discuss with the students why people in tropical climates wear white, and why people feel cooler in the shade on a hot day, when the air temperature is the same as in the sun––because, in the sun, the skin is absorbing some light energy and changing it into heat.*
- o Read the temperatures and have the students record the readings on the pictures. Have the students number the thermometers 1 and 2, with 1 as the hotter in the lower part of the pictures, as indicated.
- o Discuss the worksheet with the students, explaining that the black paper absorbs light energy while the white paper reflects it. The energy from the sun is light energy and changes into heat when it is absorbed by a substance.
- o Have the students hold one hand in the sun and one away from the sun and see if they can feel a difference in temperature.
- o Vary the amount of light in the classroom and demonstrate how much better the students can see when there is more light––when more energy is reaching their eyes. *Point out that colors are harder to see as the amount of light decreases. Discuss why it is dangerous to look directly at the sun–– because our eyes will absorb too much light, turn it into heat and our eyes will burn.*

ACTIVITY 31: TEACHER DEMONSTRATION: ARTIFICIAL LIGHT (15 MINUTES)

MATERIALS FROM KIT: 2 thermometers.

MATERIALS NEEDED: Black and white construction paper, artificial light source.

Objective: To compare the energy in sunlight to the energy in artificial light.

- o Set up a demonstration center with an overhead projector or other bright artificial light, and the two thermometers with the 3” x 3” squares of black and white construction paper.
- o **Go to ACTIVITY 31 in the Student Guide**. Explain the demonstration to the students. Have the students predict whether the artificial light will provide as much energy as the sun. Will the thermometer readings be higher, lower, or the same as in the last activity?
- o Place the thermometers approximately 18 inches from the artificial light source. Cover the bulb of one with black paper and the bulb of the other with white paper. Wait five minutes. *While waiting, discuss different ways we produce artificial light––candles, lanterns, electric lights, etc. and how artificial lights make it possible for people to do things at night and in places where no sunlight reaches, such as in caves, basements, mines, and submarines.*
- o Read the temperatures and have the students record the readings on the pictures. Have the students compare the thermometer readings with the ones from the previous activity.

ACTIVITY 32: LIGHT TRAVELS IN STRAIGHT LINES (30 MINUTES)

MATERIALS FROM KIT: Flashlight, wooden spool, ruler.

Objective: To use shadows to show that light travels in a straight line.

- Set up a center with a table beside a blank wall, a flashlight, a ruler, and a wooden spool.
- **Go to ACTIVITY 32 in the Student Guide**. Explain the worksheet to the students.
- Have the students go to the center in groups of five to complete the worksheet.
- Review the worksheet with the students.
- Use Transparency 7 (Page 30) to show students that light travels in transverse waves and that visible light is only a small part of the electromagnetic (radiant energy) spectrum.
- Use Transparency 8 (Page 31) to explain the formation of shadows (areas without light). *Explain that the closer the object is to the light source, the more light is blocked by the object and the larger the shadow is. Explain that the umbra is the area where there is no light from the light source, and the penumbra is the area where there is some light because of the angle of the light. Emphasize the fact that the light travels in straight lines and cannot bend around an object.*

ACTIVITY 33: DEMONSTRATION: TRANSVERSE LIGHT WAVES (20 MINUTES)

MATERIALS FROM KIT: Slinky.

Objective: To demonstrate transverse waves using a slinky.

- Set up a long table and the slinky.
- With the teacher holding one end of the slinky at one end of the table, have each student in turn hold the other end of the slinky at the other end of the table. Have the student hold his/her end of the slinky still while the teacher moves the slinky up and down with some energy, creating crests and troughs along the length of the slinky. Explain the parts of the wave to each student.

ACTIVITY 34: LIGHT CAN BE REFRACTED (30 MINUTES)

MATERIALS FROM KIT: Pitcher, 100 ml beaker, magnifier, flashlight, ruler.

MATERIALS NEEDED: Large glass bowl, water.

Objective: To show that light waves can bend (be refracted) when they pass through a substance with a different refractive index than air.

- Fill a large glass bowl with comfortably warm water in a place where all of the students can see. Hold a pencil in the water so that the students can see how its image is distorted. Place one hand in the water so that students can see the distortion. Pour out the water and place one hand in the empty bowl so that the students can see the distortion. *Explain that the water and the glass bend the light waves because they are made of different material than the air.*
- Set up a center with a table beside a blank wall, the flashlight, magnifier, a ruler, a 100 ml beaker, and water in a pitcher.
- **Go to ACTIVITY 33 in the Student Guide**. Explain the worksheet to the students.
- Have the students go to the center in groups of five to complete the worksheet.
- Review the worksheet with the students.

ACTIVITY 35: LIGHT CAN BE REFLECTED (20 MINUTES)

MATERIALS FROM KIT: Ruler, flashlight, mirror with stand.

MATERIALS NEEDED: Full-length mirror.

Objective: To show that light can be reflected.

- o Set up a center with a flashlight, a mirror, and a ruler.
- o Make lists on the board of the things in the classroom that can reflect light and the things that don't. Discuss the properties of things that reflect light—most are flat and smooth. *Rough objects can reflect light, too, but the light is scattered because it bounces off surfaces at so many different angles that it is more difficult to notice.*
- o **Go to ACTIVITY 34 in the Student Guide**. Explain the worksheet to the students.
- o Have the students go to the center in groups of five to complete the worksheet.
- o Review the worksheet with the students.
- o If a full-length mirror is accessible, have 10–14 students form a straight line about five feet from the mirror and parallel to it, to 'see who they can see' in the mirror, depending upon the angle. By drawing a diagram of the mirror and the students, you can show how the angle of incidence equals the angle of reflection.

ACTIVITY 36: DEMONSTRATION: LIGHT CAN BE DIFFRACTED (15 MINUTES)

MATERIALS FROM KIT: Spectroscope.

MATERIALS NEEDED: Bright light source––not the sun.

Objective: To show that light can be diffracted (separated) into the colors of the spectrum.

- o Have each student look at a bright light through the spectroscope and use crayons to draw the colors they see in the same order. *Explain that white light is made of all colors and that the white light can be separated into its individual colors by a spectroscope or a prism.*

SOUND IS ENERGY

Sound is a special kind of mechanical energy; it is the back-and-forth vibration of the molecules through a substance caused by the application of a force on the substance. Sound travels in longitudinal waves–– waves in which there are compressions and expansions as the molecules vibrate back and forth. For more detailed information about sound, see page 37.

ACTIVITIES 37, 38, 39, & 40: SOUND IS ENERGY (30 MINUTES)

MATERIALS FROM KIT: 2 tuning forks, 2 metal cans, pitcher, rubber bands, mallet.

MATERIALS NEEDED: Pepper shaker, plastic wrap, water, paper.

Objectives: To introduce sound as a form of energy.

To demonstrate that sound is caused by vibrations.

- o Set up a center with 2 tuning forks, a rubber mallet, an empty metal can, a metal can covered tightly with plastic wrap held in place with a rubber band, water, paper, and a pepper shaker.
- o Have the students place their fingers lightly on the sides of their throats and hum at different pitches to feel the vibrations.

- Have the students tap their desks several times, each time with more energy, and observe that the more energy they put into their motion, the more energy is produced as sound. Their mechanical energy is changing into sound energy.
- **Go to ACTIVITIES 35-38 in the Student Guide**. Explain the worksheets to the students and demonstrate how to hold and strike the tuning forks with the mallet. *Explain that the tuning forks vibrate at different frequencies––they move back and forth, or vibrate, a number of times each second. The number of times they vibrate each second is written on the tuning fork. The number of vibrations each second determines the pitch of the sound––how high or low the sound is.*
- Have the students go to the center in groups of five to complete the worksheets.
- Review the worksheets with the students.

ACTIVITY 41: DEMONSTRATION: LONGITUDINAL WAVES (30 MINUTES)

MATERIALS FROM KIT: Slinky.

Objective: To demonstrate longitudinal waves using a slinky.

- Set up a long table with the slinky.
- With the teacher holding one end of the slinky at one end of the table, have each student in turn hold the other end of the slinky at the other end of the table. Have the student hold his/her end of the slinky still while the teacher moves the slinky forward and back along the table with some energy, creating compressions and expansions along the length of the slinky. Explain the parts of the longitudinal wave to each student.
- Use Transparency 9 (Page 32) to explain the parts of a longitudinal wave.

