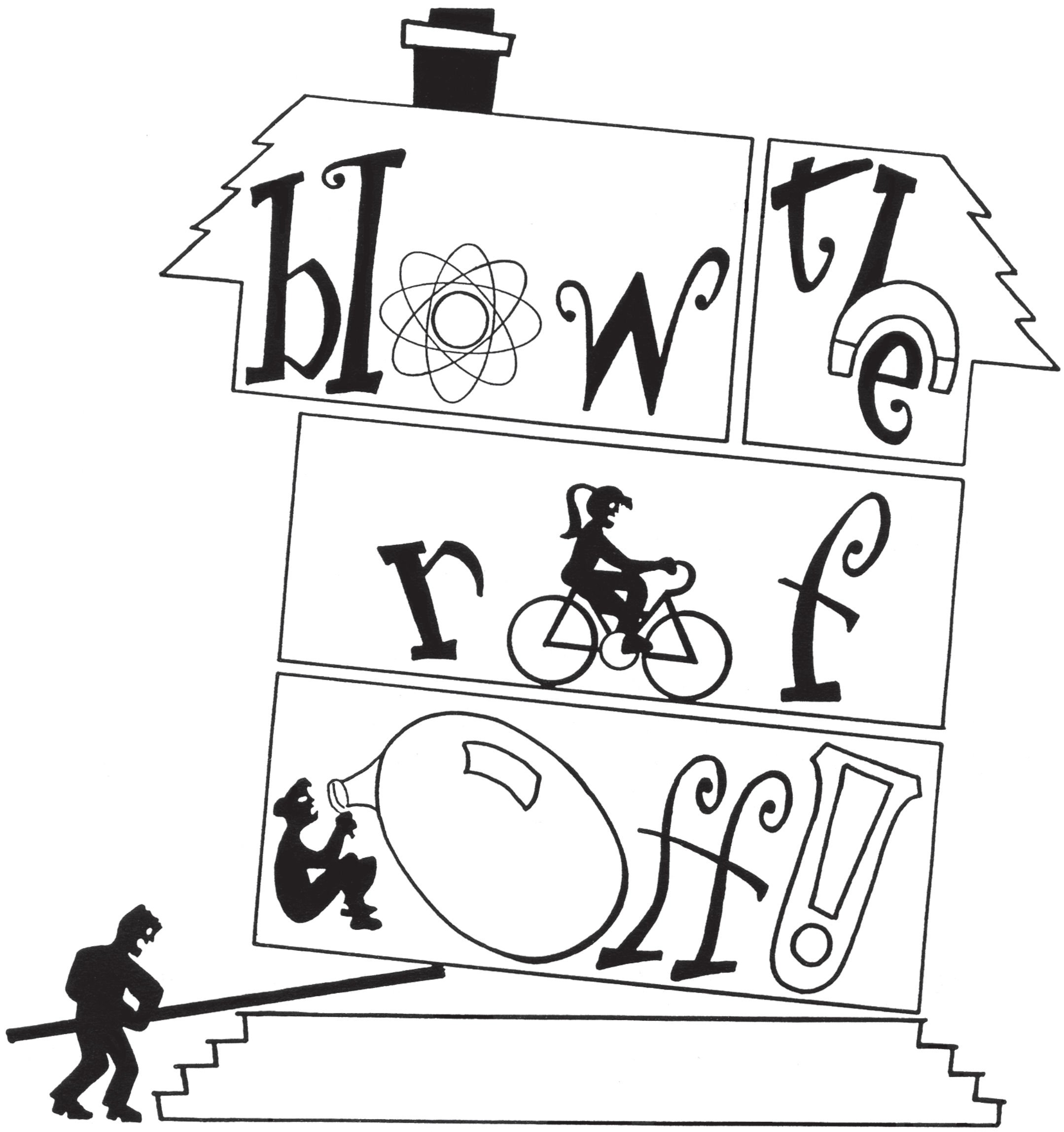
A "hands-on, minds-on" science series for fourth and fifth grades



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Programs one through eight

Contents

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GENERAL GUIDELINES FOR SAFETY IN SCIENCE

Use CAUTION in unknown situations and with unknown materials.

Take appropriate measures to protect your senses when investigating unknown materials.

1. WEAR GOGGLES.

2. HANDLE LIQUIDS CAREFULLY TO AVOID SPILLING. If spills occur, rinse off skin immediately and wipe up the area thoroughly.

3. NEVER TASTE ANYTHING.

4. SNIFF VAPORS BY WAFTING THEM TOWARD YOUR NOSE WITH YOUR HAND. Using this method prevents you from being overcome by noxious fumes.

5. LABEL EVERYTHING.

6. WRITE EVERYTHING DOWN.

Please post these safety guidelines in clear view in the classroom after discussing them with your students.

SOME SCIENCE EXPERIMENTS CAN BE DANGEROUS. SUPERVISE THE CHILDREN CLOSELY WHEN DOING AN EXPERIMENT. GOOD SCIENTISTS AVOID ACCIDENTS.

TEACHERS GUIDE #1: HOW DO WE KNOW?: THE SCIENTIFIC METHOD

MAIN IDEAS:
1. "Science" is the process of investigation to obtain evidence.
2. We use science every day of our lives.
3. Our senses are the **primary** tool we use to gather evidence.
4. The **scientific method** is the logical process we follow to gather evidence.

BACKGROUND: From the moment we are born, we explore the world around us. We are scientists. We continue to test our world as we grow. As human beings, we are naturally curious. We gather evidence and draw conclusions about things as simple as what outfit to wear to school today. As we grow older and gain more experience, we test out previous conclusions based on all the evidence we continue to collect.

BEFORE VIEWING:
1. ALIENS ACTIVITY
Purpose: Students will discover the variety of ways they can gather evidence; learn the most effective ways of gathering evidence; and understand how to interpret and re-evaluate the evidence obtained. The students will have to formulate questions about an unknown being (e.g. Does it breathe? Can it see?) and then think of ways to measure the activity in question.

Materials Needed: Worksheet 1-1 • white paper (one sheet per group) • scissors (one pair per group)
• tape (scotch or masking)

Background: A team of starship scientists is investigating an alien life form. The object is to learn as much about it as they can in a fixed period of time.

Procedure:
1. Divide the students into groups of four. One student will be the alien and the other three are scientists. The alien, using a sheet of white paper, will draw alien features such as the nose, mouth, ears, legs and arms. The alien will cut these parts out and affix them to himself/herself. Be imaginative!

2. The scientists have to investigate this alien in a fixed period of time (set by the teacher). Prepare the students by asking questions like:

> "How would you describe your alien?"
> "How many ways can you measure this alien?"
> "Your mission is to come up with ways to do it."

Have the students record their ideas for measuring and describing the alien on the ALIEN ID SHEET (Worksheet 1-1).

3. At the end of the time period, all students reconvene and share their methods of describing and measuring the alien. Ask the students to report which methods they thought were most successful and why.

EXTENSION: Have the scientists write a story about the alien they investigated. The story should address what the alien's life on its planet would be like: How would it communicate? How would it get from one place to another? How and what would it eat? Have the alien from each group write a story about how it felt to be studied by these scientists.

2. WEATHER OR NOT?
Purpose: The students will observe the weather using only their senses.

Materials: Worksheet 1-2

Background: We know a lot about our surroundings because of our senses.

Procedure: The students observe today's weather from inside the room using their senses. This may be done individually, in small groups or as a class (as you choose). Using only the senses, students will fill in the responses on the weather worksheet.

Cloudy or sunny? (sight)
Precipitation? (sight and/or sound)
Windy or calm? (sight/sound)
Relative temperature (touch the window)

Discussion: What are other ways to find out about the weather? [The discussion should bring up other ways we learn about the day's weather (e.g. TV, radio broadcasts) and extend to how those sources find out about the weather (e.g. instruments, weather patterns).]

3. THE BALL BOUNCE
Purpose: The students gain experience in measurement through observation and comparison by testing which ball has the better bounce.

Materials Needed:
• two balls (one tennis and one rubber) for every group of four students • one meter or yardstick for every four students
• masking tape • Worksheet 1-3, Worksheet 1-4

Procedure:
1. Divide the students into groups of four.
2. Tape the stick to the wall or side of the desk with the bottom resting on the floor.
3. The students will test-drop one ball from the fixed heights of 12, 24, and 36 inches. Drop each ball three times at each of the heights listed.
4. One student will hold the ball with the bottom of the ball at the 12-inch mark on the stick. Two other students will be at ground level to observe how high the ball bounces up the stick after it first hits the floor. The fourth student will record the data on Worksheet 1-3.
5. Repeat the process with the second ball and record the data.
6. Review how to graph with your students. The initial height (12, 24 or 36 inches) is the x-axis value and the height of the bounce is the y-axis value. They will graph all three points for each test on Worksheet 1-4.

Discussion:
As a group, the students will use the data they generated to make a decision as to which ball has the better bounce. Talk about their graphs and how the three trials' data points cluster so close to one another. Discuss stray points and ways in which a scientist might handle them.

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PROGRAM SYNOPSIS:
• What's in the Small Box?
• **Viewer Question #1: "What other ways, using only the senses, could TJ have used to figure out what was in the box?"**
• Introduce the Mystery Box
• The Powder Test
• **Viewer Question #2: "What tools can we use to find out what's in the box?"**
• Testing Soil
• Testing Tennis Balls and Rubber Balls
• Trip to a Car Care Diagnostic Center
• Trip to a Hospital and an Airportb
• **Viewer Question #3: "What do you think is in the big box?"**
• Discover What's in the Box

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AFTER VIEWING:
1. DO YOU KNOW?
Purpose: The students will test their evidence gathering skills by describing the item in the box using their senses.

Materials Needed: • cylindrical containers such as coffee cans or oatmeal containers (one for every three to four

students) • socks, stretchy enough to cover the mouth of the can (one sock per can is needed) • various small household items including beans, washers, paper clips, measuring spoons, paper clips, wrapped candies and erasers
• Worksheet 1-5

Procedure:
Place an object in each can and stretch a sock over the opening. Give a can to each group of three to four students. One person in the group will feel inside the can through the sock and describe what he/she feels. The students will make suggestions as to how to gather evidence about the contents; they are to write down all the evidence gathered on Worksheet 1-5. Then, they predict the contents.

Once they each make a prediction, the testing student opens the can and reveals the identity of the object. The students in their group should discuss what other tests they could have performed to gather more evidence. (Variation: Place a time limit on the groups, then bring the class back together as a whole to report their findings and collaborate on additional methods of investigation.)

(This activity can be repeated several times by having one group fill the can for another group.)

Discussion:
What was the most difficult part to describe? Other than touch and sight, what other senses could be used to determine the can's content?

2. IT MAKES SENSE
Purpose: To describe the physical properties of powders and crystals using our senses.

Materials Needed: • flat toothpicks or fast-food coffee stirring sticks • baby food-sized jars with lids (six for every set of powders prepared) • baking soda • powdered starch • ascorbic acid powder • table salt • plaster of Paris • table sugar • trays • magnifiers • small plastic cups • black construction paper • safety goggles • Worksheet 1-6

Preparation (in advance of class):
1. Each team of students will need:
• one tray • one strip of black paper (l0 x 20 cm.) • one magnifier • two safety goggles (cleaned)
• six small plastic cups labeled #1 through #6 • six flat toothpicks/coffee sticks

2. Prepare three sets of unknown powders by labeling the six baby food jar sets #1 - #6. Several work groups can use one set of powders. Prepare your key to identify the powders (#l=Baking Soda, #2=ascorbic acid, etc.). Fill all the labeled jars with its respective substance. Prepare three additional sets of KNOWN powders with their names clearly marked on the labels. These will be used in the second half of the activity.

3. Copy Worksheet 1-6 for distribution (two per student).

Procedure:
1. You may choose to identify the substances at the outset with the preface that these are common household substances, most of which they'll probably find in their kitchen or basement. On the program, we're looking at them from a different point of view, studying each of them more closely
than we ever would at home.

2. Discuss the safety rules to follow (see the front of Teacher's Resource Book). Ask the students if they can think of any additional safety guidelines they should follow while working with these powders. Ask them how they would test these solids for any odor.

3. In following the guideline of "Write Everything Down," have the students copy the safety rules on a sheet of looseleaf paper.

4. Divide the students into work groups. Distribute one tray of materials to each group. Distribute one worksheet to each student. Show the students how to label their cups and spoons #1 - 6. Tell them it's very important to keep each spoon with its respective powder to prevent contamination.

5. Tell the students to use various senses (EXCEPT TASTE) to observe each of the substances and to record their findings on the worksheet. The following guidelines are for your use. Encourage the children to determine their method of testing with their senses.

a. **SIGHT:** Use the flat end of a toothpick and transfer a small portion to the black construction paper. Use the magnifier to observe. They should note several shapes and shades of white. Record observations.

b. **TOUCH:** Have students take a small amount of each powder between their index finger and thumb and feel the texture. Have them rub a small amount onto the construction paper and observe how it looks. Have them record observations.

c. **HEARING:** Put a small amount of powder on the flat end of the toothpick and then pour it onto paper and observe the difference between the sounds that powders and crystals make.

d. **SMELL:** Test the way described in safety guidelines. Record observations.

