Exploring Energy

Use these hands-on activities to explore relevant energy topics with upper elementary students.

E
GENERAL ENERGY

Grade Level:
- Elementary
- Intermediate

Subject Areas:
- Science
- Social Studies
- Math
- Language Arts

NEED
National Energy Education Development Project

Teacher Advisory Board

Teacher Advisory Board Vision Statement

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.

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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TABLE OF CONTENTS

NEED
Putting Energy into Education

Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

INTERMEDIATE (GRADES 5-8) CONTENT STANDARD–A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Identify questions that can be answered through scientific inquiry.

b. Design and conduct a scientific investigation.

c. Use appropriate tools and techniques to gather, analyze, and interpret data.

d. Develop descriptions, explanations, predictions, and models using evidence.

e. Think critically and logically to make the relationships between evidence and explanations.

f. Recognize and analyze alternative explanations and predictions.

g. Communicate scientific procedures and explanations.

h. Use mathematics in all aspects of scientific inquiry.

INTERMEDIATE CONTENT STANDARD–B: PHYSICAL SCIENCE

3. Transfer of Energy

a. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.

b. Energy is transferred in many ways.

c. Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

d. Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection).

e. Electrical circuits provide a means of transferring electrical energy.

f. In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.

g. The sun is the major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths.

Teacher Guide

TO INTRODUCE ELEMENTARY STUDENTS TO A VARIETY OF ENERGY TOPICS WITH HANDS-ON ACTIVITIES.

BACKGROUND

Exploring Energy is a series of separate backgrounders and hands-on activities that explore familiar energy topics. Each of the activities can be used individually to supplement other activities.

TIME

Each activity has individual time requirements.

MATERIALS

Each activity has individual material requirements.

PROCEDURE

- Choose an activity.
- Gather the materials necessary for the activity.
- Make copies of the backgrounder and other forms required in the activity.

How Do Cars Work?

Turn the key. Shift into gear. Hit the gas. And away you go! Aren't cars amazing? Pump in some gas and they'll take you almost anywhere. Driving a car seems simple. Understanding how a car works is another story. Cars are full of strange gizmos and mysterious parts.

Gasoline is the fuel for most cars. Gasoline is made from petroleum—it contains chemical energy. How does a car engine change that chemical energy into motion? Let's start at the gas pump to solve the mystery of the car, one step at a time.

When you pump gasoline into a car, it goes into the **fuel tank.** This is where the gas is stored. The fuel tank is usually away from the engine and passengers, for safety. Most fuel tanks hold about fifteen gallons of gasoline.

A **fuel line** runs from the fuel tank to the engine. It is a thin metal pipe. A **fuel pump** pumps the gasoline through the fuel line into the carburetor. Electricity from the car's **battery** runs the fuel pump.

The **carburetor** mixes the gasoline with just the right amount of air. Then, it sprays the mixture through an air pipe into the **cylinders** of the engine. Some cars use **fuel injectors**, instead of carburetors, to control the gas-air mixture.

The **accelerator** (gas pedal) controls the amount of gasoline and air that go into the engine. When you push down on the gas pedal with your foot, it opens a valve in the air pipe. The harder you push on the gas pedal, the more fuel goes into the cylinders. Most car engines have four cylinders. High-powered cars might have six, eight, or even more. These cylinders are attached to each other by a **crankshaft**.

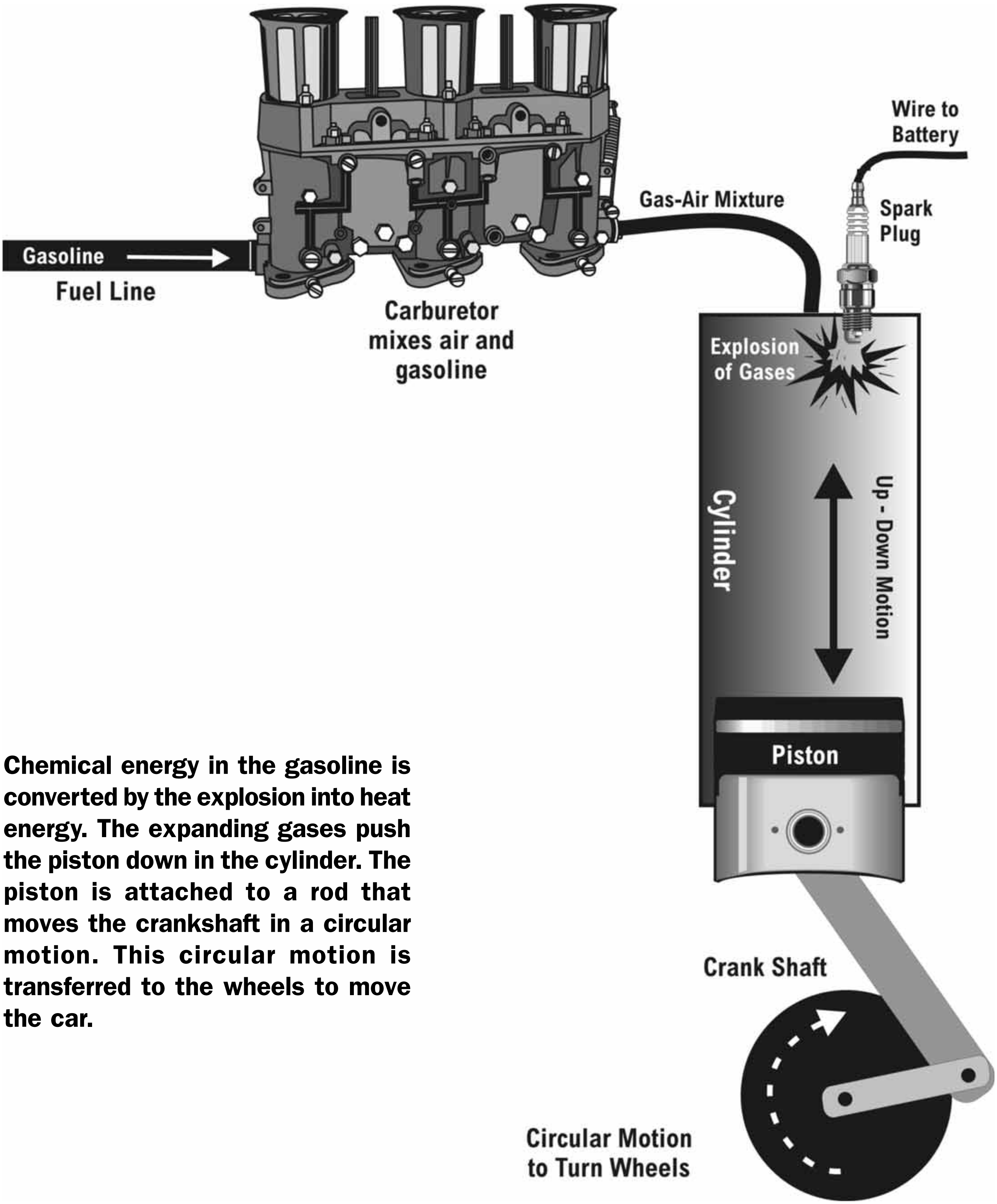
Inside each cylinder, the gas-air mixture is compressed or squeezed to make it hotter. Then, a spark from a **spark plug** ignites it, causing a small explosion. The explosion pushes a **piston** down inside the cylinder, moving the crankshaft. The chemical energy in the gasoline is burned to make mechanical energy.