SUPPLEMENTAL ACTIVITY: PRODUCING & DEMONSTRATING SOUND (30 MINUTES)

Objective: To make objects that produce sound and explain them to the class.

- Have the students make musical instruments with objects they find at home, on the playground, or in the classroom. Have the students demonstrate and explain their instruments to the class. Have the students experiment with musical instruments in the music room or classroom.

MATERIALS NEEDED

Food packages with Nutrition Information
Seeds, Soil & Cups or Small Plants
New Pencils & Crayons
Warm Water
5 Thin Books of Identical Thickness
Ice Water/Very Hot Water
Spoon or Tongs
Clear Glass Pan
Heat Source - Hot Plate
Ice Cubes
Pot Holder
Perfume
White & Black Construction Paper
Artificial Light Source - Overhead
Large Clear Glass Bowl
Pepper Shaker
Plastic Wrap

MATERIALS IN KIT

Class Set of Student Guides
Balance with Masses
5 Large Plastic Balls
5 Tape Measures
6 Rulers
2 Plastic Containers
1 Set of Happy/Sad Balls
4 400-ml beakers
4 100-ml beakers
2 Pitchers
1 Flip Top Water Bottle
2 Small Balls - Plastic & Metal
2 100-ml Graduated Cylinders w/stands
1 Packet of Clay
10 Thermometers (C & F)
1 Radiometer
2 Flashlights
1 Wooden Spool
1 Slinky
1 Mirror with Stand
1 Spectroscope
2 Tuning Forks
2 Metal Cans
Mallet
Rubber Bands
Magnifier
Today in Energy Activity Booklet

FOOD CHAIN SONG

(To the tune of There's a Hole in the Bottom of the Sea)

There's a plant at the bottom of the lake
There's a plant at the bottom of the lake
There's a plant
There's a plant
There's a plant at the bottom of the lake

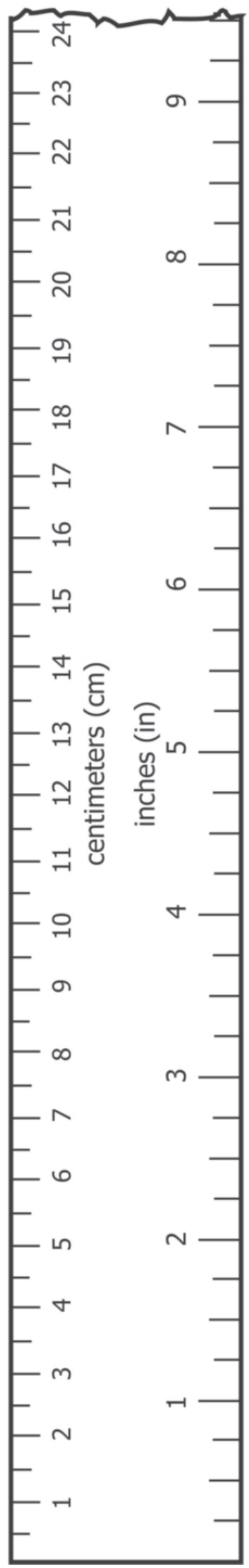
There's a leaf on the plant at the bottom of the lake...

There's a bug that eats the leaf on the plant at the bottom of the lake...

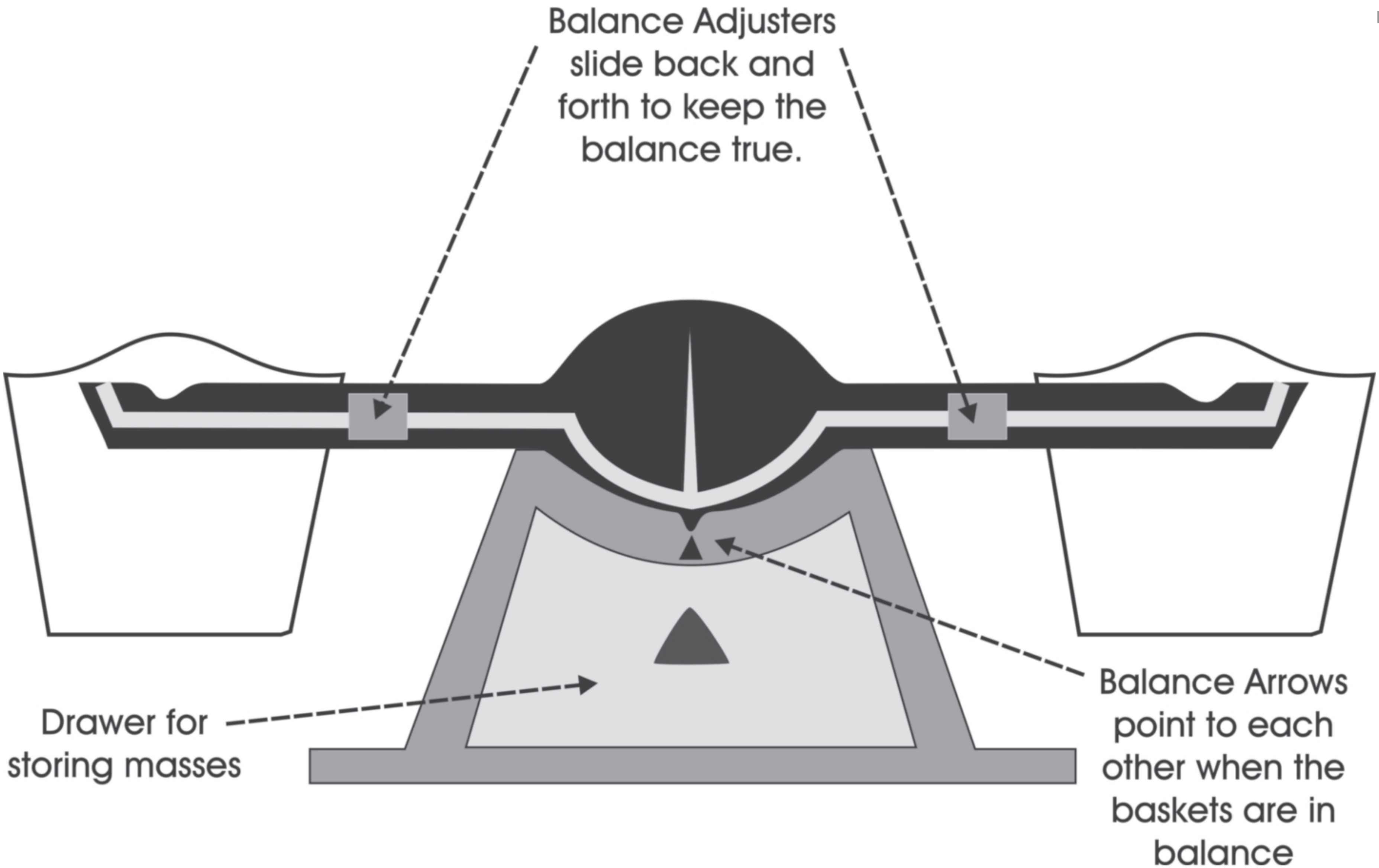
There's a fish that eats the bug that eats the leaf on the plant at the bottom of the lake...

There's a kid who eats the fish that eats the bug that eats the leaf on the plant at the bottom of the lake...