6. When completed, have the students dump all substances in the trash. Do not return used powders to the jars.

7. Have the students repeat their test, this time using the teacher's set of clearly labeled KNOWNS and recording their data on a second copy of Worksheet 1-6.

8. The students now have a worksheet with characteristics of substances that are UNKNOWNS and a worksheet with characteristics of substances that are KNOWN.

9. Have the students compare the two sets of characteristics to determine the identities of their unknowns.

Worksheet 1-1: Alien I.D.

Name:____________________________________

What do we want to know?	How do we measure it?

Worksheet 1-2: Weather or Not?

Name: ________________________________

Observations of today's weather	How measured?

Worksheet 1-3: Follow the Bouncing Ball Data Sheet

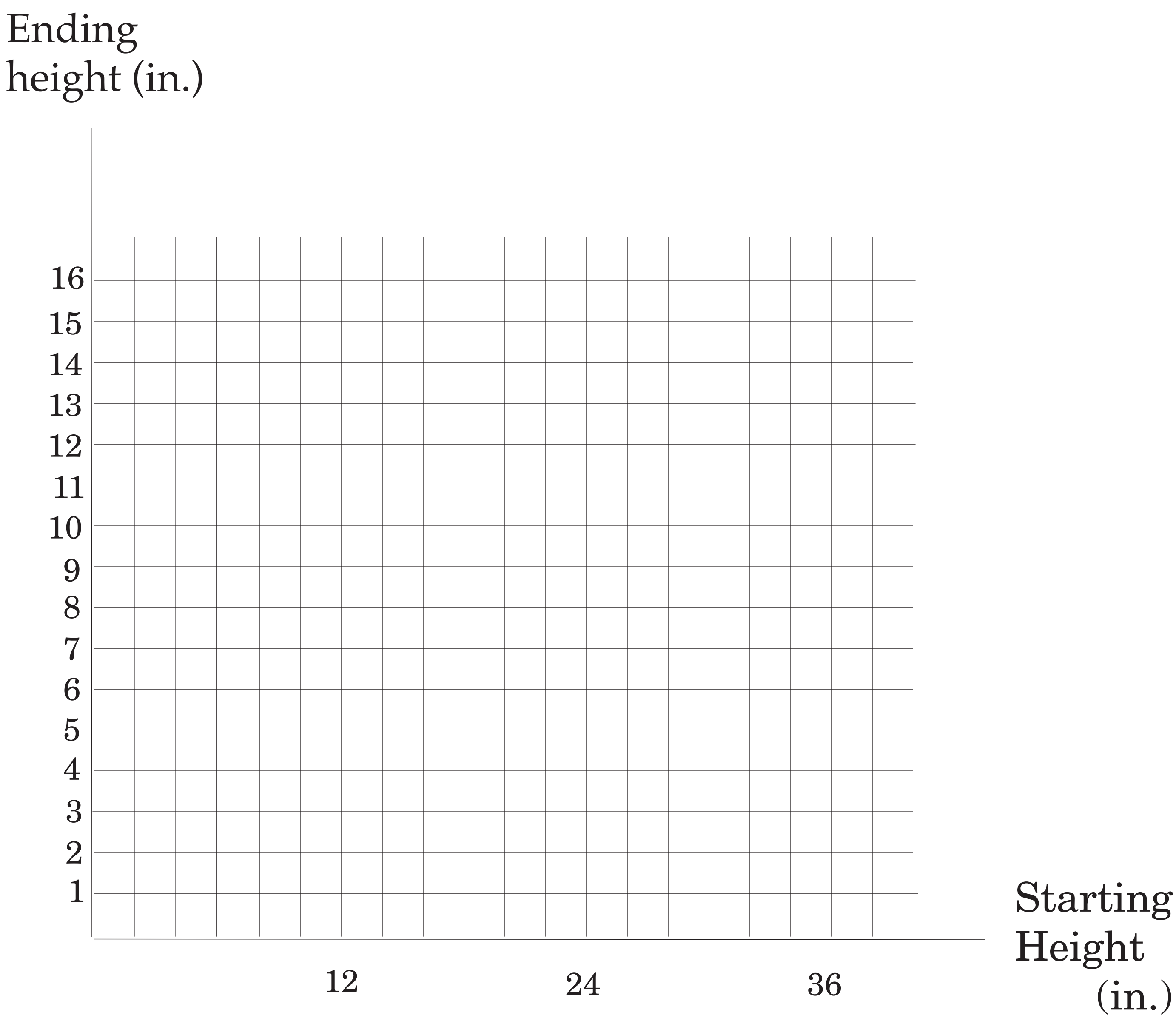
Name:_______________________________

	Trial 1	Trial 2	Trial 3
Ball A: ______________ (type?)			
12-inch height			
24-inch height			
36-inch height			
Ball B: ______________ (type?)			
12-inch height			
24-inch height			
36-inch height			

Worksheet 1-4: Graphing Your Data

Name:______________________________________

Use RED for tennis ball
Use BLACK for rubber ball



Worksheet 1-5: Do You Know?

Name:______________________________________

DIRECTIONS: In the space provided, write down all the evidence given by the tester of the "mystery" object in the can.

Trial 1:	Trial 2:
Trial 3:	**Trial 4:**

Worksheet 1-6: "It Makes Sense"

Name:____________________________________

	#1	#2
Sight: Sound: Touch: Smell:		
	#3	#4
Sight: Sound: Touch: Smell:		
	#5	#6
Sight: Sound: Touch: Smell:		

Worksheet 1-7: How Do We Know?

(Use this worksheet during the broadcast.)

	SIGHT	HEARING	TASTE	SMELL	TOUCH	TOOLS
POWDERS						
CAR						
HOSPITAL						
AIRPORT						

Using the grid, make check marks to indicate the senses used at each of the above locations. If a tool was used, which sense did it help?

Where else could we have visited? What scenes would we have used? What tools would we have used to help our senses?

TEACHERS GUIDE #2: WHAT GOES AROUND?: CYCLES ARE PREDICTABLE PATTERNS

MAIN IDEAS:
1. Cyclical patterns are evident all around us.
2. What we do affects everyone else today, tomorrow and in the future.
3. We can make better decisions if we understand that everything has cycles.

BEFORE VIEWING:
A. DISCUSSION
1. Ask students "What does the phrase, 'As sure as the sun will rise tomorrow?' really mean?"
2. Ask students "What others things do you know that are PREDICTABLE?" (List them on the board or overhead. Entertain all suggestions. Bring students to the realization that the activities listed are RECURRING and PREDICTABLE.)
3. Choose one of their suggestions and ask: "What might disrupt this recurring pattern?" (The conclusion is that external factors can affect a pattern or cycle.)
4. Distribute Worksheet 2-1. Have the students classify the cycles listed by the length of time required to complete one cycle. Conclusion: "Cycles have different lengths of time; some actions may not complete their cycle in our lifetime." Ask the students to suggest a few.

B. ACTIVITIES:
1. FEEDING FUNGI
Purpose: Observe the growth cycle of a living organism (yeast) and how the cycle rate is affected by food and temperature.

Background: Yeast is a member of the plant family known as fungi. Each yeast pellet consists of hundreds of tiny yeast cells. The yeast we are studying reproduce by growing an extension called a bud and then dividing.

Materials Needed:
sugar • magnifiers • toothpicks • measuring spoons • yeast • medicine cups • tap water • Worksheet 2-2

Preparation:
1. Measure 1 milliliter (ml) of yeast into medicine cups (two per every group of students).
2. Measure 1 ml of yeast and 2 ml of sugar into medicine cups (one per group).
3. Measure 1 ml of yeast and 1 ml of honey into medicine cups (one per group).
4. Prepare warm water.

Procedure:
1. Divide the class into groups of three. Give each group a magnifier and a medicine cup with only yeast in it.
2. Have the students examine the yeast with the magnifier and record their observations.
3. Have the students add warm water to the yeast and observe. They will record observations on the worksheet.
4. Distribute the remaining cups containing yeast only; the cups with the yeast/sugar mixture; and the cups with yeast and honey. Have students add water to each cup and observe activity. Which cup shows more activity?

Discussion:
Ask students "What Happened?"
(The yeast grew in water but when extra food was added, the cycle rate was faster.) Mushrooms, molds and yeast, unlike green plants, cannot make their own food. They must obtain food from a living or once-living organism.

2. THE WATER CYCLE
Purpose: The students will create a model of the water cycle to observe and make inferences about the global water cycle.

Materials Needed:
matching containers • light sources • masking tape • ice • Ziploc sandwich bags • water • Worksheet 2-3

Procedure:
1. Divide the class into groups of four. Give each group two matching containers.
2. Have the groups add about 2 cm. of water to their container. Place the empty container on top of the water container and seal it with the masking tape.
3. Place the containers under a light source and observe for any changes inside the containers. It will take some time for any visible changes to occur. Talk about what occurred. Have the students draw a diagram on the worksheet.

4. Once changes are observed under the light source, have the students place six ice cubes in a Ziploc bag and place it atop the container. Again, it will take some time for observable changes to occur. Discuss what occurred and have students draw a second diagram on the worksheet to define what occurred.

Discussion:
Talk with the class about the activity they observed in the chamber. Refer to the diagrams they drew. Guide the students to the conclusion that the water is going through a cycle (e.g. condensation/evaporation). Ask them to think of examples of the way water goes through its stages (e.g. steam from a boiling pot of water condenses on the windows; foggy mirrors after a shower; steamy windows in the car on a cold day; their breath when they go outside today).

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PROGRAM SYNOPSIS:
- "What's Going Around?" (cycles, that is)
  Viewer Question #1: "What kind of cycles can you name?"
- Sound Cycles
- Life Cycles: A Visit to a Greenhouse
- Clean Lungs Demo: How Cigarettes Yuk Them Up
- Affecting Cycles at the Greenhouse
- **Viewer Question #2: "How can farmers affect their crop growing cycle?"**
- Earth Cycles
    * Visit a Landfill
    * Erosion is Ruining My Day
- **Viewer Question #3: "How does cutting down the rainforest affect us?"**
- Visit to a rainforest.

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AFTER VIEWING:
1. COMPLETING THE CYCLE (Builds on The Water Cycle from pre-viewing activities)
Purpose: Observe the water cycle, predict what happens to precipitation and compare the cycle to the environment.

Materials Needed: • matching containers • light sources • modeling clay • masking tape • ice • water
Background:
Most precipitation falls back into the oceans because of the great surface area. Some precipitation falls on high ground and subsequently flows in rivers and streams back to oceans and lakes. The remainder evaporates straight from the ground or is taken up by plants and evaporates from their leaves. Rain is the most common type of precipitation and may take the form of fine mist or large drops. Sleet or hail occurs when rain falls through a layer of cold air where it is frozen before hitting the ground. Snow is formed when water vapor freezes as it condenses, forming delicate crystals.

Procedure:
1. Divide the class as in the Water Cycle pre-viewing activity. Distribute the following to each group: two matching containers; masking tape; and a fist-sized lump of modeling clay.
2. Instruct students to make model mountains of their clay. These mountains should have a wide base and grooves to indicate rivers.
3. Have students reconstruct their Water Cycle models but to add their mountains before adding the water.
4. Students will seal their containers and place the bag of ice cubes atop the model and place them under the light source.
5. Observe the activity inside the models.

Discussion:
Where does the condensation go? Have the students predict what the effect would be if loose dirt were used instead of the clay. What would happen to the water that falls on loose or porous dirt?

2. CARRY YOUR OWN TRASH
Purpose: To make students aware of just how much trash each individual generates in one week.

Background: Discuss how much trash students think they create from the time they get up in the morning until the time they go to bed each night. Ask them to give a volume example (e.g. a paper bag full). Tell them that they are going to collect their own trash for a given time interval of your choice (e.g, one day or one school week) to see how much they generate.

Materials needed: One large plastic trash bag per student.

Procedure:
1. Distribute one large trash bag to each student.
2. Have students label their bags using masking tape.
3. Instruct students that they are to throw everything that they would normally throw into a trash can into their own trash bag. Students will follow this procedure during all their waking hours at home and school. They are to carry the bag with them all day long, every day of the experiment.

Discussion:
When the time is up, all students will put their bags in the center of the classroom. Do their predictions of how much trash they generate agree with their actual evidence? Discuss the volume created by the class; multiply it by the whole school, the whole neighborhood, etc. to make them aware of how much is generated (one bag per person multiplied by the population of your state, the USA). Discuss how they could reduce the volume they created.