As the piston rises again, it pushes out any leftover gases. It is ready for the next explosion. Hundreds of these tiny explosions occur every minute. Each cylinder fires in turn, pushes down a piston, and moves the crankshaft. The more cylinders you have, the faster the crankshaft moves.

The **crankshaft** changes the up-and-down movement of the pistons into a circular motion. And this circular motion is what turns the wheels of a car. Of course, it isn't as simple as it sounds. The turning motion has to go through the **transmission**, with all its **gears**, and through the **drive shaft** to reach the wheels. Sometimes the motion is sent to the front wheels, sometimes to the back and, sometimes, to all four wheels.

Every car has a **battery** that makes electricity. It's the battery that makes the spark plugs *spark* and the fuel pump *pump*. It runs the radio, the wipers, the signals, the air conditioner, and the lights. It's a rechargeable battery. Once the car is running, energy from the engine keeps it recharged. Otherwise, you'd need a new battery every day.

A car has many other systems. It has **brakes** and a **steering system**. It has a **cooling system** for the engine and an **exhaust system** to get rid of waste gases. It has **springs** and **shocks** for a comfortable ride. Add all of these systems together and you get a moving machine. It might be complicated, but it doesn't have to be mysterious.



Chemical energy in the gasoline is converted by the explosion into heat energy. The expanding gases push the piston down in the cylinder. The piston is attached to a rod that moves the crankshaft in a circular motion. This circular motion is transferred to the wheels to move the car.

Activities: How Do Cars Work?

1. This morning, Georgia and her mother climbed into their trusty old station wagon. When Georgia's mom turned the key, the car sputtered a few times, but wouldn't start. It was running fine last night! What could the matter be?

Georgia decided to investigate. She made a list of all the things about the car that she noticed. Put a check beside the things you think might be important.

o Mom put a different kind of gas in the car yesterday.

o I can't see any gas in the fuel tank.

o Someone left the gas cap off and it rained last night.

o Someone left the windows open.

o Someone left the headlights on all night.

o The back tires look like they need air.

o A wire to the battery looks loose.

o There's not enough oil in the engine.

o The engine looks dirty.

o It looks like the engine is wet from the rain.

o The radio doesn't work.

o The emergency brake is on.

Why do you think the car won't start?

2. Ask an automobile mechanic to come to the school to show you the different parts of a car and how they work together.

The Greenhouse Effect

Our earth is surrounded by a blanket of gases called the atmosphere. Without this blanket, our earth would be so cold that almost nothing could live. It would be a frozen planet. Our atmosphere keeps us alive and warm.

The earth's atmosphere is made up of nitrogen, oxygen and greenhouse gases—water vapor, carbon dioxide, methane, chlorofluorocarbons (CFCs), ozone, and nitrous oxide.

Rays of sunlight (radiant energy) shine down on the earth every day. Some of these rays bounce off clouds and are reflected back into space. Some rays are absorbed by molecules in the atmosphere. About half of the sunlight passes through the atmosphere and reaches the earth.

When the sunlight hits the earth, most of it turns into heat (thermal energy). The earth absorbs some of this heat. The rest flows back out toward the atmosphere. This keeps the earth from getting too warm.

When this heat energy reaches the atmosphere, it stops. It can't pass through the atmosphere like sunlight. Most of this heat energy becomes trapped and flows back to the earth. We usually think it's the sunlight that warms the earth, but actually it's this heat energy that gives us most of our warmth.

We call this trapping of heat the greenhouse effect. A greenhouse is a building made of clear glass or plastic. In cold weather, we can grow plants in a greenhouse. The glass lets the sunlight in, then traps the heat inside. The light energy can pass through the glass; the heat energy cannot.

What is in the atmosphere that lets light through, but traps heat? It's those greenhouse gases—mostly water wapor, carbon dioxide and methane. These gases are very good at absorbing heat energy and sending it back to earth.

In the last 50 years, the amount of some greenhouse gases has increased dramatically. We produce carbon dioxide when we breathe and when we burn wood and fossil fuels—like coal, oil, and natural gas. Some methane escapes from coal mines and oil wells. Some is produced when plants and garbage decay. Some animals also produce methane. One cow gives off enough methane in a year to fill a hot air balloon!

Many scientists think these greenhouse gases are trapping more heat in the atmosphere. They think the average temperature of the earth is beginning to rise. They call this global warming. They think that if the temperature of the earth rises just a few degrees Fahrenheit, it will cause major changes in the world's climate. Some scientists think there may be more floods in some places and droughts in others. They think the level of the oceans might rise as the ice at the North and South Poles melts. They think there might be stronger storms and hurricanes. They think we need to act now to lower the amount of carbon dioxide we put into the atmosphere.

Other scientists disagree. They think it is too soon to tell if there will be long-term changes in the global climate. They are not sure that a little global warming would cause bad things to happen. They think some good things might happen—like longer growing seasons for crops and milder winters. They think we should do more studies before we make major changes in the way we use fossil fuels.

What do you think? Do you have enough information to make a good decision?

Activity: Explore the Greenhouse Effect

Purpose: To investigate the effect of carbon dioxide on the temperature in a greenhouse.

Concepts: The earth's atmosphere acts like a greenhouse, warming the earth.

The earth's atmosphere is made up of water vapor and other gases, including carbon dioxide.

Plants take in carbon dioxide and produce oxygen.

Humans and other animals breathe in oxygen and breathe out carbon dioxide.

Burning biomass and fossil fuels uses oxygen and produces carbon dioxide.

Time: One hour a day for five days.

Materials:

20-gallon aquarium with clear glass or plastic top

Sand and a shallow dish of water

Bright light source

Thermometer

Two small paper cups

Several small potted plants with lots of leaves

Plastic straw

Small tea-light candle

Optional: Spray bottle (fine mist) filled with water

Preparation:

Place a one-inch layer of sand and a flat dish of water in the aquarium.

Place the two cups upside down in the middle of the aquarium and rest the thermometer on them so that it is not touching the sand. You want to find the temperature of the air, not the sand.

Procedure:

Part I. Control

Record the temperature.

Cover the aquarium with the clear glass or plastic. Allow to stand in natural light for an hour.

Record the temperature. Note the time of day and lighting conditions. (Is it sunny, is it overcast?)