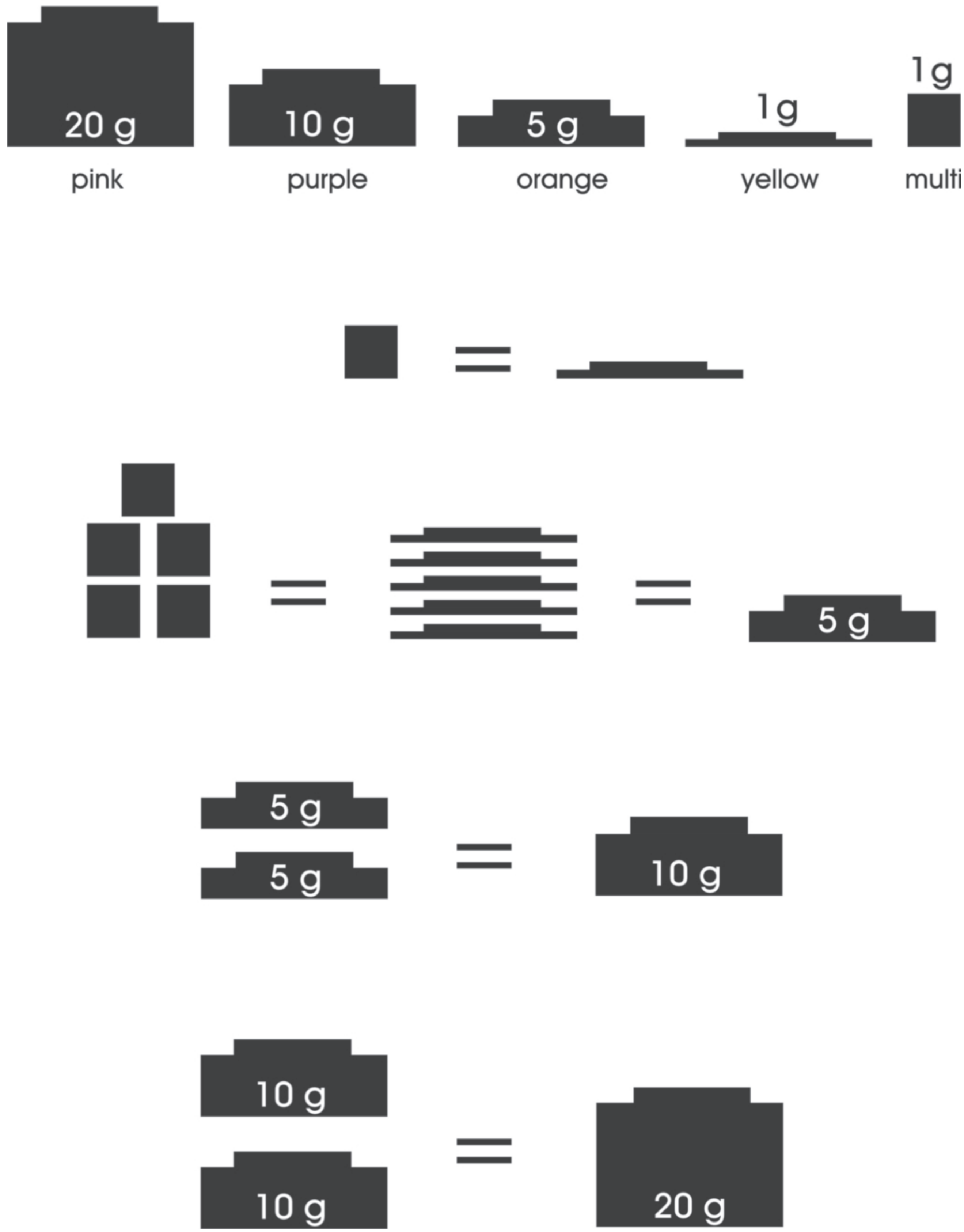
There's a bear ... *optional*


centimeters (cm)
inches (in)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1 2 3 4 5 6 7 8 9

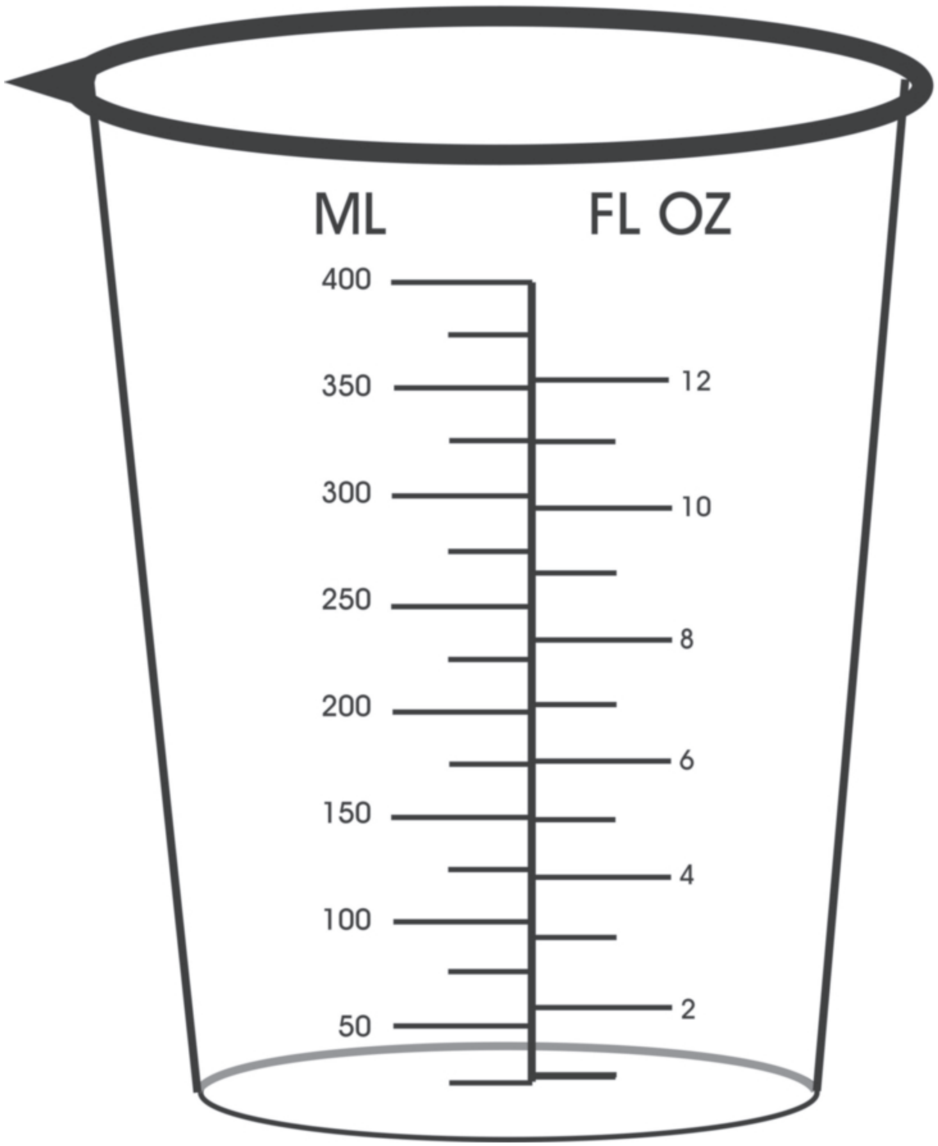
BALANCE


Balance Adjusters slide back and forth to keep the balance true.
Drawer for storing masses
Balance Arrows point to each other when the baskets are in balance