3. THE BEAN BAG
Purpose: The growth cycle of a plant is observed using a green bean seed.

Materials Needed: • One Ziploc bag (sandwich size) • potting soil • green bean seed

Procedure:
1. Tell the students that they will be farmers in their own environment. They will observe the growth of the bean through its cycle and will control several factors that affect its growth.
2. Give each student one bag, a handful of potting soil and a bean seed. Have them label the bag with their name and the date.
3. Put the dirt in the bag and sprinkle about three tablespoons of water into the dirt. Position the seed in the soil so that it is partially exposed against the side of the bag. In this way, the student can observe the beginning of the growth cycle.
4. Place the bags in the locations that the students have chosen for light and warmth. Have them observe the growth each day and keep a record of the progress.

Discussion:
Discuss what the optimum conditions for growth would be. Ask them to think of factors beyond their control in the bean's growth cycle.

Worksheet 2-1: Cycles: The Long and Short of it

Name:____

DIRECTIONS: Write the cycles under each column heading that best describes the rate at which the cycles pattern begins to repeat itself.

Quick	Medium	Long	Forever

Worksheet 2-2: Feeding Fungi

Name:____________________________________

How does yeast look?

How does yeast and water look?

How does yeast and sugar react with the water?

How does yeast and honey react with the water?

Worksheet 2-3: The Water Cycle

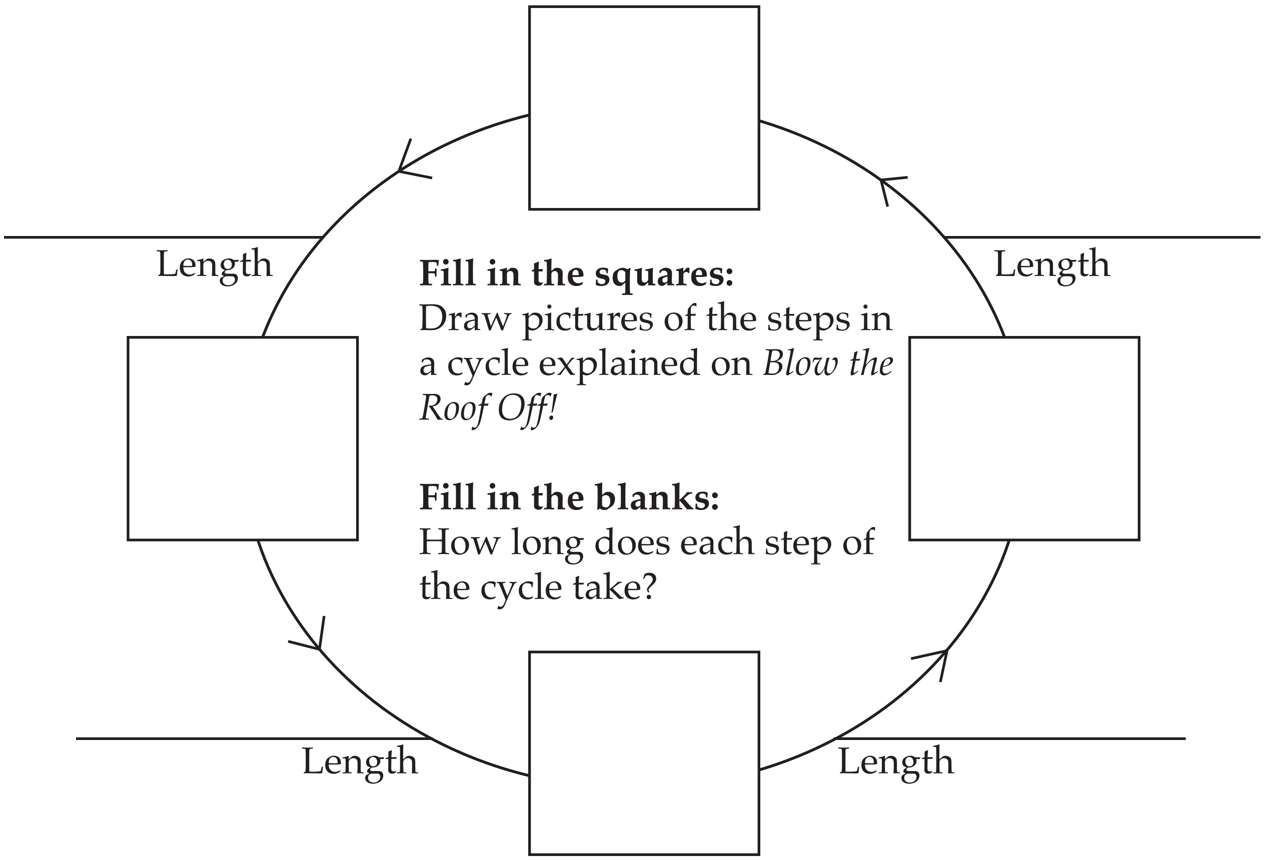
Name:__________________________________

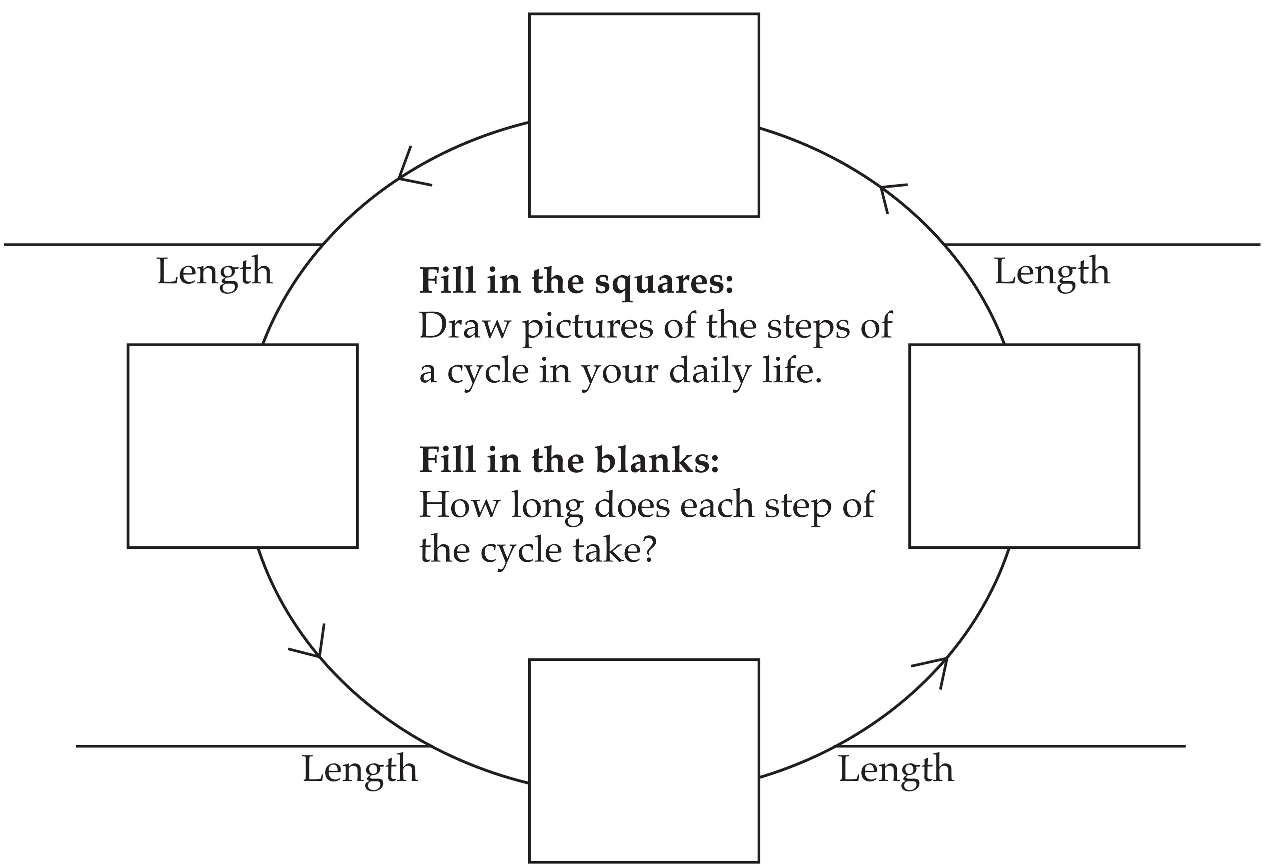
PART 1: In the space provided below, draw a diagram showing the activity in the chamber. Use the arrows to show the direction the water took and label everything.

PART 2: In the space provided below, draw a diagram showing what happened in the chamber when the ice pack was added to the top. Use arrows to show the direction the water took and label everything.

Worksheet 2-4: What Goes Around . . .

(Use this worksheet during the broadcast.)





TEACHERS GUIDE #3: LET THERE BE LIGHT: THE PROPERTIES OF LIGHT

MAIN IDEAS:
1. Light is energy
2. Visible white light is made of many colors

BEFORE VIEWING:
A. DISCUSSION: Ask the students if they can see you. Of course, they can. But, why? Guide their responses to the idea that light makes it possible. Ask them if they could see you if you were all in a deep cave underground?
Talk with them about light and how it:

- affects their lives
- sets their pattern or cycle
- provides day and night
- affects our seasons

Your discussion should lead them to how the sun is our source of light; we have extended our waking hours by inventing the light bulb.

B. **ACTIVITIES: (NOTE TO TEACHERS: "A Bowl of Rainbows" and "Rainbow Colors" both demonstrate the same concept. You may choose either. If your desks need cleaned, you might consider "Rainbow Colors.") Both of these activities reach the same conclusion, so the discussion is applicable to both.**

1. A BOWL OF RAINBOWS
Purpose:
To separate white light into colors.

Materials: • one quart bowl or wide-mouth container of water per group • bottle of clear fingernail polish

Procedure:
1. Divide the class into groups of four. Give each group a bowl of water.
2. Place the bowl of water away from direct lighting.
3. Hold the brush of the nail polish bottle over the bowl of water and allow one drop of liquid polish to fall into the bowl.
4. Watch the surface of the water. Instruct the students to move their heads so that they can see the surface from different angles. Provide the students ample time to reflect on the color movement.
5. Students may write their observations on a sheet of notebook paper.

Results: A rainbow of colors is seen in the thin layer of fingernail polish. The nail polish forms a thin film across the water. When the light rays strike the film, part of each ray is reflected from the surface; part of the ray goes through and is reflected off the bottom of the film. If the reflected rays overlap as they leave the film, color is seen. The thickness of the film determines the speed of the reflected rays. The timing has to be just right for the reflected rays from the surface and the bottom of the film to meet as they leave the film. If this doesn't happen, areas without color are seen. The rainbow is called a SPECTRUM.

Discussion: Ask students if they have ever seen oil or gasoline on the street. Discuss with the class where they think the colors come from.

2. RAINBOW COLORS
Purpose: To observe the dynamics of the spectrum of colors in bubbles. (It's also a great way to get the desktops clean!)

Materials Needed:
Dishwashing detergent (like Dawn) • Glycerin (available at most drug stores) • water • straws • cleared desktops • cloth or paper towels • paper plates (optional)

Preparation:
Make a soap solution (1 part detergent, 2 parts water, 1 tsp. glycerin). The solution can be made in a one-gallon milk container.

Procedure:
1. Have each student clear off his/her desk. If you wish to have them contain their bubble work, distribute the paper plates.
2. Give each student about three tablespoons of soap solution on his or her work surface.
3. Using a straw, they should blow the largest bubble they can on their surface and observe the bubble as the light hits it.
4. Have them look for color changes and movement. Have them observe the color of the bubble just before it pops. Allow the students ample time to reflect on the color movement. They may repeat their testing numerous times.
5. The students may write their observations on a sheet of paper.

3. COLOR IMAGES
Purpose: Compare color and black-and-white printed pictures. Observe how the primary colors are used to produce full color images and investigate the production of color pictures in magazines.

Materials needed: • magnifiers • textbook with color pictures • newspaper with black-and-white and color pictures

Background: Color pictures in textbooks are printed by a process that uses color subtraction. First, printers separate the picture into four component colors: cyan (blue-green), magenta (purple), yellow and black. Four printing plates are then produced, one for each color ink. For example, if the grass is green in the picture, the grass will show up on the cyan and yellow plates but not on the magenta and black plates. The picture is created by printing each of the four colors separately, one on top of the other. The overlapping of colors (like pigments in painting) absorb light to produce the color we see.

When we look at the color picture through a magnifier, we see dots of various sizes and colors. Dots, rather than solid color, are used to achieve a variety of color shadows and densities without having to make more than four printing plates.

Preparation: Have the students bring to class a black-and-white picture from the newspaper. A color picture from the newspaper would be also be helpful.

Procedure:
1. Review with the students what we learned in the first show "How Do We Know?" about the limitations of our senses in investigations and the need for instruments to amplify our senses.
2. Pair the students; give each pair a magnifier.
3. Have the students take out their black and white newspaper picture and examine it with the magnifier.
4. If they have a color picture from the newspaper, have them magnify it as well and tell what they see.
5. Next, have the students open their textbook to a page with a color picture on it and study it with the magnifier. (If possible, bring in a color television or color computer monitor, plug it in and get a color picture on the screen. Have the students use their magnifiers to study the screen.)