Place the light source so that it strikes the aquarium from above, about two feet from the top.

Record the temperature at fifteen-minute intervals over a one-hour period.

Part II. Less Carbon Dioxide

Place the plants into the aquarium. Cover with the clear glass or plastic. Allow to stand overnight so that the plants can 'breathe' in some of the carbon dioxide and 'breathe' out oxygen.

Record the temperature at approximately the same time of day as above in natural light. Note the time and lighting conditions.

Place the light source in the same position as before.

Record the temperature at fifteen-minute intervals over a one-hour period.

Part III. More Carbon Dioxide (respiration)

Remove the plants from the aquarium. Cover with clear glass or plastic. Insert the straw into the aquarium by slightly lifting the cover. Have a student breathe through the straw for about a minute. Remove the straw and quickly reseal the cover.

Record the temperature.

Allow to stand in natural light for an hour.

Record the temperature. Note the time of day and lighting conditions.

Place the light source over the aquarium in the same position as before.

Record the temperature at fifteen-minute intervals over a one-hour period.

Part IV. More Carbon Dioxide (combustion)

Place the tea-light candle into the sand away from the paper cups and thermometer. Carefully light the candle and cover the aquarium. (If you are using a plastic cover, use a metal or glass cover for this portion of the experiment until the candle burns out.)

Allow the candle to burn itself out. (If you need to replace the cover, be careful not to allow too much air into the aquarium.)

Record the temperature.

Allow to stand in natural light for an hour.

Record the temperature. Note the time of day and lighting conditions.

Place the light source so that it is in the same position as before.

Record the temperature at fifteen-minute intervals over a one-hour period.

Part V. *(Optional)* Is Water Vapor a Greenhouse Gas?

Place the cover on the aquarium. Through a small opening, spray water vapor into the aquarium. Replace the cover. Record the data as you did in the previous experiments.

Further explorations: Experiment with different sized openings in the cover to allow for circulation, extending the time, removing the water dish, varying the number or kinds of plants, placing colored filters over the top of the aquarium, and varying the distance of the light source from the aquarium. Try spraying other liquids—such as hair spray—into the aquarium.

Recording Form

	Initial Temp	Temp—Natural Light	Temp—Light Source			
Without Plants (control)						
With Plants (less CO_2)						
Respiration (more CO_2)						
Combustion (more CO_2)						
Water Vapor (more H_2O)						

1. Did your aquarium act like a greenhouse?

2. Did reducing the amount of CO_2 change the greenhouse effect?

3. Did increasing the amount of CO_2 change the greenhouse effect?

4. Did adding water vapor change the greenhouse effect?

5. Did your experiment show that CO_2 is a greenhouse gas?

6. Did your experiment prove that global warming is occurring? Why or why not?

Composting

I'll bet most of you recycle at home and at school. In many places, there are recycling programs for paper, glass, aluminum cans, and plastics. If you are already recycling these things, that's good. But you can do more. Did you know that yard waste and food scraps take up more space in dumps, or landfills, than anything else besides paper? It's true. In the summer and fall, grass clippings and leaves can make up almost half the trash sent to landfills. And most of it can be recycled without much work.

Recycling the leftovers of living things like grass, leaves, and food is called **composting**. Composting turns these wastes into humus (hyoo' mas). Humus can be used to mulch around plants or be mixed into the soil to add nutrients, help it hold water, and keep it loose and crumbly.

The waste of all living matter decays in time. You've all seen food in the refrigerator with mold growing on it. That's decay. You've all slipped on the black, slimy leaves in the woods after a long winter, or picked up a huge stick that crumbled in your hands. That's decay, too. Decay is caused by bacteria feeding on the dead matter and breaking it down.

Composting speeds up the natural decay of yard wastes and food scraps to make humus. All you need is the right mixture of waste, water, soil, and air. If the mixture is right, billions of bacteria will break down the waste in a very short time, usually six weeks to three months. This fast decay produces a lot of heat—the inside of a good compost pile can reach 140-160 degrees Fahrenheit.

If the mixture doesn't have enough air (oxygen), it will rot instead of decay. Different kinds of bacteria will be at work, ones that don't need oxygen. They will break down the waste, but it will take much longer and it might smell bad. Many of the nutrients will be lost and the humus won't be as good for the soil. A rotting pile doesn't produce heat like a compost pile does. Too much (or too little) water can also slow down the decay. A good compost pile should be damp, but not soggy. Bacteria need water to do their work, but you don't want to drown them.

Before you put sticks, bushes and tree limbs into a compost pile, you must cut them into small pieces. There are machines called **chippers** to do this. If the pieces of wood are too big, they will take longer to decay. Meat, bones, dairy products, and grease should not be put in a compost pile. They will smell bad and attract wild animals and flies. Other kitchen scraps are good for the pile and will help it decay faster. The best compost piles have a mixture of food wastes, grass, wood pieces, and leaves.

Why should we compost when we could dump or burn our kitchen and yard wastes? First, putting these wastes in landfills takes up a lot of valuable space. We need to put only necessary trash in our landfills. Burning leaves and grass clippings is not the answer either. In many states, open burning is banned because of the risk of forest fires. Breathing the smoke is unhealthy, too. And **incineration** (burning in a furnace) is very expensive.

Farmers have composted their wastes for a long time. In the last few years, compost piles have been turning up in backyards and on school grounds. Some communities have begun to compost on a large scale. Residents separate kitchen waste that can be composted and put it at the curb with their grass clippings, leaves, and tree limbs. Trucks take it to huge composting plants, where it is turned into humus, put into bags, and sold.

Composting is the best solution to the problem of yard and kitchen waste. These wastes are really resources. We can easily recycle them and put them to good use. Why don't you start your own compost pile and encourage your school and community to start composting, too?

Activity: Setting Up a Compost Pile

Purpose: To investigate organic decomposition by setting up a compost pile.

Concepts: Humans produce a lot of organic waste every day. Much of this waste can be composted to produce humus—a usable product.

Composting organic waste reduces the amount of waste placed in landfills and reuses the valuable materials in the waste.

Time: Three hours set-up, plus a few minutes daily for maintenance.

Materials: Compost bin or fencing
Pitchfork
Leaves, soil, water, tarp, and organic waste

Preparation: Get permission from parents or principal.

Procedure:

Pick a place away from buildings, in the shade, and close to an outdoor faucet.

A simple pile will work, but a container is better. You can build a fence with wire or buy a container. It should have holes in it to let in air. A good size is about three feet square and three feet high.