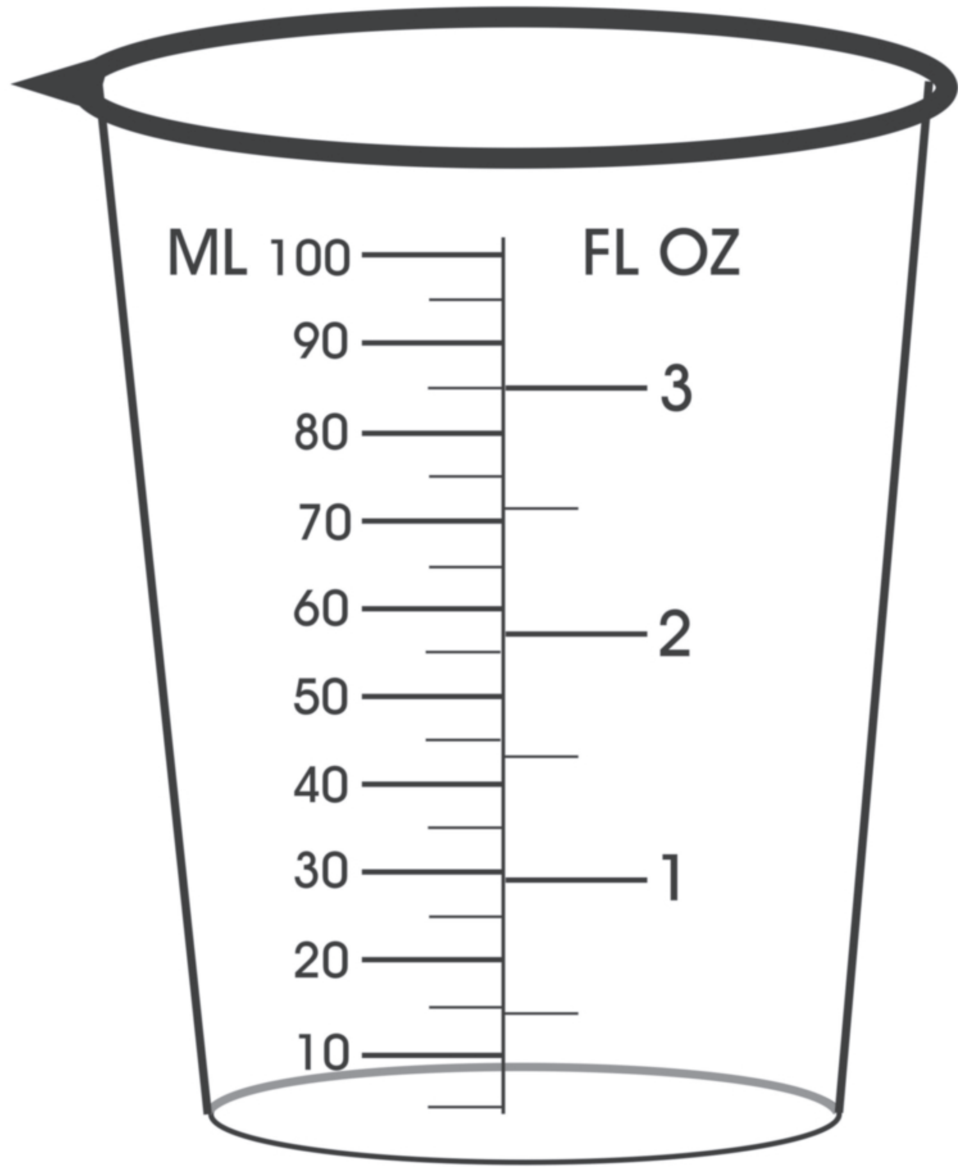
BALANCE MASSES



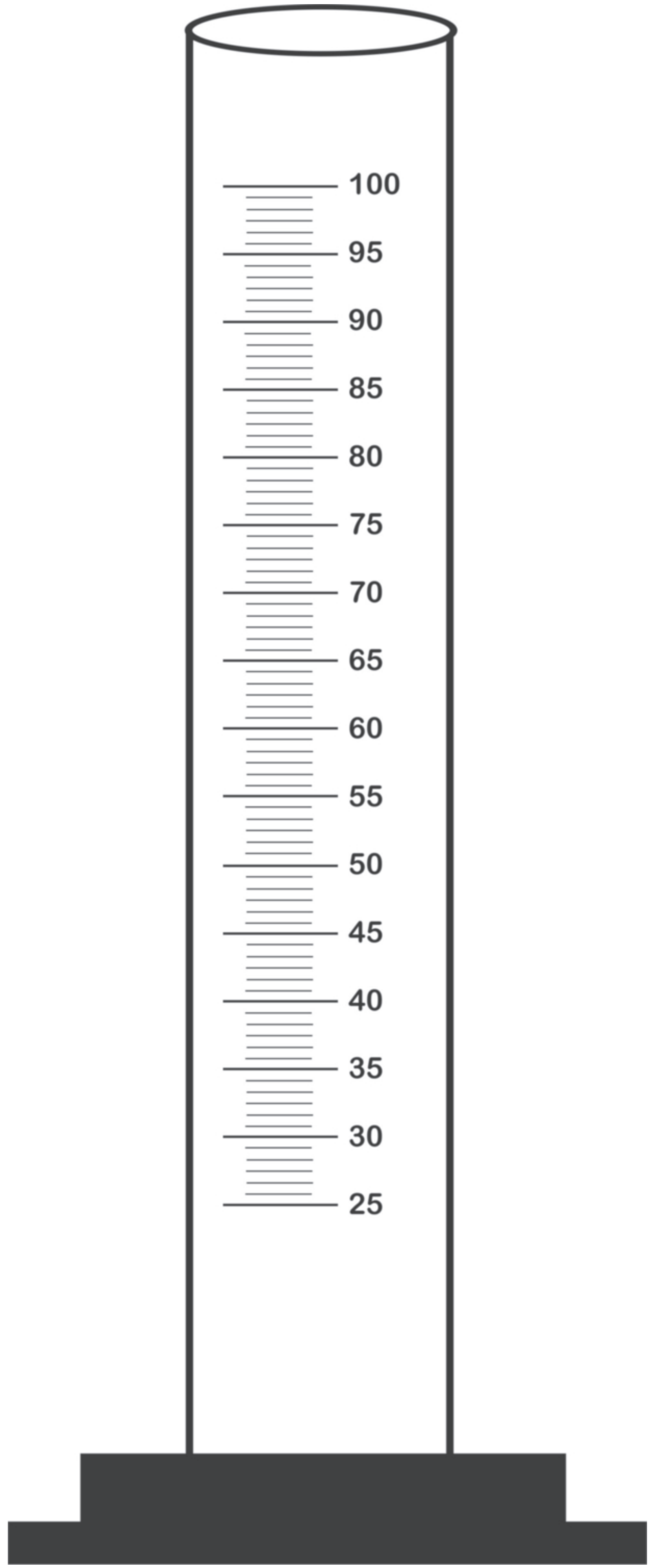
400 ML BEAKER



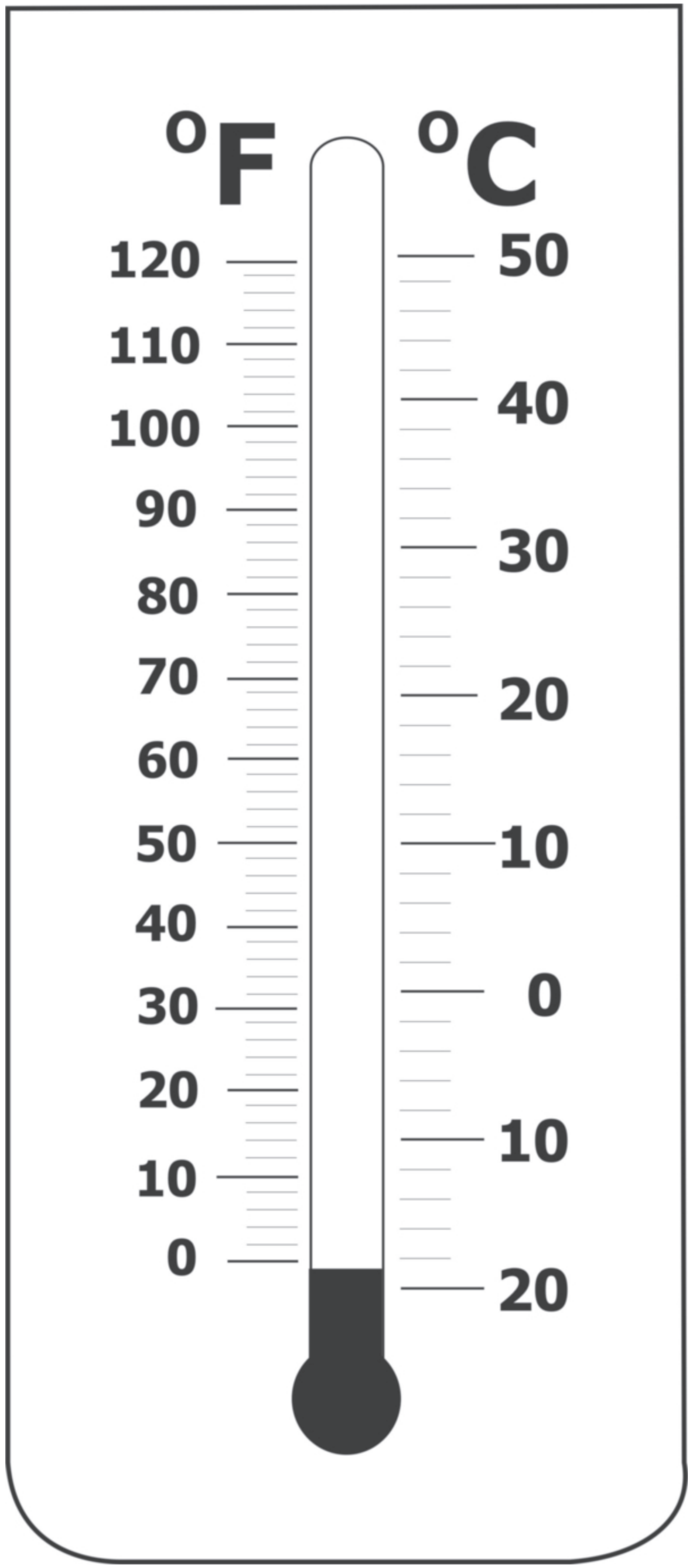
100 ML BEAKER



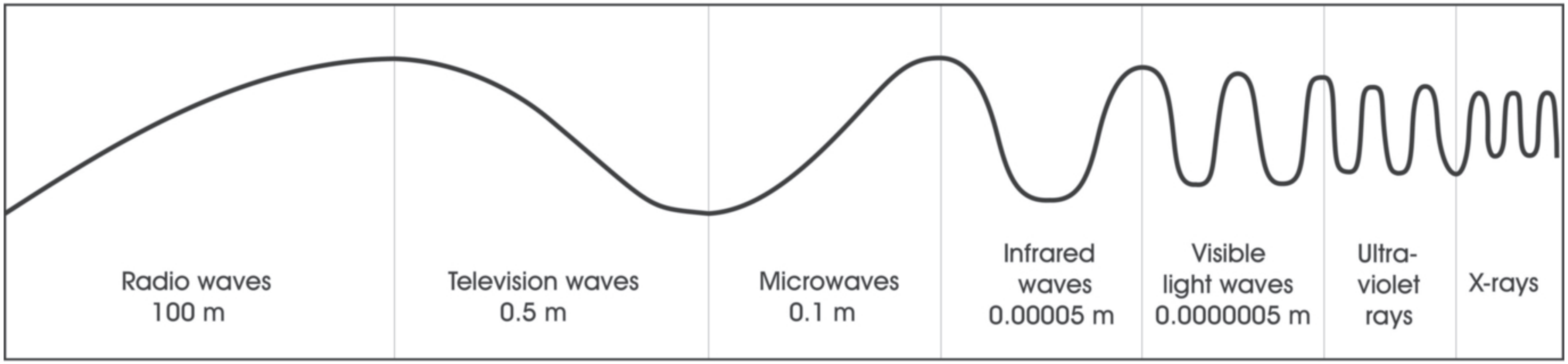
GRADUATED CYLINDER 100 ML