Discussion:
Have the students discuss what they see. Guide them to the realization that all examples of pictures are made up of millions of dots and bars. The density and shading of color or darkness is caused by the placement of the dots or bars.

4. FOCUS IN
Purpose: To observe the effect of collecting light rays.

Materials needed: • magnifiers • a sunny day or bright light

Procedure:
1. Divide the class into groups. Give each group a magnifier.
2. Place a drop of water on a nonflammable surface. One student positions the magnifier so that a bright beam of light is focused on the drop of water.
3. After a few seconds have a student place his/her finger in the water. Caution students not to hold their hand in the beam of light. It could cause a burn!
4. Each student takes a turn feeling the water.

Discussion:
"What did you feel?" "Where did the heat come from?" Light is a form of energy. When collected and concentrated through the lens of the magnifier, some of the light beam was absorbed by the water as heat; some is reflected off as light and heat.

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PROGRAM SYNOPSIS:

- Let There Be Light!
  Viewer Question #1: "What other types of light energy do you use in your home?"
- Cooking Hot Dogs with Solar Power
- Refraction and Fiber Optics
- Telescopes and Light
- The Color Spectrum
- Pour Light From a Bottle
- All the Colors of the Spectrum
  Viewer Question #2: "How do we get Ed and TJ back to normal color?"
- How Do You Know If You're Color-Blind?
- Laser Power
  Viewer Question #3: "Why didn't the fiber optic light beam cut the wood but the laser beam did?"
- Grocery Store Scanners and Holographic Games

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AFTER VIEWING:

1. COLOR FILTERS AND LIGHT

Purpose:
Observe the effect of colored filters on light. Predict the effect of passing white light through various combinations of filters. Compare this process with other color-mixing processes.

Materials Needed: • flashlight • white paper • color filter gels • Worksheet 3-1

Background:
A pure filter removes (absorbs) light of certain colors and allows other light to pass through. The wavelengths of light that can pass through the filter(s) give the resulting light its color.

Procedure:
1. Divide the class into groups of three and give each group a set of filters and a sheet of white paper. Give each student a worksheet.

2. Instruct the students to write down on the worksheet all color combinations using two filters at a time They will test and predict what the resulting light color of each filter pair might be.

3. As each group completes this, give them a flashlight and instruct them to test their predictions. Remind them to record their experimental data on the worksheet.

4. Encourage them to experiment with more than two filters and record their data on the worksheet.

Discussion: Discuss how their predictions turned out. Talk about what colors the PRIMARY COLOR combinations created. Review secondary colors (green, orange, purple) and bring students to the realization of how the secondary colors are generated. Discuss the results of their various combinations. (If you have access to a color wheel, this may be an opportunity to review the color combinations in relation to it.)

2. COLOR FILTERS AND SIGHT:

Purpose: To observe the effect of viewing color drawings through a filter. To interpret data derived from the observations and formulate a hypothesis as to why colored filters change the color of objects.

Materials Needed:
• filters • index cards • white paper • crayons (red and green) • glue • scissors • stapler • Worksheet 3-2

Background: A piece of white paper reflects light of all colors, so the paper looks white. A red line reflects only red light so it looks red. Since a red filter only allows red light to pass through it, the paper will appear red when viewed through a red filter. If there is a red line on the paper when viewed through the red filter, it will seem to disappear. If there is a green line on the paper, it will appear black through the red filter. The green line reflects green. The red filter absorbs all color except red. Therefore all light reflected by the green line will be absorbed. The resulting absence of color makes the line look black.

The filter glasses the students will make are like those used to view the 3-D comics. When you look at a real object, each eye receives slightly different information because each eye views the object from a slightly different angle. The brain synthesizes the information into a single three-dimensional image. This effect is simulated in 3-D comics by slightly overlapping two different pictures, one printed in red and the other printed in green. When you wear the glasses with one green filter and one red filter, each eye sees only one picture on the page. Then your brain synthesizes what each eye sees into a 3-D picture.

Preparation:
1. Cut two sheets of red and green filters into 5 x 12.5 cm. pieces. Cut enough pairs for every student in the class.
2. Make a demonstration set of filter glasses.

Procedure:
1. Distribute the worksheet and explain to the class that they are going to observe the effects of color filters on sight. Show them the demonstration set of filter glasses. Then distribute the materials and have them begin.

2. As they complete the glasses, have students wear them to explore the room.

3. Next, give each student two sheets of white paper. Ask them to take out their red and green crayons and make tiny, **faint** dots of red on one sheet and tiny **faint** dots of green on the other. Have them look at the sheets through their glasses. Discuss what they see.

4. At this point, encourage the students to design a dot picture using the red and green crayons that will change when they use the glasses. The artwork can be hung in the classroom to be viewed and admired through their glasses.

Discussion:
Ask the students why they think they cannot see the line through the filter of the same color. Guide them to the concept of similar light waves begin absorbed and reflected.

Worksheet 3-1: Color Filters and Light

Name:____

DIRECTIONS: In the first column, list the filter combinations you choose to use. In the second column, predict what color you think you will see. In the third column, write the actual color observed when you test it.

TWO FILTERS	COLOR PREDICTED	COLOR SEEN
THREE FILTERS	**COLOR PREDICTED**	**COLOR SEEN**

Worksheet 3-2: Making Your Own 3-D Glasses

1. Cut out the rectangles along the **solid line**.

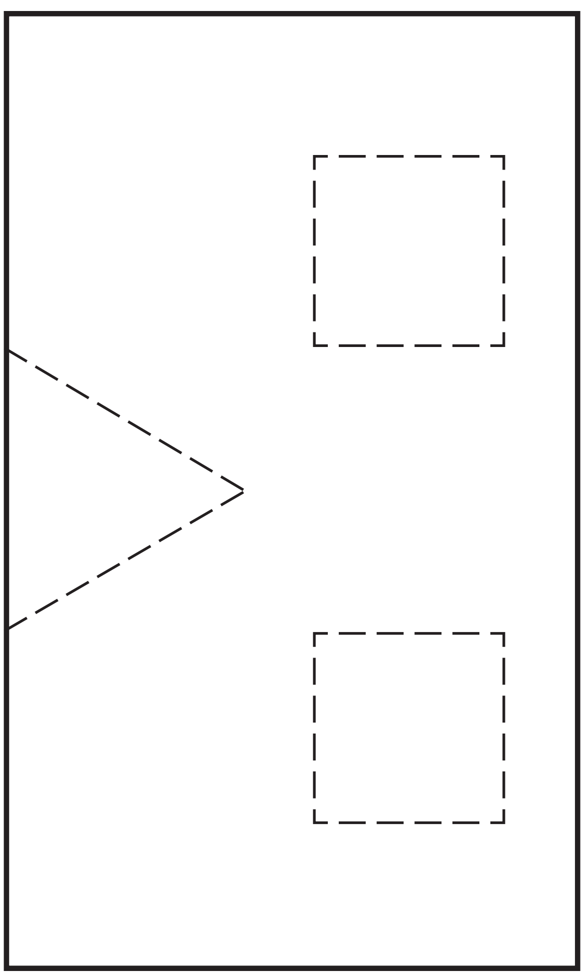
2. Glue each rectangle to a 3" x 5" index card.

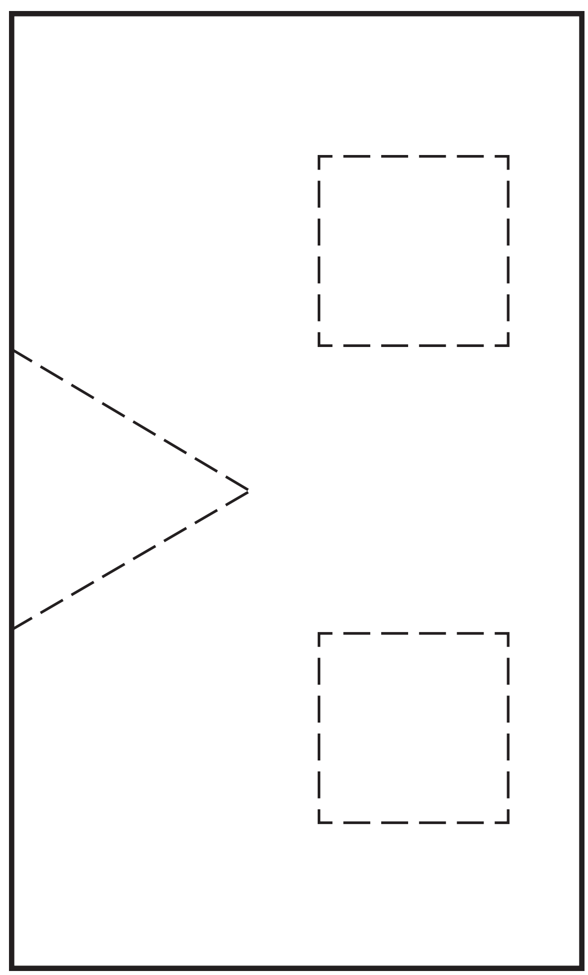
3. Cut out the squares and triangles along the **dotted lines**.

4. Put a green filter over the right square.

5. Put a red filter over the left square.

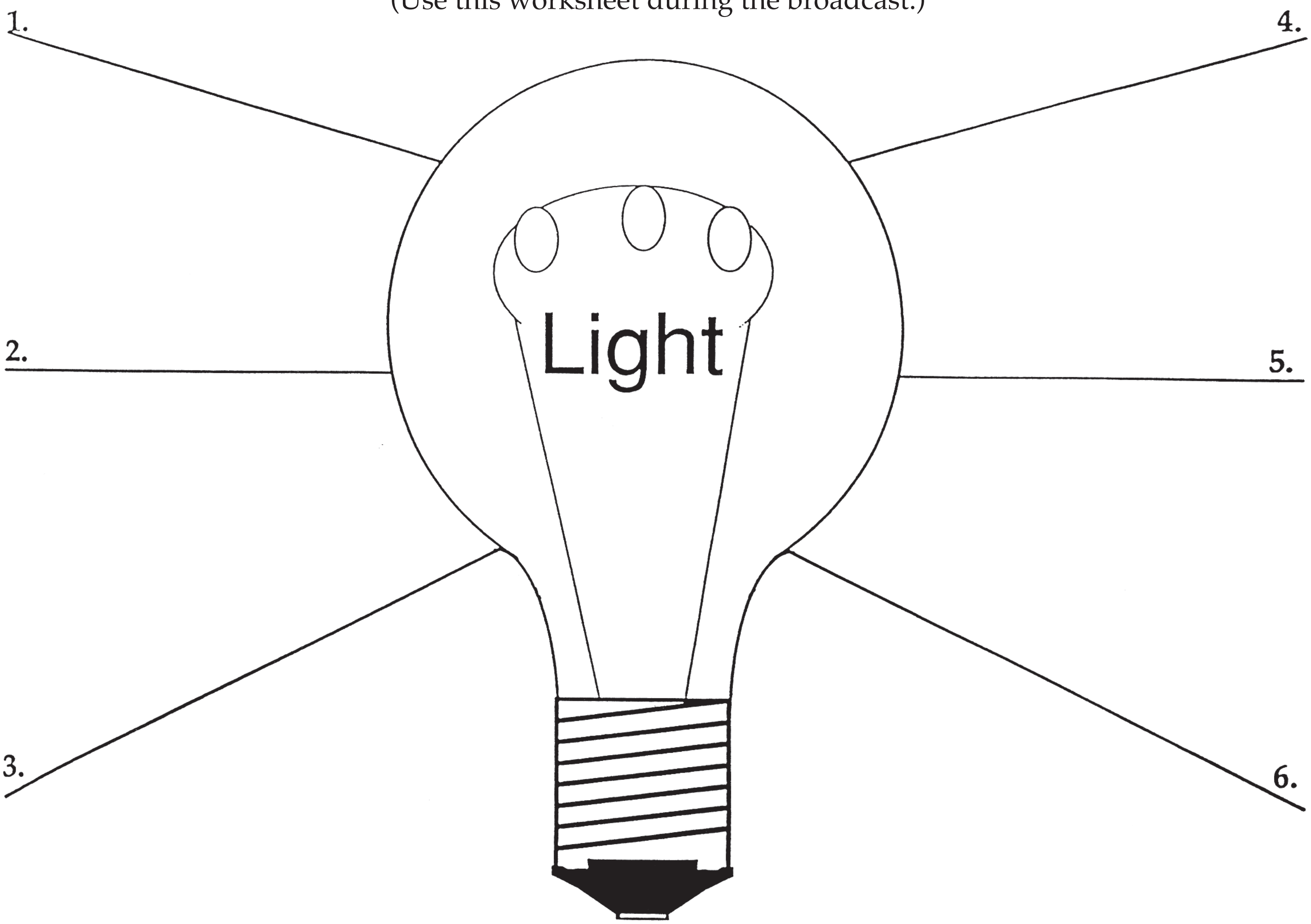
6. Place the second index card over the first and staple them together.