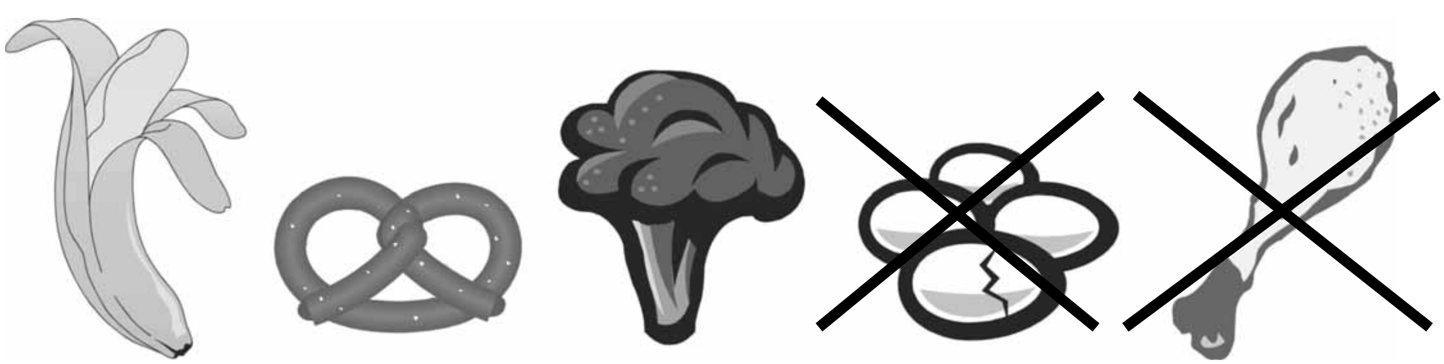
Add layers of leaves, food scraps, and grass clippings. Do not put meats or greasy scraps into the pile. Remember, a good mixture of wastes is the important thing.

Water the pile to keep it damp, but not soggy. Covering it with a tarp will help keep in the moisture.

Turn the pile with a pitchfork once a week to add air to the pile. You should feel heat coming from the pile. (If you like, keep a record of the temperature inside the pile.)

When the mixture becomes dark and crumbly, it is ready to be used. You now have humus to put around bushes and flowers, or spread in a thin layer on the grass.

Start a new pile!



Refrigerators

As autumn leaves begin to fall and the days grow shorter, the air gets brisk and fresh—a welcome change after a long, hot summer. It's a great feeling to sit outside in the evening and enjoy the cool air. Suddenly, you feel cold. You head inside to get warm. Keeping warm in the winter is easy. Build a fire. Keep fuel in the fire. Keeping cool in the summer is a different problem, and not always as easy. Cooling is just as important, though, and not just for comfort. Our food must be kept cool or it will spoil.

An early solution to this problem was to store some of winter's cold in the form of ice and break it out during the summer. There were a lot of problems with this method of cooling. A better solution is to remove the heat energy from the food and move it to another place. This is the job of a refrigerator.

Refrigerators and air conditioners do similar jobs. They move heat from one place to another. Air conditioners move heat from inside your house to the outside. Refrigerators move heat from your food to outside your refrigerator, into the air. To understand refrigerators, we have to know about molecules.

Everything is made of molecules. All molecules contain heat energy that causes them to move. The more energy they have, the faster they move. Often, they run into each other—or collide. With enough heat energy, water molecules collide with such force that they break the bonds that hold them together and expand into a gas.

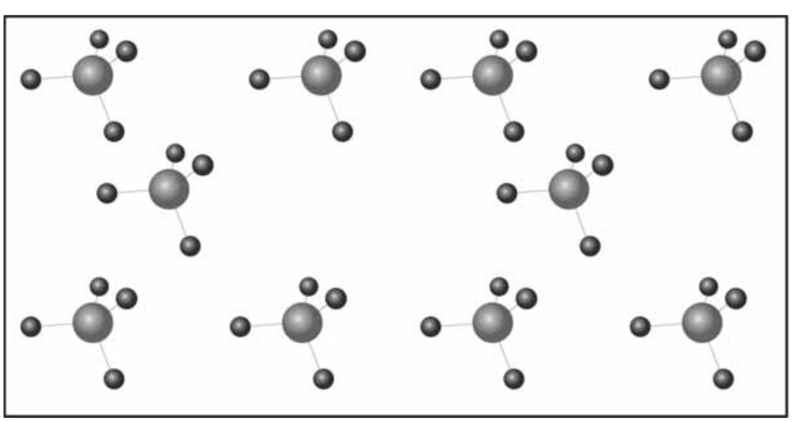
The temperature of a substance is directly related to how fast its molecules are moving. If you have two molecules, the one that is moving faster has more energy and feels hotter.

Refrigerators slow down the molecules by removing energy from them. One way to do that is to have the energy absorbed by other molecules that can carry the energy away. This means that the molecules used to carry away the heat must be cooler than the food you are trying to cool—that is the problem. How do you cool those molecules? The answer is expansion and compression.

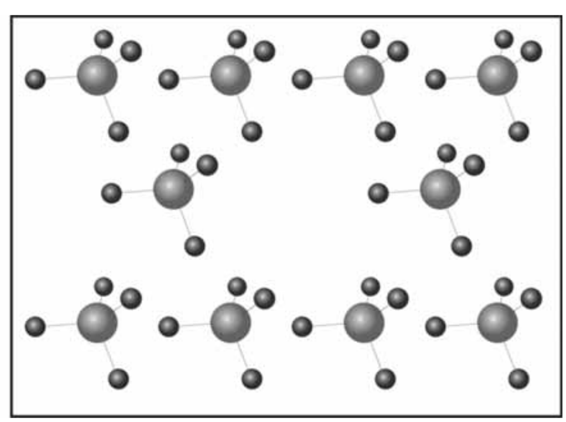
As a substance expands, its molecules move farther apart and don't have as many collisions. The amount of energy in the substance remains the same, but the substance feels cooler.

The opposite is true for compression. If you shrink the size of a container, the molecules inside are closer together and have more collisions. The amount of energy remains the same, but the temperature rises as the molecules are compressed.

Same amount of energy but cooler



Same amount of energy but warmer



Compression and expansion are used to heat and cool a gas, usually freon, inside the cooling system of a refrigerator. The cooling system is a long tube that carries the freon through a compressor, a condenser, and a long path inside the walls.

The cooling starts in the compressor, where the freon gas is compressed, raising its temperature. This warm, compressed gas travels down a tube into the radiator, or condenser. The freon molecules collide with the large surface area of the radiator. Some of the energy from the freon is transferred to the radiator walls.