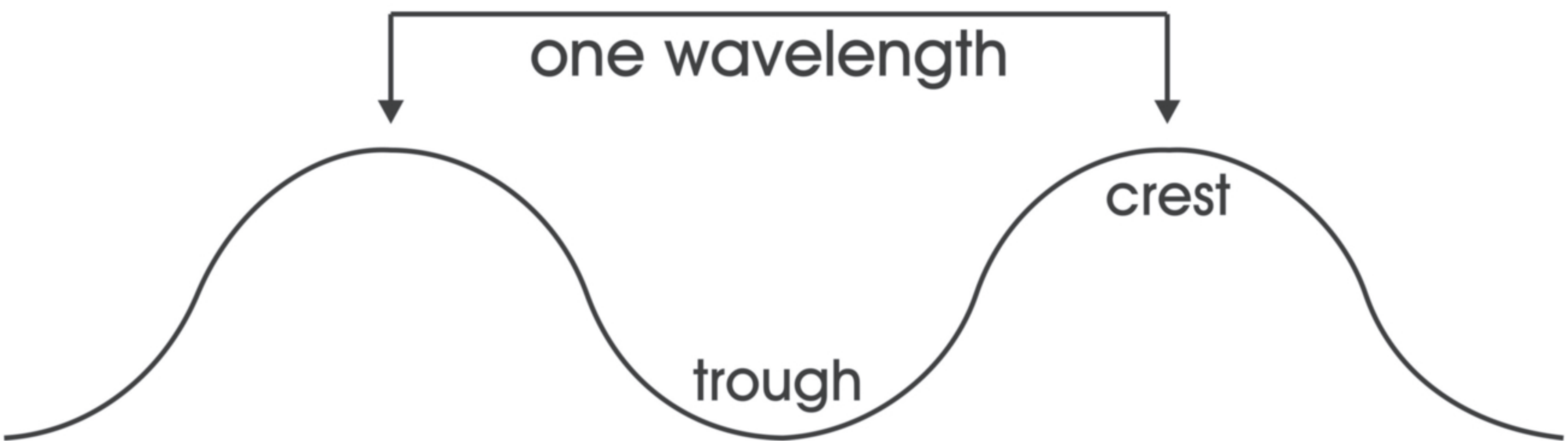
THERMOMETER FAHRENHEIT AND CELSIUS



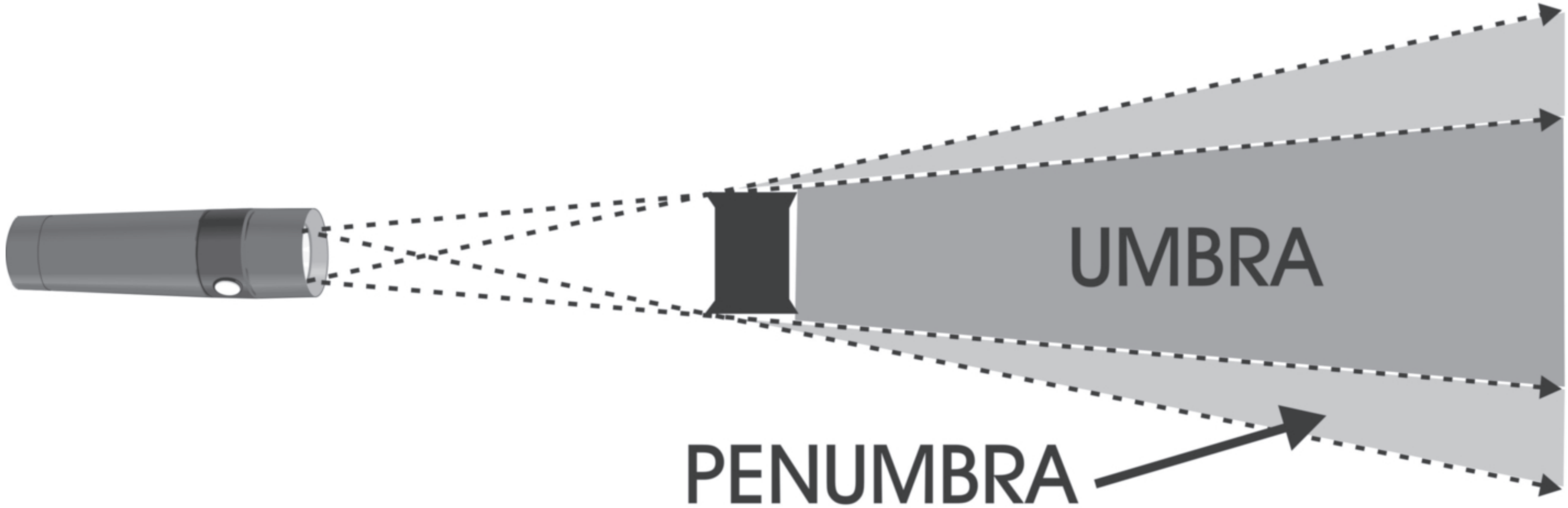
Light Energy-Transverse Waves

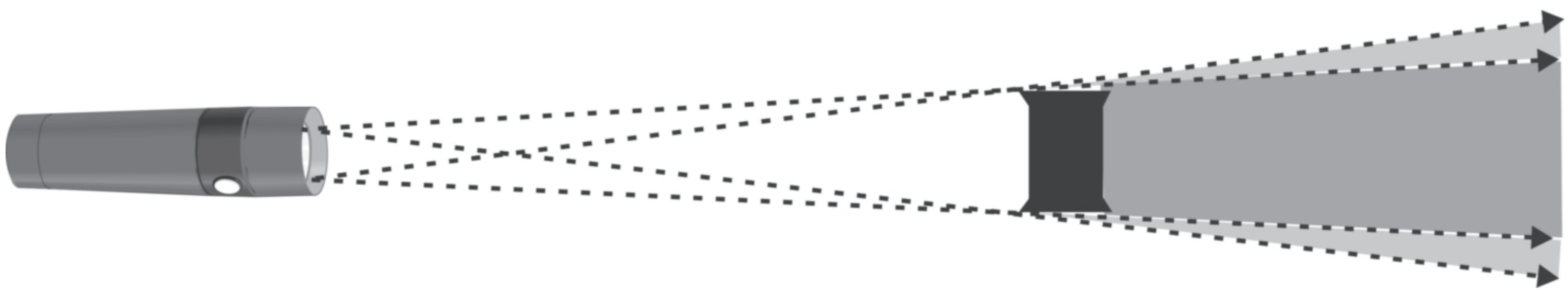


The shorter the wavelength, the more energy a wave has.