Worksheet 3-3: Let There Be Light

(Use this worksheet during the broadcast.)



During **Blow the Roof Off!** we will be using lots of words about light.
On each line, write a word you hear during the show that has to do with light.

How do these things make a difference in your life?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

TEACHERS GUIDE # 4: IS THERE AN ENERGY STORE?: WHERE DOES ENERGY COME FROM?

MAIN IDEAS:
1. Energy we observe is neither created nor destroyed. It comes from somewhere.
2. We should get into the practice of tracing energy to its source so we can make knowledgeable decisions about our energy usage.

BACKGROUND:

Without the sun, there would be no life on Earth as we know it. The energy from the sun is transformed into a variety of different energy types in order to be used on the planet. Green plants use carbon dioxide, water and the energy from the sun to produce products through the chemical process of photosynthesis. Animals eat these plants and use them to grow, releasing the energy stores in the process.

We can trace our dependence on the sun for our food and survival. As our environment becomes more sophisticated and technical, we can still trace our dependence ultimately to the sun as the source of most of our energy requirements.

BEFORE VIEWING ACTIVITIES:
1. LIGHTEN UP
Purpose: To demonstrate the transformation of energy from light to heat and the impact of color on absorption of the heat energy.

Materials Needed:
- black construction paper, 6" x 8"
- white typing paper, 6" x 8"
- two thermometers
- light source
- Worksheet 4-1

Background:

Light is a form of energy. It can be converted to other forms and measured. We are going to observe the conversion of light energy into heat energy. It is not something that we can see with our eyes but we can see the results as we measure the heat energy with a tool called a thermometer (thermo = heat; meter = measure). Some substances are good reflectors of energy and some are absorbers.

Procedure:
1. Divide the class into working groups. Give each group one sheet of black and one sheet of white paper, two thermometers and access to a light source. If it is a sunny day, try to arrange some or all of the students so that they can use sunlight as their light source. Each student should have a copy of Worksheet 4-1.

2. Have the students lay the thermometers on the table. Time for one minute and then record the temperature registered on each thermometer.

3. Cover the bulb of each one with a sheet of paper: one black and one white. Expose enough of the stem so that the temperature changes can be easily read. Apply the light source to both covered thermometers. Wait for two minutes and record the temperatures. Wait two more minutes and record. Repeat for a total of ten minutes.

Discussion:

Which thermometer registered the greatest increase in temperature over the measured time period? (The one covered with the black paper) How did that happen? (The black paper absorbed more of the light energy converted to heat.) What statement can be made about the absorption of energy based on the evidence gathered in this activity? (The light is absorbed by the paper and converted to heat energy in the process. The black paper absorbs more energy since the thermometer showed an increase in temperature. The white paper must have reflected the light because the thermometer registered a lower temperature increase.) Discuss with the students what other heat applications they have experienced.

2. HOW DOES YOUR GARDEN GROW?
Purpose: To observe the impact of light on the growth cycle of plants. NOTE: This project will take about two weeks to complete.

Materials Needed:
- seeds
- rulers
- potting soil
- a large packing carton
- paper cups (6 or 8 oz. size)
- light source
- labels
- Worksheet 4-2

Background:

All living things require energy to grow and to thrive. In the case of seeds, they require energy to start the growing process. The seeds have food stores inside their shell that carry enough nutrients to support growth (under the right conditions). A test of the light factor will provide evidence for the students to decide the optimum conditions for growth.

Procedure:

1. Divide the students into groups of three. Each student in the group will grow a plant according to the following three categories: continuous darkness, continuous light and light/dark cycle.

2. Each student will prepare the cup with potting soil and plant their seed.

3. Designate certain locations in the classroom for each of the categories. The light/dark cycle plants follow the normal light patterns of your classroom. The continuous dark should all be placed in a large cardboard carton and opened only to provide water. The continuous light plants should be placed around a light source that will be lit 24 hours a day.

4. Have the students observe their plant every day. Water when necessary. Record all actions on the worksheet. Once the plant starts to grow, the students are to record the height of their plant on a daily basis.

****

PROGRAM SYNOPSIS:

Where does the energy that our bodies use every day come from? TJ and Ed search for an energy store. In searching for clues, they end up in some curious places collecting rather unusual evidence with very interesting conclusions.

• Human Energy
  Viewer Question # 1: "Where do Clyde and Seafus get their energy from?"
• Tracing the Path of Electricity
• Making Steam Turbine Activities
• Releasing Energy in Wood
  Viewer Question # 2: "Energy in wood can be released as heat and light, but where does the wood get its energy?"
• The Energy in Gasoline
• Where the Energy in Batteries Come From
• Putting Energy Into Batteries
  Viewer Question # 3: "Can you trace Ed's cotton shirt back to its energy source?'
• Wind Energy

****

AFTER VIEWING:

1. HOW DOES YOUR GARDEN GROW? (CONTINUED)

Procedure:

Continue the observation and recording of data on the growth of the seedling until you think a sufficient difference in growth rate has been achieved.

Discussion:

At the end of the growing session, reconvene all students to review their data.

• Collect (on the board) the data on each of the categories.
• Graph the <u>average</u> growth of the seedling in each of the categories.
• Guide the students toward drawing conclusions on the effect of light on the plant's growth.

2. MOVE IT!

Purpose: The students will use the evidence obtained from exercising to draw conclusions about effect of exercise on their own heart rate, respiration and cooling system (perspiration).

Materials Needed:

• clock with a second sweep hand
• Worksheet 4-3

Background:

Our body is a machine that does work for us. It requires energy in order to function. Some of the energy it receives, it uses immediately to continue body function. It processes and stores away other energy it receives for future energy demands. The energy it receives comes from the food that we eat. There is constant investigation (research) going on to determine which foods and food groups provide the optimum fuel for our bodies.

Our body is always consuming fuel, because there is always work being done. We are not conscious of some of the work being done, like our breathing (approximately 20,000 times per day), our heart pumping the blood throughout the body (about two oz. per beat at rest and about four to seven oz. per beat during exercise), our bone marrow making new red blood cells, and all the other organs which are constantly at work. But when we exert ourselves - like walking to the bus stop or playing at recess - our bodies require more fuel to keep up with the demand for movement. That's where stored energy can come into play. There are signals such as increased respiration and heart rate that our body gives us when there are demands for additional energy. We know that our body machine is operating at increased demand when the cooling system kicks in; we begin to perspire.

In the activity below, students will gather evidence about their bodies' operation in a controlled procedure. At the end of the activity, they will draw conclusions about the energy demands they imposed on their bodies and how their bodies responded to those demands.

Procedure:

1. Show each student how to locate their carotid pulse in their neck (to the right or left of their Adam's apple) using their index and forefinger. Have them count their heartbeats while you measure 15 seconds. Explain to them that they need to record their heart rate in beats per minute. Have them calculate what their heart rate would be for one minute [heart rate (beats per minute) = pulse @15 seconds x four.]

2. Show students how to locate their radial pulse in their writs. Have them use their index and forefinger and draw an imaginary line down their thumb to the narrow part of their wrist. Tell them not to use their thumb because it has a pulse in it as well and will confuse their reading. Have them measure their pulse for 15 seconds and record.

3. Divide the class into partners. One student will watch the clock while the other completes the activities and then they will switch roles.

4. Each student will:
   a. Take his/her own pulse at rest (either carotid or radial, whichever is better for them). The partner will count the number of breaths the student takes and record pulse and respiration.
   b. March in place for one minute.
   c. Take his/her own pulse for 15 seconds. The partner counts the breaths and records the data.
   d. Run in place for one minute.
   e. Take his/her own pulse for 15 seconds. The partner counts breaths and records the data.

Students will record all the data and make observations on their partners' perspiration/face color, etc., at each stage.

5. Students reverse roles and complete step 4.

Discussion:

1. How does marching in place change heart rate? How does it change breathing?

2. How does the running in place change heart rate? How does it change breathing?

3. What other changes did the partners observe while the activities were taking place?

4. What conclusions can they draw about exercise and heart rate? (the more energetic, the higher the heart rate)

5. What conclusion can they draw about exercise and respiration? (a direct relationship exists here as well)

6. Where does the energy come from to do these exercises? Did they have to consume food while they were exercising in order for their body to do the work? (No, the energy came from the food they had eaten at other times and their bodies stored the energy in the form of fat.)

7. Guide the students to trace the path of the sources of energy throughout the exercise sequence. (The body is using energy stored in the body fat from food consumed. The food consumed was either meat or plants that got their energy ultimately from the sun.)

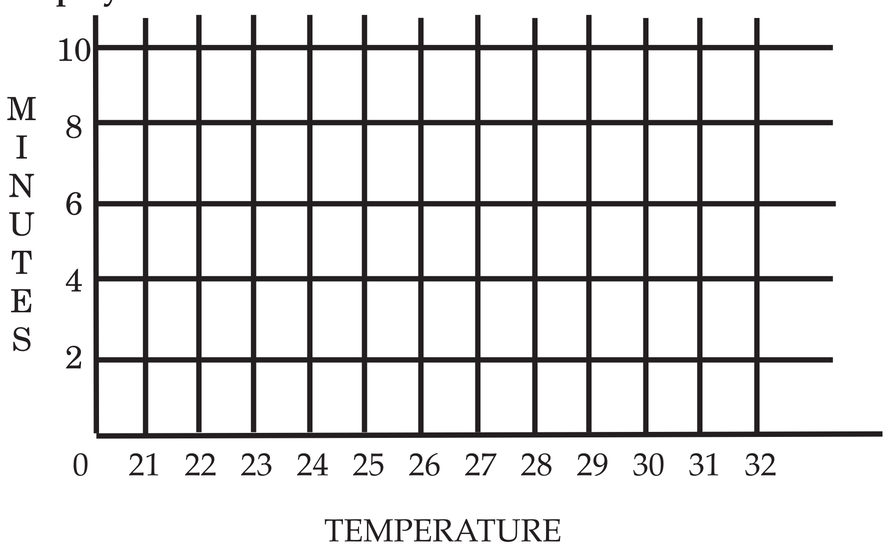
Worksheet 4-1: Lighten Up

Name: ____

DIRECTIONS: Record all your data in the spaces below.

	Thermometer #1	Thermometer #2
Temperature on table after one minute		
Color of paper covering thermometer		
Temperature after two minutes		
Temperature after four minutes		
Temperature after six minutes		
Temperature after eight minutes		
Temperature after ten minutes		

Graph your results here:



THINK ABOUT IT!

- Which thermometer recorded the higher temperature?
- What happened to the light energy that hit the black paper?
- What happened to the light energy that hit the white paper?
- What if we covered one thermometer with clear plastic?

Worksheet 4-2: How Does Your Garden Grow?

Name: ____

IDENTIFY YOUR PLANT GROWING CONDITIONS:

DIRECTIONS: Record all of your observations below. Record when the seed begins to sprout and then its height each day. Mark the days on which you water your plant. You may use the back of the worksheet if more space is needed.

	DATE	WATER	OBSERVATIONS
DAY 1			
DAY 2			
DAY 3			
DAY 4			
DAY 5			
DAY 6			
DAY 7			
DAY 8			
DAY 9			
DAY 10			
DAY 11			
DAY 12			
DAY 13			
DAY 14			

Worksheet 4-3: Move It!

Name: ____

Partner's Name: ______________________________________

DIRECTIONS: Each student will record all the data for his/her partner in the spaces below.

	PULSE		RESPIRATION	
	15 secs.	One minute	15 secs.	One minute
RESTING				
MARCHING IN PLACE				
RUNNING IN PLACE				

	OBSERVATION OF FACE COLOR, PERSPIRATION
RESTING	
MARCHING IN PLACE	
RUNNING IN PLACE	

THINK ABOUT IT!

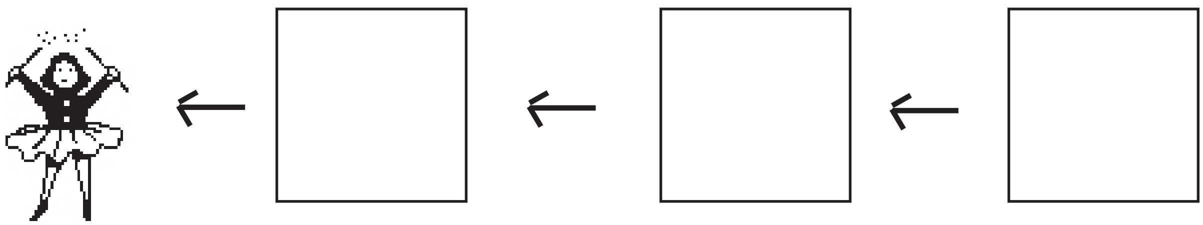
- What does moving around do to your heart rate?
- What does a lot of movement do to your respiration?
- Where does the energy come from to do this exercise?

Worksheet 4-4: "Is There an Energy Store?"

(Use this worksheet during the broadcast.)