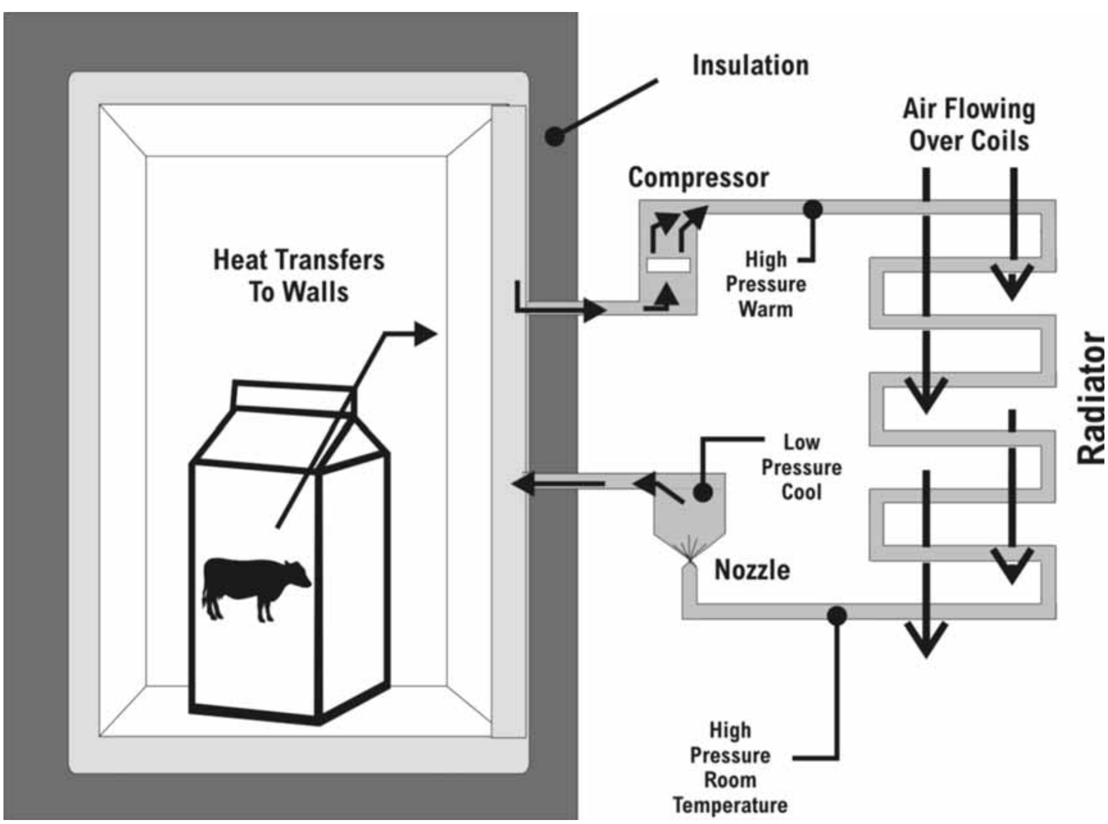
The air outside the radiator collides with the heated walls of the radiator and absorbs some of the heat energy. The freon loses some of its heat energy and the air outside the refrigerator gains some heat energy.

As the freon inside the radiator loses its heat energy, its molecules collide with less force and the freon condenses into a liquid. This radiator section of the cooling system is called a condenser for just that reason.

The liquid freon, still under pressure, passes out of the radiator through a small nozzle into a large copper tube. The pressure in the copper tube is much lower than in the radiator, allowing the freon molecules to expand back into a gas. As the freon gas molecules expand, the temperature in the copper tube drops.

This cool freon gas passes through tubes that line the inside walls of the refrigerator. Molecules inside the refrigerator give up some of their energy to the walls of the refrigerator, and this energy is transferred to the cool freon gas in the tubes. As the freon warms to room temperature, it re-enters the compressor to begin the cycle again.

To keep your refrigerator running at maximum efficiency, it is important to allow room in the back for the air to circulate, to keep the cooling system clean and free of dust, and to keep the door closed as much as possible. Remember, it takes a lot of electrical energy to operate the compressor.



Activity: Make a Cool Bottle

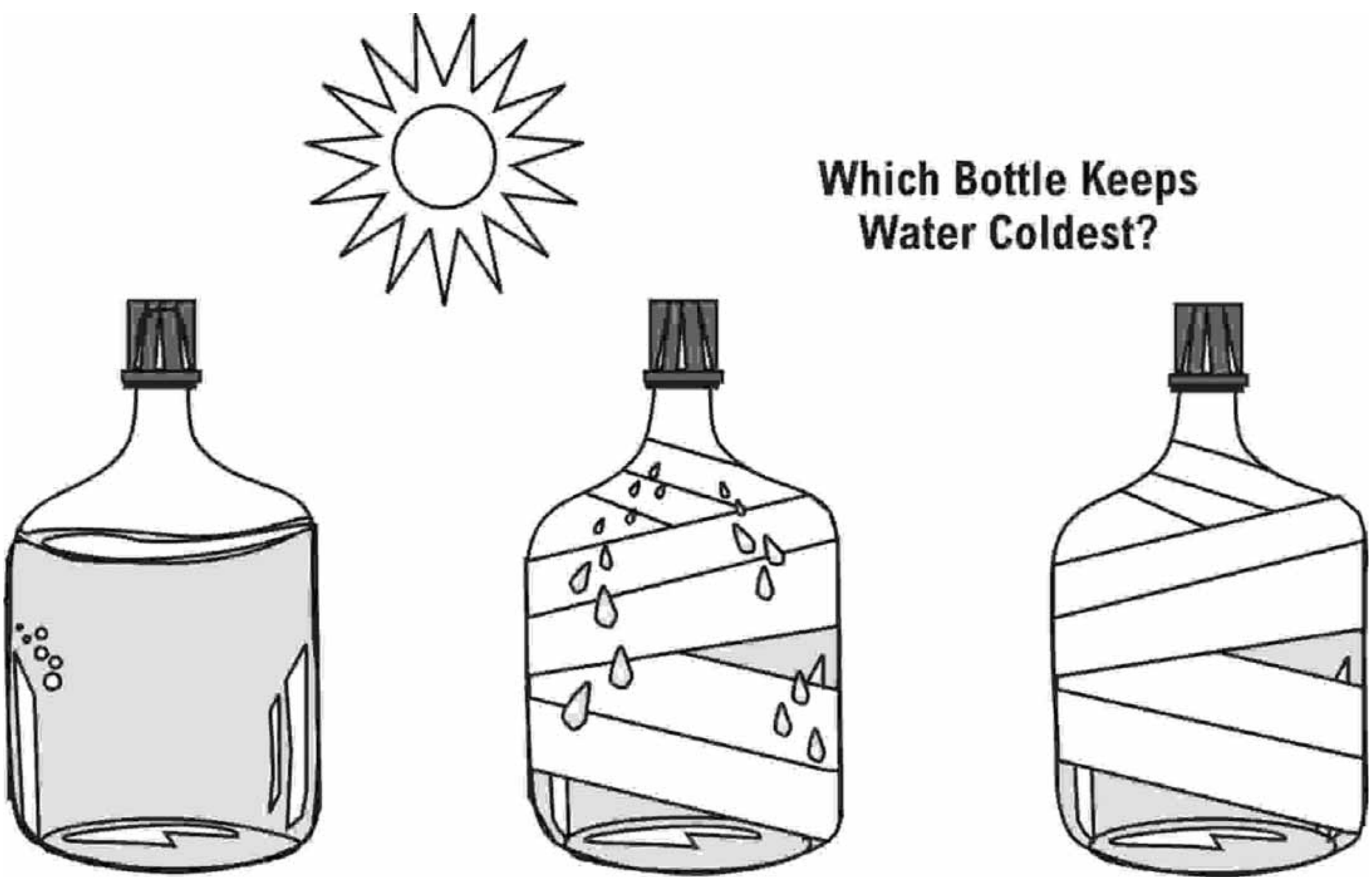
Purpose: To investigate refrigeration concepts through a simple activity.