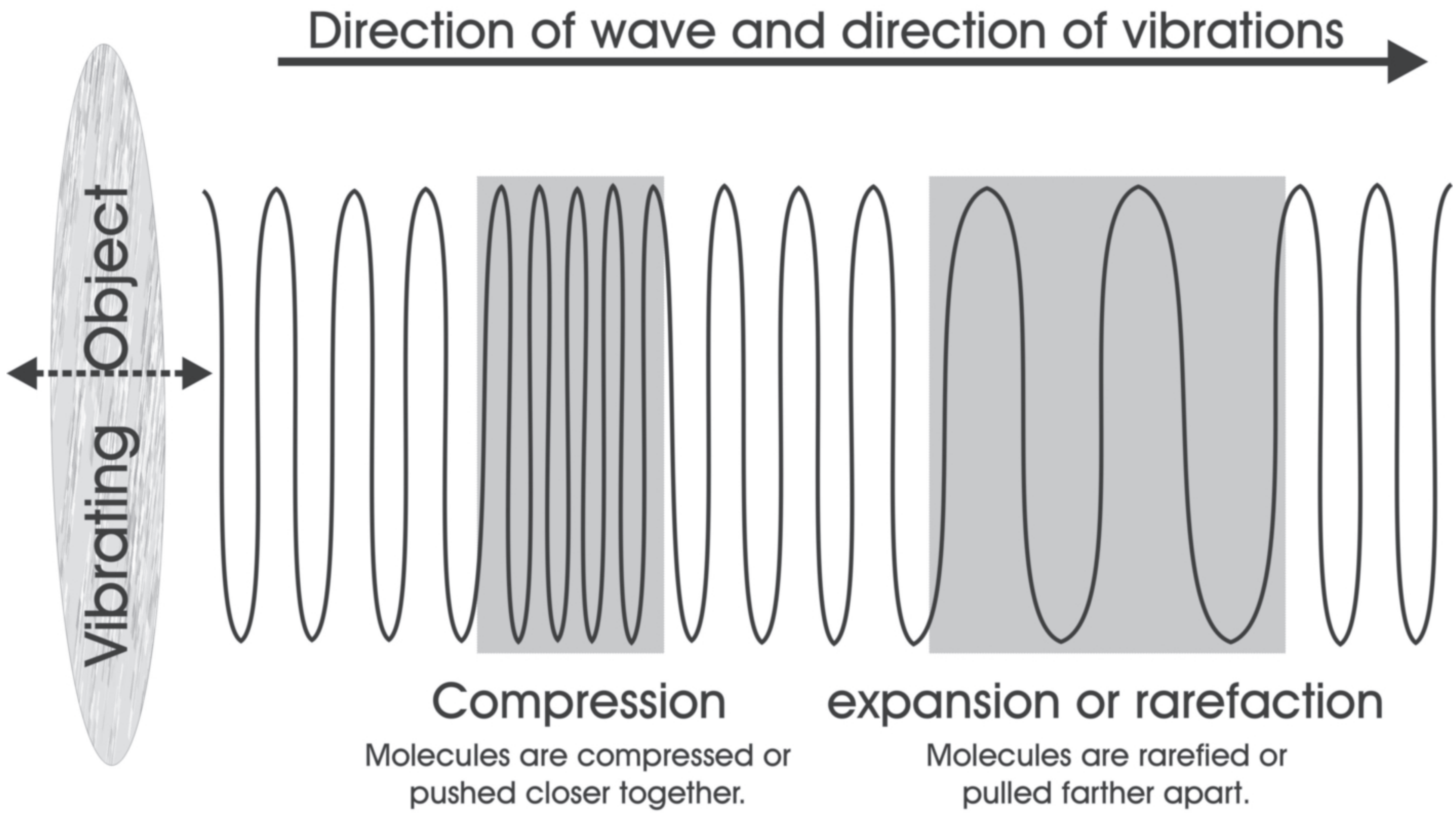


SHADOWS





LONGITUDINAL SOUND WAVE



When the vibrating object moves to the right, it pushes the molecules together. When the object moves to the left, it pulls the molecules apart.

FORMS OF ENERGY

All forms of energy fall under two categories

POTENTIAL

Potential energy is stored energy and the energy of position (gravitational).

CHEMICAL ENERGY

Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom. It is the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

STORED MECHANICAL ENERGY

Stored mechanical energy is energy stored in objects or substances by the application of a force. Compressed metal springs and stretched rubber bands are examples of stored mechanical energy.

GRAVITATIONAL ENERGY

Gravitational energy is the energy of place or position. Water held in a reservoir behind a hydropower dam is an example of potential gravitational energy. When the water in the reservoir is released to spin the turbines, it becomes motion energy.

KINETIC

Kinetic energy is motion. It is the motion of waves, electrons, atoms, molecules and substances.

RADIANT ENERGY

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

THERMAL ENERGY

Thermal energy (or heat) is the internal energy in substances. It is the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

MOTION

The movement of objects or substances from one place to another is motion. Wind is an example of motion energy.

SOUND

Sound is the movement of energy through objects or substances in longitudinal (compression/rarefaction) waves.

ELECTRICAL ENERGY

Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

MOTION

KINETIC AND POTENTIAL ENERGY: The energy of motion is called kinetic energy. All moving objects have kinetic energy. Many objects also have energy because of the place they are in—their position. The energy of place or position is called potential energy. A rock on the top of a hill has energy. It is not moving––it has no kinetic energy. But it has energy because of its position on the hill. It has potential energy. If the rock begins to roll down the hill, its energy changes. The potential energy changes into kinetic energy as it rolls. When the rock stops rolling at the bottom of the hill, it has no more kinetic or potential energy.

Potential energy is also energy that is stored in an object. When you blow up a balloon, you are putting air into it. You are also putting energy into it—potential energy. If you tie the balloon and place it on the floor, it will not move. It has no kinetic energy. But it has potential energy—stored energy. If you untie the balloon, the stored energy is released. The air rushes out in one direction. The balloon moves in the other direction. The potential energy stored in the balloon changes to kinetic energy––the energy of motion.

NEWTON'S LAWS OF MOTION: Objects move in orderly ways, in ways we can predict. They move according to laws of motion that were developed by Sir Isaac Newton and are called Newton's Laws of Motion.

INERTIA: Newton's first law is about inertia. It says that a moving object will keep moving until a force changes its motion. A force is a push or a pull. A force changes the energy level in an object. Inertia means that an object at rest––not moving––will stay that way until a force moves it. A moving object will keep moving in the same direction at the same speed until a force changes its motion.

The first part of the law is easy to understand––an object at rest will remain at rest. An object that is not moving will not start moving by itself. If we see an object start to move, we always look to see what force is moving it. If we don't see a force, we might get nervous. The second part of the law is harder to understand—an object in motion will remain in motion until a force changes its motion. On Earth, we never see an object stay in motion forever. If we throw a ball into the air, it doesn't keep going—it falls to the ground. If we roll a ball down the street, it stops after a while. Nothing on Earth stays in motion forever. Does this mean that Newton's Law is wrong? Or is there an invisible force acting on the ball?

GRAVITY: There is a force that changes the motion of all moving objects on Earth. It is the force of gravity. Gravity is the force of attraction between all objects. The more matter an object has, the greater its force of gravity. The amount of matter an object has is called its mass. Mass is measured in grams or kilograms.