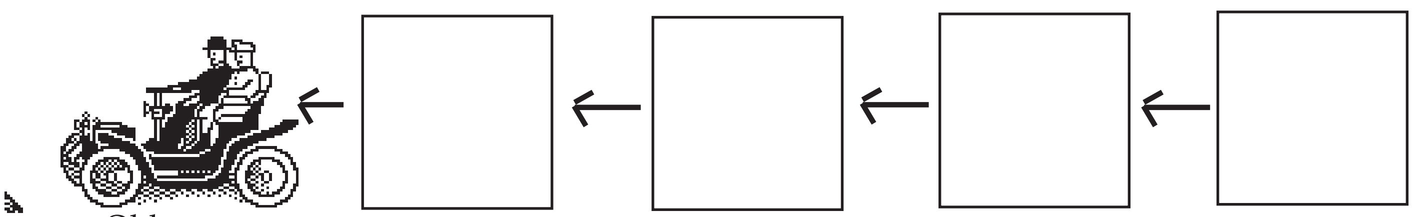
Name: ____

DIRECTIONS: Trace the energy paths shown on the broadcast. Write the sequence of energy. (Remember, you will go backwards from T.J. to the source.)



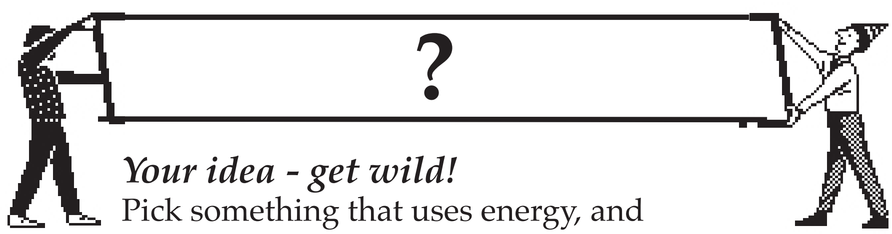
T.J.

Where does her energy come from?



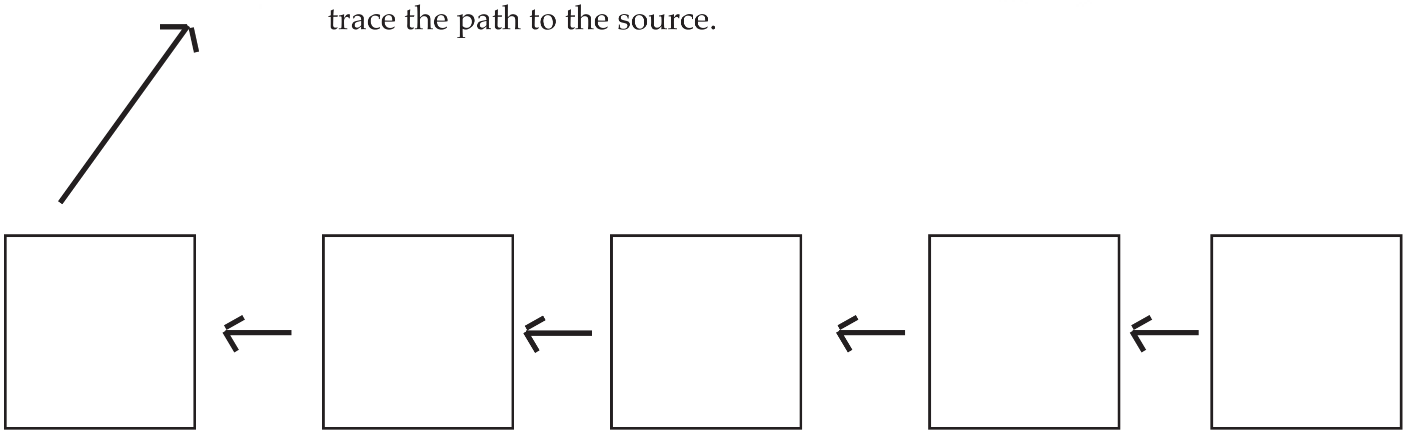
Old car

Where does its energy come from?



Your idea - get wild!

Pick something that uses energy, and
trace the path to the source.



TEACHERS GUIDE # 5: WHERE DID IT GO?: ENERGY IS NEITHER CREATED NOR DESTROYED

MAIN IDEAS:
1. Energy is neither created nor destroyed.
2. Energy can be transformed from stored to used energy and back again.

BACKGROUND:

When riding a bicycle, we used stored energy and energy of motion and transfer one to the other all the time we're traveling. We transfer energy from our muscles to turn the pedals and propel the bike forward. We expend a lot more energy pedalling up a hill. On the way down, we expend little of our own energy. We use our brakes to control the energy of motion by transferring some of that energy to friction to slow us down.

Almost every form of energy can be converted or transformed into other forms in some way. The energy in an object is either:

kinetic = energy of motion or energy being used
potential = energy of position or energy that's stored and waiting to be used

Kinetic energy can be transformed into potential energy and potential energy can be transformed into kinetic energy. In order to analyze these transformations, we need to know specific forms of energy being observed. Some forms of kinetic energy are light, heat, sound and electrical. Some forms of potential or stored energy are chemical bonds, gravitational pull and elasticity.

BEFORE VIEWING:
1. THE COMEBACK CAN
Purpose: The students will construct a device that changes kinetic energy to potential energy and back again.

Materials Needed (per pair of students):
- soda can
- rubber band
- large metal washer or sinker
- string, 10 cm. long
- two wooden toothpicks
- yard or meter stick
- scissors
- paper clip
- Worksheet 5-1

Background:

The Comeback Can (when rolled away from you) slows down, stops and reverses it roll to return to you. Is it magic? No, it's energy transfer!

When the can rolls, the weight, being pulled by energy, causes the rubber band to twist. When the rubber band twists, it stores potential energy. When the can stops rolling, the stored energy in the rubber band is transformed into kinetic energy and it rolls back. Some of the energy is converted into friction as the can rolls backwards. The students may notice that it doesn't return to its original starting position.

Preparation:
1. Using the scissors or a nail and hammer, punch a small hole in the bottom of the can in the center. The flip-top lever on top of the can may act as an anchor at the top.

Procedure:
1. Divide the students into pairs and have each pair construct a can according to the directions.

2. Tie the weight to the center of the rubber band with the string. Trim the extra string off.

3. Unfold the loops of the paper clip and create a hook with a long handle.

4. Slip the hook from the outside bottom to the inside and up through the top opening. Hook a loop of the weighted rubber band and pull the end through to the bottom of the can. Carefully slip the weight through the opening. Loop the exposed end of the rubber band under the flip-top to anchor it on top. If the flip-top is gone, use a toothpick.

5. Once you have pulled the rubber band through, slip a toothpick through the loop on the outside of the bottom, to hold the rubber band in place. Remove the paper clip hook. The Comeback Can is ready to roll.

6. One student pushes the can gently and the partner marks the point at which the can stops rolling forward and begins to roll back. Measure the distance and record it on the chart.

7. Partners take turns and repeat the roll two more times, pushing the can a little harder each time. Partners will record results.

Discussion:

• When did it roll the farthest? (when it was pushed the hardest and rolled the fastest)

• How does the strength or force of the push affect the can's kinetic energy? (The harder it was pushed, meaning the more energy you transferred to the can, the more kinetic energy it had. Thus, the more potential energy it stored and released.) As the can turns, the heavy nut makes the rubber band twist. The twisting is stored energy.

• How does this stored energy make the can return to you? (The stored energy is transformed to kinetic energy when the rubber band unwinds, causing the can to roll back.)

• How could you make the can go faster? What do you think would happen if you used more washers? What if you used a thicker or a longer rubber band? Could you design a can that will roll down a ramp and back up? Have the students try it!

2. FOLLOW THE BOUNCING MARBLE

Purpose: To determine what happens to energy after it is used.

Materials Needed (per pair of students):

• two rulers (12-inch)
• string (24 inches)
• duct tape
• a book
• two marbles
• Worksheet 5-2

Background:

According to the Law of Conservation of Energy, energy is never lost. The marbles in this activity will continue to hit each other and bounce away after the initial infusion of energy from the student until they finally stop moving. In initially raising the marble, it is given an increase in potential energy, which is released as kinetic as gravity pulls it down. The marbles exchange energy with each other as they collide, receiving a specific amount of energy with the collision. They also receive direction as they push away from each other.

The energy of motion is transformed into heat energy as the marbles collide with each other and rub against the air molecules. Because of their small mass, we are not easily able to detect the heat energy. The marbles stop moving when their energy has been released to the air around them.

Procedure:

1. Divide the class into pairs.
2. Fold the string in half and tape the center of the string to the end of the ruler.
3. Use a small piece of tape to attach a marble to each end of the string. The tape sticks best to clean and oil-free marbles. Be sure that both strings are of equal length.
4. Pull one marble away from the other and measure the distance between them. Release the raised marble. Note the time. Observe the motion of the marbles until they return to rest. Note the time when they come to a complete stop.

Discussion:

Have the students share their data on the distance of separation of the two marbles and the time it took for them to come to a complete rest. Guide them to finding a correlation between the distance and time. What impact would a larger marble have on these observations? Where did the energy go? What if two larger/smaller marbles were used? Would there be any difference? What if a large and a small marble were used? Would there be any difference?

****

PROGRAM SYNOPSIS:

Energy transfer is constantly taking place. In fact, everything we do requires an energy transfer. Ed and TJ really get things moving.

• Showing Potential and Kinetic Energy

Viewer Question # 1: "What types of energy transfer can you name?"

• Can Racing, Energy Transfer in Bikes and Rollerskates
• Potential and Kinetic Energy on the playground

Viewer Question # 2: "Where is the energy stored that a slinky uses to get down the steps?"

• Energy in Toys
• Electrical Energy
• Chemical Energy

Viewer Question # 3: "What types of energy transfer takes place to run a remote-controlled car?"

• Energy Extraction and Absorbsion
• Basketbal Energy
• Energy Transfer

****

AFTER VIEWING:
1. SLIPPING AND SLIDING!

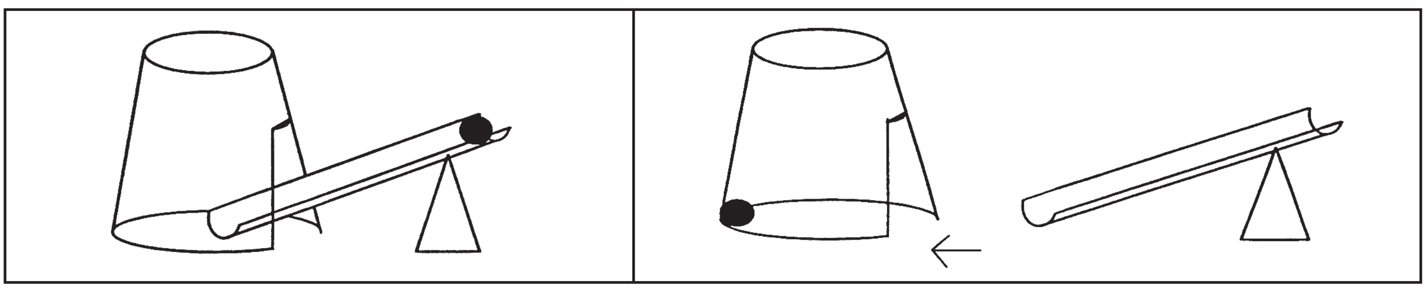
Purpose: The students will explore the transfer of energy from a rolling object to a sliding object. They will identify the variables in the systems they construct and will predict relative amounts of energy involved in activities with the stated variables.

Materials Needed (per pair of students):
- measuring stick
- hex nuts or paper cups, two oz. size
- Worksheet 5-3
- ramp made of paper towel or gift wrap, roll-sliced lengthwise
- marbles from “Follow the Bouncing Marble” activity

Background:

The students will gather evidence about energy transfer from one system to another using a slider (cup or hex nut) and a sphere. The slider (hex nut or paper cup) is stationary at the end of the ramp. The sphere (marble) will be rolling down the ramp and will impact the slider, causing it to slide. The ball has energy of position, or stored energy. When it is released, that stored energy is converted to kinetic or energy of motion. The marble has the greatest kinetic energy as it gets to the end of the ramp and hits the stationary object. The kinetic energy at impact is transferred to the slider. That kinetic energy slides the cup or nut across the floor. The amount of energy transferred is approximately equivalent to the distance it travelled (some of it is lost to friction between the slider and the floor.) The students will control the variables to draw conclusions about energy transfer.

If they increase the slope of the ramp, the distance the slider moves should also increase. Increasing the slope increases the potential energy, which means there is more energy to convert to kinetic at the end of the ramp.



Preparation

Designate an area of the classroom as the slider alley. It must be a smooth surface; either a table top or the floor if it is uncarpeted. Wood or tiled surfaces are acceptable. Each student group will require a space of about two feet by six feet. (The cafeteria or gym are ideal if available.)