Background: Long before refrigerators, ice cubes, or Thermos bottles, people had figured out a way to keep drinks cool on hot days. They stored their drinks in clay bottles and kept the bottles wet. The water on the outside of the bottles evaporated and the water molecules required heat energy to expand from a liquid to a gas. The molecules got that energy from the bottles and the liquid inside the bottles—they pulled the heat energy from the bottles. So the liquid inside the bottles stayed cool.

The same thing happens to you on a hot day. To regulate body temperature, your body produces sweat. The sweat evaporates and pulls heat from your body, making you feel cool.

Procedure: You can experiment with this yourself. Fill three bottles with the same amount of water at the same temperature. Record the temperature of the water. Wrap two of the bottles with cloth, and leave the third one uncovered. Wet the cloth of one bottle and keep the second one dry. Place all three containers in the sun. Record the temperatures of all three bottles at fifteen minute intervals for one hour. Make sure you keep the cloth on the first bottle wet.

Make a graph of the temperature changes of the water in the three containers.



The Incredible Microwave Oven

Microwaves are great inventions, aren't they? They cook so many things faster and easier, with much less energy. And they're great for warming up leftovers at the touch of a button. How do they do it?

Microwaves don't work like regular ovens. Conventional ovens use electricity or natural gas to heat the air in the oven. This hot air heats the food and cooks it from the outside in.

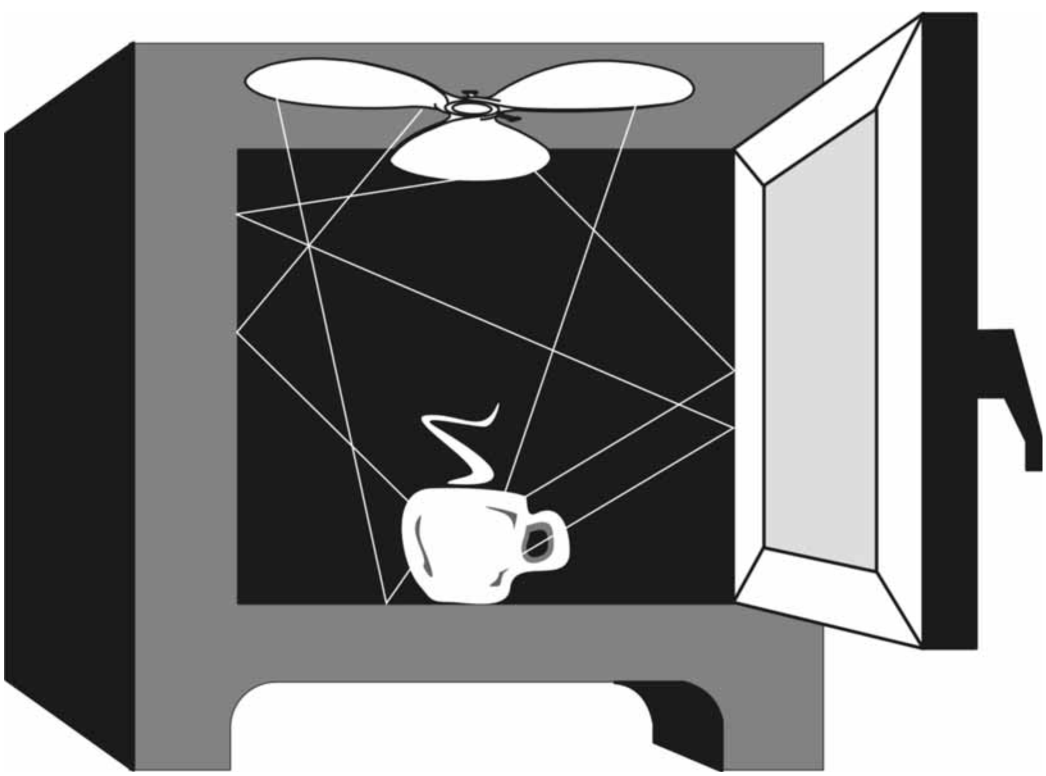
Stick your hand in a microwave after it's been cooking for a few minutes. What do you notice? The air inside isn't hot, is it? And yet the food is cooked and very hot. Is there a mystery here? Microwaves cook food a different way—not with heat. They zap the food with radiation.

A device called a ***magnetron*** converts electricity into a beam of tiny waves *(micro = small)*. This beam is aimed at a fan that scatters the waves all around the oven. They bounce off the walls and bombard the food from every direction. The waves produce an electric field that changes direction millions of times every second.

Microwave ovens can only cook foods with water in them. Water molecules are ***dipoles***—they have positive and negative ends. They react in an electric field. The molecules move back and forth as the field changes and become very hot. Their motion produces heat energy. This heat cooks the food from the inside out.

Did you ever hear of someone putting a whole egg in a microwave? **Don't do it!** You'll make a terrible mess. You might even break your oven. That's because the water molecules in the egg expand as they get hotter. Eventually the egg will explode.

Some foods taste different when they're cooked in a microwave. Bread and pizza, for example, get crispy in a conventional oven. They can turn out soggy in a microwave. The hot air in an oven evaporates the moisture on the surface of foods. But in a microwave, the air doesn't get hot. The moisture remains on the surface. Researchers are working on ways to make microwaved foods crispier and tastier.



Activity: Let's Explore Microwaves

(Warning: Remember that objects heated in microwaves can get very hot. Do not touch any of the objects you have heated with your hands. Handle only with pot holders or tongs and wear safety glasses when conducting these activities. Get permission from an adult before conducting these activities.)

Purpose: To investigate microwave ovens and how they produce heat using several activities.

Materials:

- Microwave oven & conventional oven
- Foods that can be cooked in both microwaves and conventional ovens
- Paper towels
- Water
- Balloon
- Potato
- Lemon
- Safety Glasses
- Fork
- Two foam coffee cups
- Thermometer

Activities:

1. Look at the cooking instructions on foods that can be cooked in either conventional or microwave ovens. Compare the cooking times. Cook one of the foods using both methods. Can you taste a difference?

2. Zap a dry paper towel in a microwave for 15 seconds. Carefully touch the towel with the tip of your finger and note the temperature. Wet the towel and zap it for 15 seconds. Carefully touch the towel again with the tip of your finger. Is there a difference in the temperature? Why?