The Earth is large. It has a lot of mass. Its force of gravity pulls the objects on Earth toward it. Gravity holds us to the Earth. The sun has a huge mass. The force of attraction between the sun and the planets keeps the planets in orbit around the sun. The Earth has more mass than the moon. The Earth has a stronger force of gravity. The force of attraction between the two keeps the moon in orbit around the Earth. Your body would have the same mass on the Earth and the moon. But you would weigh more on Earth. Weight is a measure of the force of gravity on an object.

FRICTION CHANGES THE MOTION OF OBJECTS: Another force that acts on objects is friction. Friction is the force that slows two objects rubbing together. Friction is a force that slows down the motion of objects. When a ball flies through the air, it rubs against air molecules. The air molecules and the molecules of the ball catch on each other. Some of the kinetic energy in the ball changes into heat. The ball doesn't have as much energy. It slows down.

If you roll a ball on a wood floor, it will roll a long way. If you roll the same ball with the same force on a carpet, it won't roll nearly as far. The ball sinks down into the carpet. More molecules of the carpet and the ball are touching each other. There is more friction between the ball and the carpet. More of the energy in the ball is turning into heat.

NEWTON'S SECOND LAW OF MOTION: Newton's second law says that the motion of an object will change when a force is applied. If an object is moving, a force will speed it up, slow it down, or change its direction. If an object is not moving, a force will put it into motion. If a ball is lying on the floor without moving and you give it a push, it will begin to roll in the direction you pushed it. It will move in the direction of the force. If you push it again in the same direction, it will go faster. If you push against it, it will slow down. If the ball is rolling along the floor and you push if from the side, it will change its direction. Every force will change the motion of an object in some way.

NEWTON'S THIRD LAW OF MOTION: Newton's third law states that for every action, there is an equal and opposite reaction. If an object is pushed or pulled, it will push or pull with equal force in the opposite direction. When you walk, you apply a force to the ground. The ground applies an equal and opposite force against you. It holds you up. If the ground didn't apply as much force, you would sink into the ground. If the ground applied more force, you would be pushed into the air. Here's another way to think about it. Forces are always found in pairs. If you apply a force to an object, the object applies a force to you.

HEAT

HEAT IS THE MOTION OF MOLECULES: Scientists say it is the kinetic energy in a substance. Kinetic energy is 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. Liquids and gases are called fluids. The molecules in fluids 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 is in.

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, 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 and the air in the oven are the same temperature. You can put your hand into the oven without getting burned. You can't touch the pan. 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 degrees. The freezing point of water is 32 degrees. On the Celsius scale, the boiling point of water is 100 degrees. The freezing point of water is 0 degrees.

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, they 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 held together, but not in one position. They are free to spin and move around each other. When heat energy is added to liquids, they expand more than solids. The bonds that hold them together are not as strong. They can push away from each other. There is a lot of space between the molecules of gases. The bonds that hold them together are very weak. When heat energy is added to gases, they expand a lot. Sometimes they break the bonds completely and float away from each other.

LIGHT

LIGHT IS ENERGY IN WAVES: What is light? 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—it is **visible** light. Some 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** 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 can 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—be **refracted**. Light passing through transparent substances like water is bent, or refracted. 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—be **reflected**. A mirror reflects light waves. Many substances absorb some light waves and reflect others.

A PRISM SEPARATES LIGHT WAVES: A prism is a piece of clear glass or plastic that bends light waves as they pass through it. A prism is often shaped like a triangle. A prism can separate visible light into its different wavelengths. It can separate all of the colors that make up white light. A prism bends—or **refracts**—light waves. The wavelengths of each color bend at a different angle. The light that goes into the prism spreads out as it leaves the prism.

We can use pieces of glass in different shapes––called **lenses**––to bend light. A **convex lens** is thicker in the middle than on the ends. It bends light waves toward a point. A convex lens can make objects look larger. A **concave lens** is thinner in the middle than on the ends. It spreads out light waves that pass through it. A concave lens can make objects look smaller.

LIGHT WAVES CAN BE REFLECTED: How do we see things? We see the light waves that bounce off things—the light that is **reflected** by substances. When there are no light waves, you can't see anything. When you look in the mirror, the image you see is made by light waves. Light from all around you bounces off of you. Some of the light waves travel toward the mirror. The mirror reflects the light waves. Your eyes see these reflected light waves.

Light waves don't just bounce around. They are reflected at **angles** we can predict. When a light wave hits an object and is reflected, it will be reflected in a straight line. If the light wave hits an object at an angle, it will be reflected at the same angle.

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 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 every day to see. We use it in many other ways, too. The leaves of plants reflect green light waves and absorb others. The energy they absorb is used by the plants to make sugars. These sugars feed the plants and the plants we eat give energy to us. All the energy we get to move and grow comes 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.

SOUND

SOUND IS ENERGY MOVING IN LONGITUDINAL WAVES: Sound is a special kind of kinetic, or motion, energy. Sound is energy vibrating through substances. All sounds are caused by vibrations––the back and forth motion of molecules. The molecules collide with each other and pass on energy as a moving wave. Sound waves can travel through gases, liquids, and solids. The sounds you hear are usually moving through air. When a sound wave moves through air, the air molecules vibrate back and forth in the same direction as the sound. The vibrations push the air molecules close together, then pull them apart. These waves are called **longitudinal** waves. Longitudinal waves move in the same direction as the force making them.

The part of a longitudinal wave in which the molecules are squeezed together is called a **compression**. The molecules are compressed, or squeezed together into a smaller space. The part of a longitudinal wave in which the molecules are pulled apart is called an **expansion** or **rarefaction**. There are the same number of molecules as in a compression, but they are farther apart.

TRANSVERSE WAVES: Energy also travels in other kinds of waves. When you throw a stone into water, waves of energy move across the surface. The waves move away from the place where the stone hit the water. The water molecules vibrate up and down, at a right angle to the direction of the wave. A wave in which the molecules vibrate in one direction and the wave of energy moves in another is called a **transverse** wave. If you've ever been to the ocean, you've probably floated on transverse waves. If you go out beyond the breakers, you can float on the waves without moving closer to shore.

AMPLITUDE OF SOUND WAVES: The loudness of a sound wave is called its **amplitude**. The amplitude of a wave depends on its size––the height of a wave from its crest to its trough. The **crest** is the highest point of the wave; the **trough** is the lowest point. The louder a sound is, the higher its amplitude. The higher the amplitude of a sound wave, the more energy it has. If you turn up the volume on your radio, you increase the amplitude of the sound waves. The frequency of the sound waves remains the same. If you push more air past your vocal cords, the sound you make will be louder. You will increase the amplitude of the sound. You will put more energy into the sound.

FREQUENCY OF SOUND WAVES: The **pitch** of a sound is how high or low it is. The pitch of a sound depends on the wavelength of its vibrations. The number of wavelengths that pass a point in one second is called the **frequency** of the wave. The more wavelengths, the higher the frequency. Objects that vibrate quickly have a high frequency. Sound waves with a high frequency produce a high-pitched sound, like a whistle. Sound waves with a low frequency produce a low-pitched sound, like a tuba. By changing the muscle tension on our vocal cords, we can change the frequency of the sound waves we make. We can change the pitch of the sounds.

HEARING SOUND: Our ears are amazing organs that change sound waves into electrical signals and send them to our brains. Sound waves enter the ear canal and travel back to the eardrum. The **eardrum** is a thin layer of skin that is stretched tightly over the end of the ear canal, much like the skin of a drum. The sound waves transfer their energy to the eardrum, which begins to vibrate. As the eardrum vibrates, it moves a tiny bone called the **hammer** back and forth. The hammer moves against the **anvil**––another tiny bone––which vibrates a third bone called the **stirrup**. The stirrup transfers the vibrations to the **cochlea**, which is filled with liquid and lined with hundreds of tiny hairs. The hairs vibrate, sending signals to the auditory nerve, which carries the signals to the brain. Our brains can also tell the direction of the sound by differences in the amplitude of the sound and when it reaches the ear. A sound on the left, for example, will reach the left eardrum before it reaches the right one. It will also be louder on the left than on the right.