Procedure:

1. Divide the class into pairs. Talk about the motion that a marble or a sphere makes when it is given energy; then talk about the motion a hex nut or cup makes when it is given energy. What are the differences? Explain that they will roll the marble down the ramp and try to hit the sliding object (either the cup or hex nut.) The object of the activity is to see how far they can get it to slide when it is hit by the marble. Ask them how they could make sure that the same amount of energy could be transferred several times in a row. Challenge them to find out what factors affect the amount of energy transferred.

2. REMEMBER: The slider is to be placed one inch from the end of the ramp. The marble is to be released in the ramp without being pushed. Try to keep as many variables constant from one trial to the next.

3. Students will adjust the height of the slope of the ramp to change the velocity of the marble.

4. Students will record the data on the worksheet.

Discussion:

Have the students exchange ideas about the energy transfer from the sphere to the slider. Encourage them to volunteer their observations about the activity and to identify the variables that affect the amount of energy transferred. Record their observations on the board or overhead.

Have the students trace the energy path for the interaction of the marble and the cup. They should easily identify the energy of the marble back to their muscles.

Ask the students to review all the variables suggested and try to group them. They will probably group out into four general headings:

- those related to the spheres and sliders used
- those related to energy transfer to the sphere while it rolls down the ramp
- those related to the interaction of the mable with the cup
- those related to the interaction of the cup with the slider alley

What if a larger marble were used? What if two marbles were used? How would this affect the energy transfer to the cup? Try it.

How could the distance travelled be improved? In other words, how could the energy transfer from the sphere to the slider be made more efficient?

2. PLAYGROUND SCIENCE

Purpose: The students will gather evidence about the different ways energy is transferred on the playground equipment by interacting with the equipment.

Materials Needed:

- one outside playground
- Worksheet 5-4

Background:

The playground equipment is really a physicists' playground. All of the big toys that the children delight in are excellent examples of energy transfer systems. Each piece of equipment demonstrates a transfer of energy either from potential to kinetic or one form of kinetic energy to another.

Playground equipment requires multiple energy transfers in order to operate so it is considered an "energy system." The systems require an input of energy from the child in order to achieve motion. On the swing, for example, a child pushes off from the ground and "pumps" his/her legs in order to cause the swing to go higher. Which way do their legs work in order to get the swing to go higher? The mission of each team of children will be to identify the energy systems; tracing the path of the energy throughout the play activity to learn where the energy comes from and where it goes.

Procedure:

1. Have the class identify all the playground equipment. List their ideas on the board or overhead. Ask them if they should include themselves on the list and why or why not? The list can include all the stationary equipment such as swings, slides, seesaws and monkey bars as well as jump ropes and the like.

2. Divide the class into working teams of three or four students. Assign each group a piece of playground equipment that the class identified.

3. Take the students out to the playground with the understanding that they are to interact with the piece of equipment they have been assigned. Give them about 10 minutes to play on their assigned equipment. Then, reconvene the working teams.

4. The working teams now have evidence to complete the worksheet.

Discussion:

Have each working team report their findings to the group using the data they recorded on their worksheet. You may want to summarize their information on the overhead or the board.

In summary, have the students identify generally for each playground system they investigated:

- Where is the stored energy?
- Where is evidence of energy being used?
- Where is their interaction?
- Where does the energy come from to make it move?
- Where does the energy go?

What kind of systems are there in their own homes that use energy? (toys, watches, cassette tape players, television, appliances) Encourage the students to think of one and have the class analyze the energy interactions.

Worksheet 5-1: The Comeback Can

Name: ____

DIRECTIONS: Construct the can according to your teacher's instructions. While one partner GENTLY pushes the can, the other marks the point where the can stops and begins its return roll. Measure the distance and record below. Repeat the test and try to come to the same distance. Partners then switch roles and repeat the procedure. This time, roll the can with a little more force. Measure the distance and record below. Repeat and try to get the can to roll the same distance.

	Trial # 1	Trial # 2	Trial # 3
Partner # 1 Name: ___________ ___________			
Partner # 2 Name: ___________ ___________			

QUESTIONS:

- When did the can roll the furthest?
- Where did the energy for the can to move come from?
- Where did the energy go?
- What would happen if you added more weights to the rubber band?
- How could you make the can go faster without pushing it harder?

Worksheet 5-2: Follow the Bouncing Marble

Name: ____

DIRECTIONS: Record all your data in the spaces below. Conduct at least two trials at the same distance in II.

		Trial # 1	Trial # 2	Trial # 3	Trial # 4
I. Measure the length of the string from the ruler to the marbles					
II. Measure the distance between the two marbles when you pull away one					
III. Record the time before you let go					
IV. Measure the distance they bounce apart from each other after the					
	first collision				
	second collision				
	third collision				
V. Time it stopped bouncing					
VI. Time it took to stop bouncing					

THINK ABOUT IT!

- Which distance of separation had the most bounces?
- Which distance of separation took the longest to stop?
- Where did the marbles get the energy to move?
- Where did the energy go?
- What if you used two marbles of DIFFERENT sizes?

Worksheet 5-3: Slipping and Sliding

Name: ____

	Trial # 1	Trial # 2	Trial # 3
Height of slope			
Start time			
Finish time			
Distance slider travelled			
Time taken			

	Trial # 1	Trail # 2	Trial # 3
Height of slope			
Start time			
Finish time			
Distance slider travelled			
Time taken			

THINK ABOUT IT!

- When did the slider move the furthest?
- What energy does the marble have when you are holding it?
- Where does the marble's energy come from?
- Where does the marble's energy go?
- What if you used a heavier marble?

Worksheet 5-4: Playground Science

Name: ______________________________________

DIRECTIONS: In the space below, record all the energy systems you see on your assigned playground equipment.

Playground toy: ____

Energy systems we found:

1.

2.

3.

4.

5.

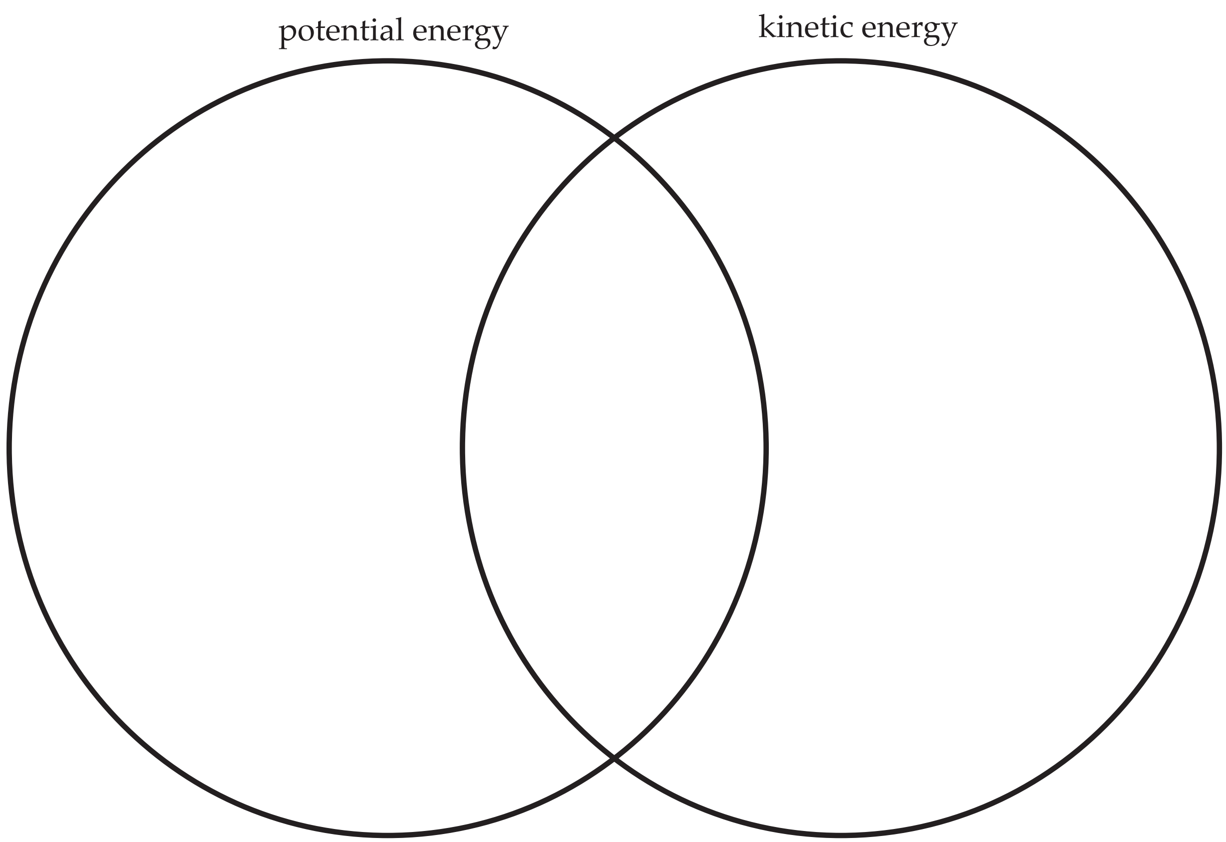
6.

THINK ABOUT IT!
- Where is the energy stored in each part?
- Where does the energy come from to make it move?
- Where does the energy go?

Worksheet 5-5 (Use this worksheet during the broadcast.)

Name:____

DIRECTIONS: As you watch the program and see examples of either potential or kinetic energy, write the example in the appropriate circle. Do you see any that might be examples of both? (Write those in the area where the circles overlap.)



T.J. and Ed mention at least two things that affect energy.
Name them:

1. ____________________________________

2. ____________________________________

TEACHERS GUIDE # 6: LET'S MOVE IT NOW!: USING ENERGY TO DO WORK

MAIN IDEA: We use energy to do work for us.

BACKGROUND:

Electricity provides energy for a motor to pull the cars of a roller coaster up the first hill. Gasoline and other fuels provide energy that makes cars and buses move. We channel energy to do work.

Work is done when a force acts on an object and changes its motion. We use simple machines to help us work by either increasing speed, increasing force or changing the direction of force. Machines use kinetic and potential energy in the forms of mechanical, chemical, electrical, solar or gravitational energy to perform their work.

BEFORE VIEWING:

1. BROOM PULLEY

Purpose: To demonstrate to the students how easily things are moved with machines. Pulleys can change direction of motion, and multiple pulleys increase force.

Materials Needed (per pair of students):

• two dowel rods (1 to 1.5 inches in diameter) — broomsticks or baseball bats work well • a nine-foot length of rope • two student chairs (if your floor is tiled) (NOTE: If your floor is carpeted, have the students do the activity standing and instruct the students holding the rods that they are going to try to keep the rods apart from one another.) • gloves • Worksheet 6-1

Background:

Pulleys are often used to change the direction of pull. A flag is raised up by pulling a rope down. Pulleys may also multiply pulls when used in combination. A combination pulley is a series of pulleys interconnected by a rope. Some of the pulleys are stationary and some have movement. A block and tackle is a combination of several pulleys and its rope.

Procedure:

1. Students will work in pairs. Try to pair two students of obviously different weights. Have two PAIRS of students (four students) work as a team.

2. Set the two chairs a few feet apart with the backs toward each other.

3. One student sits on each chair facing each other. The back of the chair will be at their chest. Each should be holding his/her stick with one hand wrapped around each end. (Caution: They should wear gloves to avoid chafing their hands.)

4. Team members tie one end of the clothesline or rope to the middle of the stick held by the smaller of the two seated partners. Curve it around the other's stick and bring it over the shoulder of the smaller student.

5. Predict whose chair will move when the rope is pulled. Will it be the chair of the smaller or larger student? Why?

6. A standing team member pulls the rope while the two seated hold their stick tightly and lift their feet off the floor.

7. Observe and record whose chair slides. Is it the one they expected?

8. Have the seated students exchange places with their two standing team members and repeat the process ONLY THIS TIME have the larger student of the two sit in the chair holding the stick with the knotted rope.

9. Predict whose chair will move.

10. Observe and record whose chair moves when the rope is pulled. Is it the one they expected? Is it because the rope pulls a normal amount on one stick but twice as much on the other stick?

11. To answer that hypothesis, loop the rope around the stick it is tied to. Now it can pull three times as much on the knotted stick and only twice as much on the other. Predict which chair will slide when the rope is pulled.

12. Observe and record whose chair moves when the rope is pulled.

Discussion:

When someone pulls on a rope with a given amount of force, the pull acts all along the rope. But if the rope goes around a stick, the force pulls doubly on the stick. Have the students predict, based on their experience, how a 2,000 pound crate of cargo is hauled off a ship.

2. JET INVENTION

Purpose: The students will investigate the use of stored air pressure as a means of doing work.

Materials Needed (per class): • string (at least 40 meters)

Materials Needed (per student pair):

- three medium balloons or one large balloon
- scissors
- one sheet of construction paper, 9" x 12"
- one plastic straw
- two rubber bands
- tape
- Worksheet 6-2

Background:

Transportation is one area that has depended uponthe design of machines. Discuss with the students the methods of transportation devised over the years, beginning with foot travelers and riding animals up to present day (boats, cars, trains and planes). Discuss the changes these modes of transportation have had on our society. One of the major impacts in transportation was the jet engine. The activity below demonstrates the basic concept behind jet propulsion.