3. Get a small potato and a lemon, as close to the same size as possible. Use a fork to poke holes in them. Fill two cups half-full of water at the same temperature. Use a thermometer to determine the temperature of the water. Cook the potato for 5 minutes, then use tongs to drop the potato into one of the cups of water. Wait two minutes then record the temperature of the water in the cup. How much does the temperature of the water increase? What do you think will happen with the lemon? Find out. Were you right? What is your explanation?

4. Pour a tablespoon of water into a sturdy 9-inch balloon and tie it. What do you think will happen if you cook the balloon in the microwave? Cook on high power for 30 seconds. Observe the balloon through the window of the microwave, but **DO NOT TOUCH**. It will be very hot! Was your prediction right?

Cookin' with Sol

We use the sun's energy all the time. It gives us light. It makes plants grow. It dries our clothes. We use it to make electricity. And we can cook with it!

Energy from the sun reaches the Earth as radiant energy. We can turn this energy into heat for cooking. A solar oven focuses the sun's energy onto a dark cooking pot. The oven is made of a light, shiny material that reflects the rays. The dark cooking pot absorbs the radiant energy and converts it into heat.

The clear plastic bag around the pot creates a **greenhouse effect**. The radiant energy passes through the plastic to the pot. The radiant energy turns into heat energy. The heat energy cannot pass out through the plastic. The heat stays in the bag and cooks the food in the pot.

People all over the world use solar ovens. Campers use them instead of campfires. No risk of forest fires! No smoke in your eyes! No marshmallows! What? Okay, so solar ovens can't do everything. But, you can put your dinner in the oven and go for a long hike. The food cooks all by itself—no watching, stirring, or turning needed. And the food won't burn if you're an hour late getting back to camp.

In Third World countries, wood is still the main fuel for cooking. Many families spend hours every day trying to find wood for the evening meal. As the trees disappear, their lives become harder and harder. And their land becomes a desert.

Solar ovens can free these families from hours of work. The ovens are easy to use and affordable. Simple ovens can be made for a few dollars. But you can't just give a family a solar oven and expect them to use it.

Training is very important. Most people are used to stirring their food often, especially over a wood fire. With a solar oven, it's important to keep the cooking pot closed. Too much heat escapes when it is opened. It's hard to convince people that food can cook for hours in a solar oven without burning.

At a refugee camp in Kenya, a special program is underway. Refugees who plant 25 trees and take care of them for three months are given a solar oven. There are similar programs in other parts of Africa, China, Nepal, and Costa Rica.

Some solar ovens are big and fancy. The Army used giant solar ovens mounted on trucks during the Gulf War. The ovens cooked meals for hundreds of troops. National Guard camps are also using big solar ovens for cooking.

It's easy to cook with solar energy and the fuel is free, renewable and non-polluting. You can even use a solar oven in the winter on a bright, sunny day. Just add some insulation under the oven and protect it from the wind. The food will take longer to cook, but that's no problem. Just start your dinner in the morning and turn the oven a few times to make sure it's facing the sun.

You can't broil in a solar oven, but you can bake, boil and roast. You can even pasteurize water—simple solar ovens made of cardboard boxes can reach 325^{o} F. You can make almost all of your favorite foods without changing the recipes much.

Activity: Making a Solar Oven

NEED's most famous solar cook, Kathryn McCoy, offers these tips for cooking with a solar oven:

1. Think dark! Use black metal pans and dark brown glass dishes. Never use light colored cookware. A canning jar painted flat black works fine to boil water.
2. Use an oven thermometer. It will help you figure out how long to cook things.
3. Use black cast iron if you're cooking something that must be stirred. It won't lose as much heat when you open the lid.
4. Don't add water when roasting vegetables. Use a pan with a lid and they'll cook in their own juices.
5. When baking potatoes, rub with oil and put in a pot with a lid. Don't wrap with aluminum.
6. Bake bread in dark glass dishes with lids. If you use a cookie sheet, it won't have a nice crust.
7. When baking cookies: chocolate cooks fastest, then peanut butter, then sugar cookies. Use a dark cookie sheet!
8. Marinate meats in advance. Place on a rack in a cast iron pot.
9. One pot meals are great! Cut everything up, throw it into the pot, put a lid on and walk away.
10. Remember—food won't burn in a solar oven. It might lose too much water, though, if you cook it too long.

Purpose: To explore cooking with solar energy.