SOUND CAN MOVE THROUGH LIQUIDS AND SOLIDS: Sound travels faster and farther through liquids than through air. The molecules of liquids are closer together than the molecules of gases. It is easier for energy to move from one molecule to another when the molecules are close together. Sound travels best in solids because the molecules are so close together. Sound travels about five times faster in water than in air, and almost 20 times faster in steel. In air, sound travels at 1,130 feet per second (343 meters per second). It takes almost five seconds for sound to travel one mile. In water, it only takes about one second for sound to travel a mile.

Whales and dolphins use sound to navigate and communicate with each other. Scientists believe whales sing songs underwater that are heard by other whales hundreds of miles away. The builders of the underwater tunnel between England and France communicated by tapping signals on the steel tunnel. The signals traveled quickly to the other end of the tunnel.

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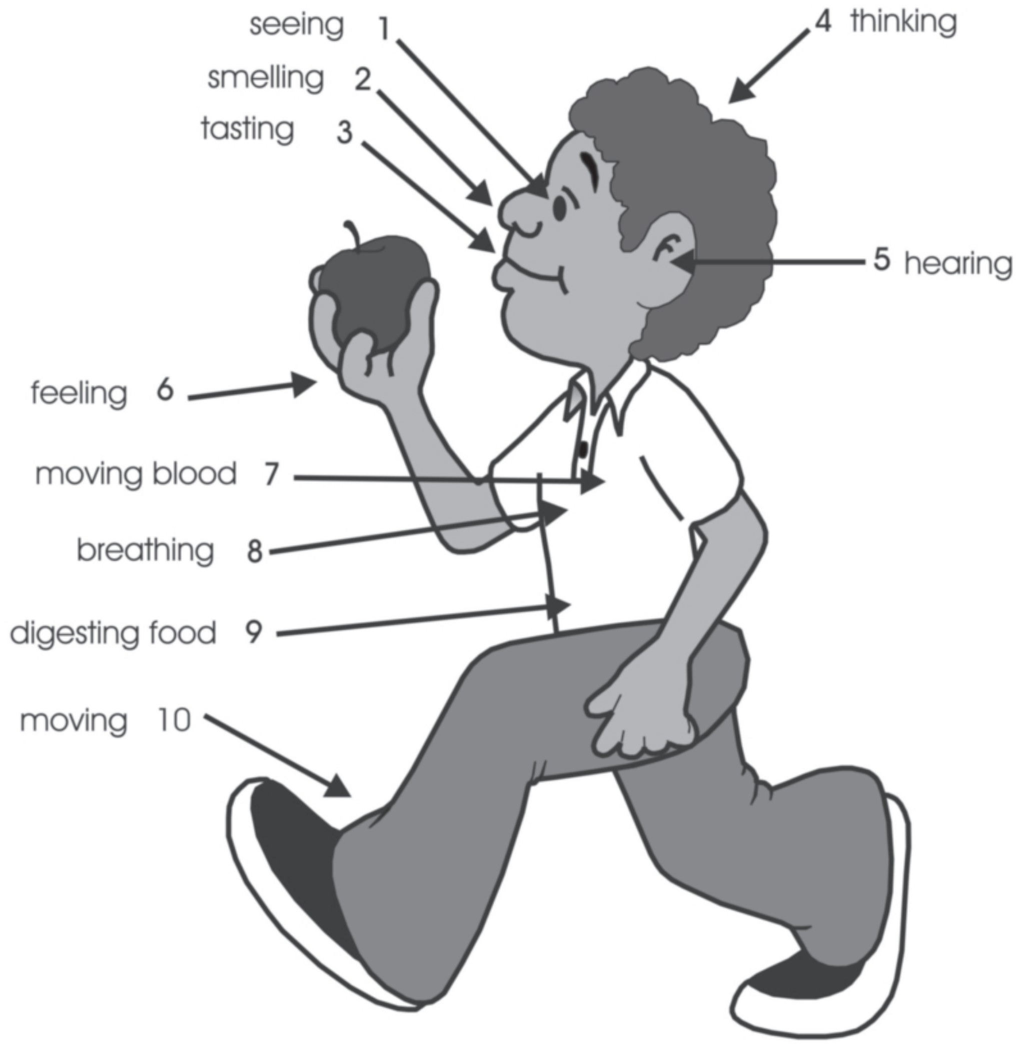

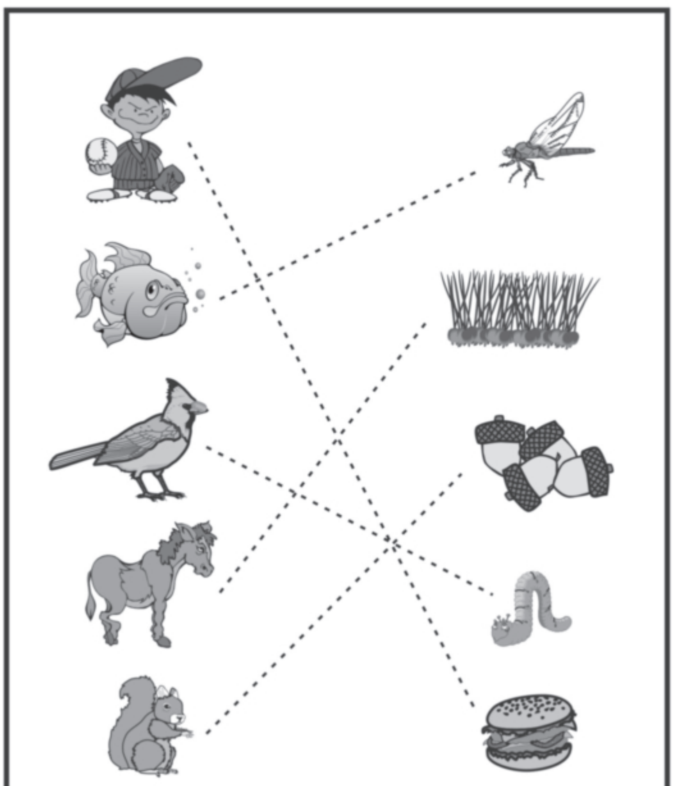

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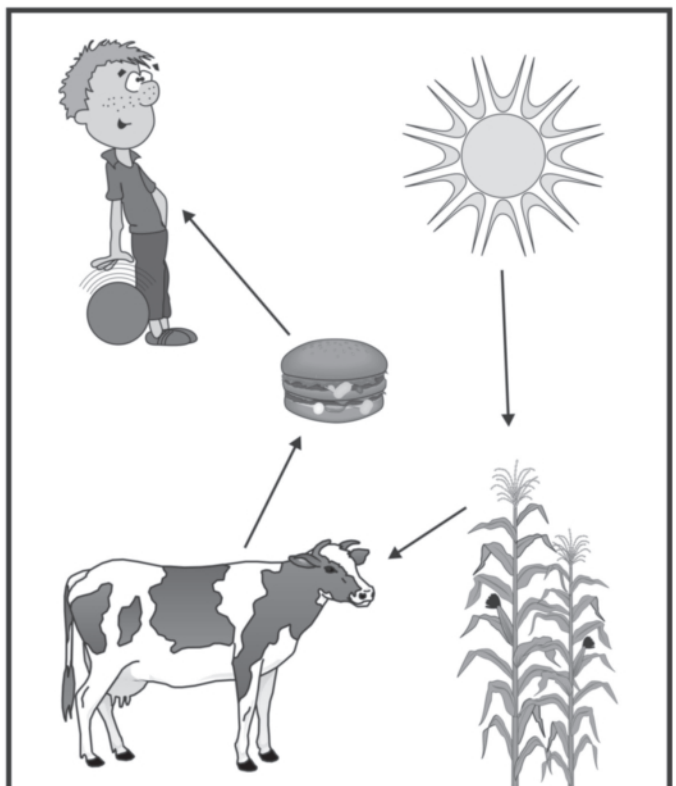

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PRIMARY SCIENCE OF ENERGY

Evaluation Form

State: ___ _ Grade Level: ___ _ Number of Students: ___ _

1.	Did you conduct the entire activity?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activity meet your academic objectives?	Yes	No
4.	Was the activity age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activity?	Yes	No
6.	Was the activity easy to use?	Yes	No
7.	Was the preparation required acceptable for the activity?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

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Manassas, VA 20108
FAX: 1-800-847-1820

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