Procedure:

1. Divide the class into working partners.

2. Cut the construction paper lengthwise into three equal strips. Roll the first strip into a tube so that the hole is about 1/2 cm. in diameter. Use two or three pieces of tape to hold the tube closed. Use the two other strips to make tubes that are one and two cm. in diameter.

3. To construct the engines, blow the balloons up a few times to stretch them out. Attach a balloon to the end of each tube. Put about half the tube into the opening of the balloon. Carefully wrap a rubber band over the balloon and tube. Don't crush the tube. The widest tube may fit snugly inside the balloon without using a rubber band. If your engines are getting crushed by the rubber bands, re-roll the tube using a longer or a double thickness of paper to increase the thickness of the walls of the tube.

4. Pace out an area of the classroom for the launch string. Decide on how many runs you want to create and cut the string accordingly. Use two chairs as the ends of the run and tie the starting end of the string(s) onto one chair.

5. Thread the other end of the string through the straw, then tie the end of the string to the other chair at the end. MAKE SURE THE STRING IS TIGHT AND LEVEL.

6. Blow up the balloon on the narrowest tube. Pinch the balloon so no air comes out, taking care not to crush the tube.

7. The other partner tapes the tube to the straw. Slide the "vehicle" to the starting end of the string. The partner gets ready to time the launch. Launch the vehicle by letting go and allowing the air to rush out of the "engine" when the partner says "GO." The partner stops timing when the jet stops moving on the track.

8. Record the time taken. Measure and record the distance that the vehicle travelled.

9. Make a prediction as to whether the other engines with the larger tubes will travel faster and/or farther than the first one.

10. Repeat the procedure using the other two engines. Record the time and distance of each flight.

Discussion:

Which vehicles travelled the fastest according to the students' data? Which one travelled the farthest? What conclusions can they draw about the best type of engine for jets? Can they invent another kind of vehicle, engine or launch string that will work better? Would more than one engine help? What problems might it cause? The students might test out their hypotheses for more efficient engines. You may want to have them race their own designs against one another.

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PROGRAM SYNOPSIS:
We use energy to do work. Simple machines use energy and make our lives a whole lot simpler.

• Simple Machine Balloon Launcher
Viewer Question #1 "Can you name a simple machine?"
• Levers and Fulcrums
• Clever Levers
Viewer Question #2 "What simple machine or combination of simple machines can TJ use to get Ed, in a wheelbarrow, over a curb?"
• Pulleys
• Simple Machines at a Tool Rental Store
Viewer Question #3 "How could you move a heavy phone booth to the other side of the room?"
• Simple Machines in Toys
• Simple Machines in a Robot

****

AFTER VIEWING:
1. IMAGINATION CREATION
Purpose: Using the information gained throughout the activities of this lesson on work and simple machines, the students will devise a whimsical invention (made of multiple machines) that does the work assigned.

Materials Needed:
• WORK! Cards (Worksheet 6-3)
• Students will gather up all the materials they require for their machine.

Background:
Machines that do work for us have been discussed throughout the previewing activities and the show. Ask students if they've ever seen the Mouse Trap board game. Discuss with the class different types of multiple, roundabout machines they might devise to complete a simple task. The students are to take their knowledge of simple machines and devise a whimsical machine to do the work described on the card they pick.

Remind them that they will have to experiment with their system to make sure that their machine completes the task assigned.

Procedure:
1. Divide the class into teams of four.

2. Give each team a WORK! card from Worksheet 6-3.

3. Instruct each team that they are to devise the wacky machine to do the work described on their card. They are to use at least four different machines. They can be ones that they tried in the Before Viewing Activities or ones that they saw on the program itself or any others that they think might work.

4. The team is to diagram the machine with all of its components on paper. They are to list out all materials required to build the machine and decide among themselves who will be responsible for obtaining which components.

5. The teams will build their machines and test them. They are to make necessary modifications to make them successful. Remind them that it is vital that they record all changes to their original design.

Discussion:
Each team should demonstrate their machine to the rest of the class and discuss what changes they had to make from their original design to the final product. Discuss with the class after all presentations have been made what they thought about the changes they had to make to their design in order to make it work. Have the students discuss how they think new cars are developed, or new products like Trapper Keepers.

Worksheet 6-1: Broom Pulley

Name: ______________________________________

DIRECTIONS: Record all your observations of the pulley system in the spaces provided.

Trial 1: Single Loop System A. First team: Who will move?	
Predict:	
Actual:	
B. Switch places: Who will move?	
Predict:	
Actual:	
Trial 2: Double Loop System A. Second team: Who will move?	
Predict:	
Actual:	
B. Switch places: Who will move?	
Predict:	
Actual:	

QUESTIONS:
- Which chair moved in the SINGLE loop trials?
- Which chair moved in the DOUBLE loop trials?
- What do you think would happen if you had an equal number of loops on each bar?

Worksheet 6-2: Jet Invention

Name: ____

DIRECTIONS: Record the time and distance traveled for each of the three engines you have constructed in the spaces provided below.

	Trial # 1		Trial # 2		Trial # 3	
	Distance	Time	Distance	Time	Distance	Time
1/2 cm. tube						
1 cm. tube						
2 cm. tube						

QUESTIONS:
- Which engine traveled the fastest?
- Which engine traveled the farthest?
- What made the fastest engine different from the other two?
- What if you added another balloon to the slowest one?

Worksheet 6-3: Work! Cards

DIRECTIONS: Separate and distribute one of these cards to each of the working teams. REMEMBER, EACH MACHINE SHOULD CONSIST OF AT LEAST FOUR SIMPLE MACHINES.

CLOSE A DOOR	DROP A LID ON A JAR
FLIP A COIN INTO A BOWL	PLACE A SPOON IN A GLASS
TURN THE PAGE OF A BOOK	DROP A NAPKIN ON A SPOT OF WATER
PLACE A WAD OF PAPER IN THE BASKET	FLIP A LIGHT SWITCH

Worksheet 6-4: Predictions (Use this worksheet during the broadcast.)

Name:____

DIRECTIONS: Today's program is about simple machines. Before watching "Blow the Roof Off!," write down as many simple machines as you can think of. While you watch the show, check off all the ones you actually see. After the program, compare your list with others in your class. Did you think of some you saw? Some that you didn't see? Some that no one else thought of?

	Prediction	Viewed on "Blow the Roof Off!"
(example)	**T.J. and Ed**	✓

TEACHERS GUIDE #7: INVENTIONS . . .WHAT IF? USING SCIENCE TO CREATE INVENTION

MAIN IDEA:
Students will identify a need that is not currently satisfied and will design and build an invention to solve the need.

BACKGROUND:
Throughout the 6 previous programs of "Blow the Roof Off!," ideas and applications in various areas of science have been presented and discussed. Each of the topics presented was supplemented by a variety of "Before Viewing" and "After Viewing" activities which were geared to guide the student to a clearer understanding of the principles addressed in that particular episode. In "Energy: Let's Move It Now!: Using Energy to Work," the "After Viewing" activity titled "Imagination Creations" encouraged students to create a machine to perform a task. The extension of that project is to challenge the student to use their imaginations to invent something that solves a problem or need.

This seventh episode of "Blow the Roof Off!" will feature students who have identified a problem or need and have developed an invention to satisfy or solve it.

Procedure: (This project may take as long as you deem necessary to complete)
1. Divide the class into cooperative working groups of three or four.

2. Each group brainstorms to create a list of problems or needs that they can address. Have each group come to a consensus on ONE identified need or problem.

3. Each group works cooperatively to invent a product to solve their problem or satisfy their identified need.

4. Each group will present their invention to the rest of the class.

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PROGRAM SYNOPSIS:

- Solar Car
- Student Inventions
- One-Wheeled Motorcycle
- Student Inventions
- Kidney Dialysis Machine
- Camp Invention
- Chemical Inventions
- Potty Light

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TEACHERS GUIDE #8 : SHOPPING FOR SCIENCE: SCIENTIFIC APPARATUS AVAILABLE AT A DISCOUNT STORE

MAIN IDEAS:

1. Inexpensive materials for science activities can be found in your neighborhood discount store.
2. Fifteen science activities you can do in your own classroom.

BACKGROUND:

More often than not, the most difficult part of doing hands-on science activities is finding the materials and organizing them. This program shows how to shop at discount stores, grocery stores and the local electronic store to find all you will need to do 15 different activities. The total cost for all the items is $50.

All the activities address topics commonly found in the fourth- and fifth-grade curriculum.

Materials Needed:
Our "Science Sleuths" will show you where to shop for science materials at the following locations:

Grocery Store

Materials	Activity
Flavor extracts	Sense of smell
Food coloring	Surface tension
Plastic cups	Surface tension
Meat trays	Planetary motion
Tuna cans	Barometer
Ziploc bags	Activity storage
Straws	Barometer

Discount Pet Center

Materials	Activity
Thermometer	Heat absorption

Discount Hardware Store

Materials	Activity
Wire	Simple circuits
Pulleys	Simple machines
Washers	Simple machines
Paint stirrers	Reaction timer

Radio Shack™

Materials	Activity
30X Microscope	Observations
Magnets	Floating magnets
Test leads	Simple circuits
Light bulbs	Simple circuits
Bulb holders	Simple circuits

Plastics Company

Materials	Activity
Plexiglass mirrors	Mirrors that multiply
Plexiglass	Frictionless pucks

Photo Store

Materials	Activity
Film canister	Sense of smell

Discount Plumbing

Materials	Activity
4" PVC pipe	Erosion trough
Couplings	Erosion trough
Grate	Erosion trough
PVC elbow	Simulated eardrum

Barbershop

Materials	Activity
Plastic bottles	Surface tension

The following science activities will be demonstrated:

- Sound and how your ear works
- Soil profiles
- Static electricity
- Reflection and math concepts using mirrors
- Simple spring scales
- Repelling magnets
- Simple electric circuits
- Simple machines
- Reaction timer using a paint stirrer
- Sense of smell
- Phases of the moon
- Air pressure
- Surface tension
- Heat absorption
- Making a barometer

Blow the Roof Off
Science Standards

(updated Oct. 2005)

Video 1 How Do We Know? The Scientific Method

Grade 4

Scientific Ways of Knowing

Nature of Science

1. Differentiate fact from opinion and explain that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.
2. Record the results and data from an investigation and make a reasonable explanation.
3. Explain discrepancies in an investigation using evidence to support findings.

Ethical Practices

4. Explain why keeping records of observations and investigations is important.

Grade 5

Scientific Ways of Knowing

Nature of Science

1. Summarize how conclusions and ideas change as new knowledge is gained.
2. Develop descriptions, explanations and models using evidence to defend/support findings.
3. Explain why an experiment must be repeated by different people or at different times or places and yield consistent results before the results are accepted.
4. Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer (e.g., observations of things or events in nature, data collection and controlled experiments).

Ethical Practices

5. Keep records of investigations and observations that are understandable weeks or months later.

Video 2 What Goes Around? Cycles Are Predictable Patterns

Grade 4
Life Science
Heredity

1. Compare the life cycles of different plants including germination, maturity, reproduction and death.

5. Describe how organisms interact with one another in various ways.

Grade 5
Science and Technology
Understanding Technology

1. Investigate positive and negative impacts of human activity and technology on the environment.

Video 3: Let There Be Light: The Properties of Light

Grade 5
Physical Sciences
Nature of Energy

5. Explore and summarize observations of the transmission, bending (refraction) and reflection of light.

Video 4: Is There an Energy Store? Where Does Energy Come From

Grade 7
Physical Sciences
Nature of Matter

1. Investigate how matter can change forms but the total amount of matter remains constant.

Nature of Energy

2. Describe how an object can have potential energy due to its position or chemical composition and can have kinetic energy due to its motion.
3. Identify different forms of energy (e.g., electrical, mechanical, chemical, thermal, nuclear, radiant and acoustic).
4. Explain how energy can change forms but the total amount of energy remains constant.
5. Trace energy transformation in a simple closed system (e.g., a flashlight).

Video 5: Where Did It Go? Energy is Neither Created Nor Destroyed

Grade 5

Physical Sciences

Nature of Energy

2. Trace how thermal energy can transfer from one object to another by conduction.
3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.
4. Trace how electrical current travels by creating a simple electric circuit that will light a bulb.

Video 6: Let's Move It Now! Using Energy To Do Work

Grade 3

Physical Science

Forces and Motion

2. Describe an objects motion by tracing and measuring its position over time.
3. Identify contact/noncontact forces that affect motion of an object (e.g., gravity, magnetism and collision).
4. Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Video 7: Inventions…What if? Using Science eto Create Invention

Grade 3

Science and Technology

Abilities To Do Technological Design

4. Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions and design a solution).
5. Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).

Grade 4

Science and Technology

Abilities To Do Technological Design

3. Describe, illustrate and evaluate the design process used to solve a problem.

Notes

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