Materials: *(for two ovens)*

Tri-fold presentation board

Sharp knife or scissors to cut board

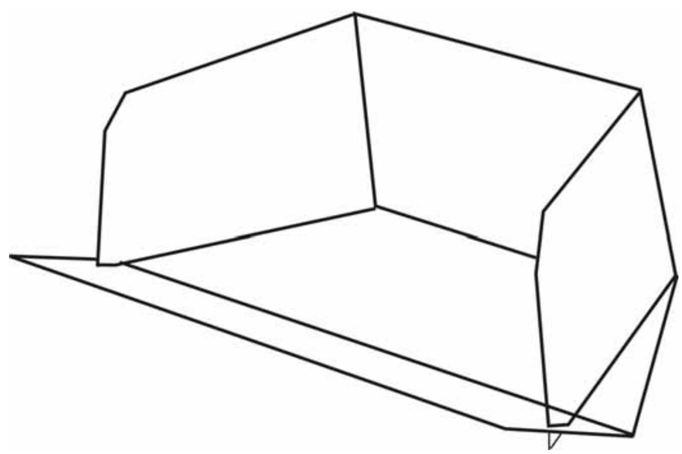
Wide, heavy-weight aluminum foil

Glue stick and clear packing tape

Clear plastic bags

Cooking pot

Food

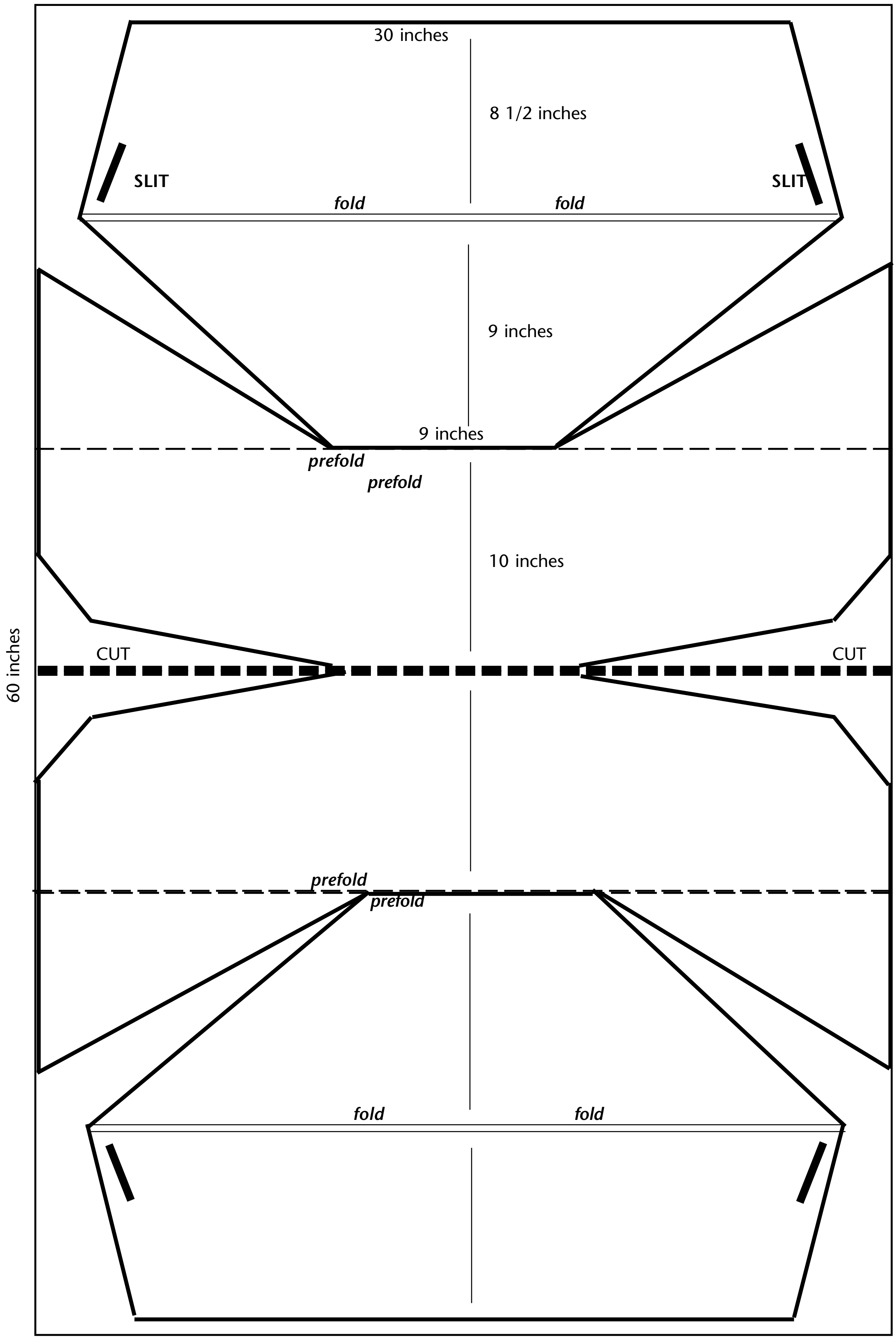


**Optional: Use pizza boxes covered with foil to make mini-ovens*

Procedure:

1. Cut board according to the diagram on page 22.
2. Lightly score new fold lines before folding.
3. Use tape to reinforce folds and to straighten pre-fold on wings.
4. Cover entire board front with aluminum foil, taping or gluing securely.
5. Slide points of wings into slits as shown in the diagram above.
6. Enclose cooking pot in plastic bag and place in middle of oven.

BI-FOLD DISPLAY BOARD MAKES TWO SOLAR OVENS



Trash Talk

Every day the average American throws away four and a half pounds of trash! That means you! Four and a half pounds a day adds up to a lot of trash. Let's do some simple math:

Trash per day	**=**	**4.5 lb**
Trash per week	**=**	**4.5 lb/day X 7 days**
Trash per week	**=**	**31.5 lb**
Trash per year	**=**	**4.5 lb/day X 365 days**
Trash per year	**=**	**1,642.5 lb**

If you live to be 70 years old, you will throw away 114,975 pounds of trash in your lifetime—that's more than 57 tons! That sounds like a lot of trash, doesn't it? Stop and think about the things you throw away every day, such as:

- Food you don't eat and the containers that hold it—cans, boxes, plastic, foil
- Paper––school papers, tissues, paper towels, paper plates, paper cups, newspapers, magazines, junk mail, love notes, boxes, wrapping paper
- Drink containers—soda cans, juice boxes, milk cartons, cups with lids and straws, plastic bottles
- Packaging—on toys, junk food, school supplies

Now think about the trash you throw away once in a while:

- Old batteries, light bulbs, pens that run out of ink, empty cans of hair spray and shampoo bottles
- Old or broken toys, bikes, radios, tapes, video games, CDs
- Clothes that are torn or too small or out of style
- Books and magazines
- And what about the lawn mower that won't start anymore, the TV that dies during the Super Bowl, and the old refrigerators, washers, dryers, cars and boats?

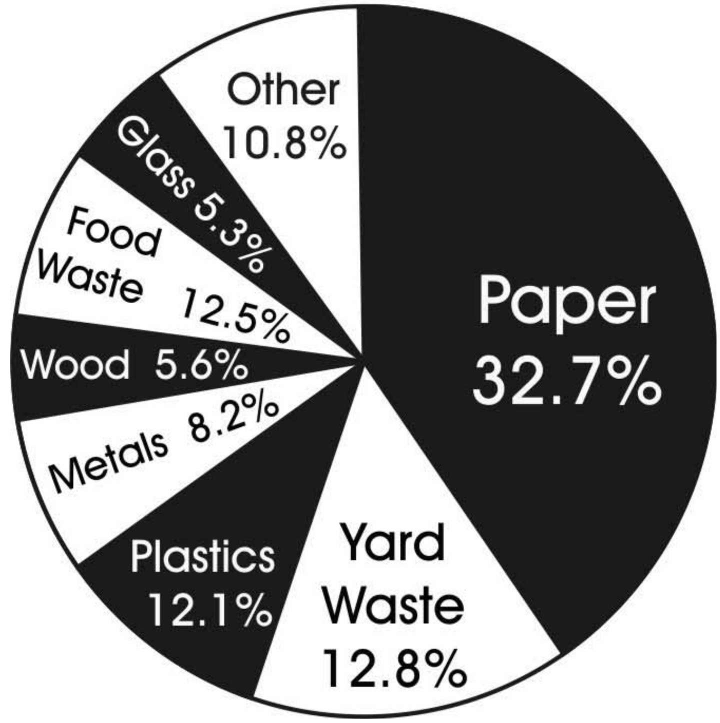
All of a sudden, four pounds a day makes more sense, doesn't it? It's a lot of trash. Especially, when you realize there are 298 million people (298,000,000) in the United States. Let's do some more math:

Trash per day in U.S.	**=**	**4.5 lb/day X 298,000,000**
Trash per day in U.S.	**=**	**1,341,000,000 lb/day = 670,500 tons/day**
Trash per year in U.S.	**=**	**670,500 tons/day X 365 days**
Trash per year in U.S.	**=**	**244,732,500 tons/year**

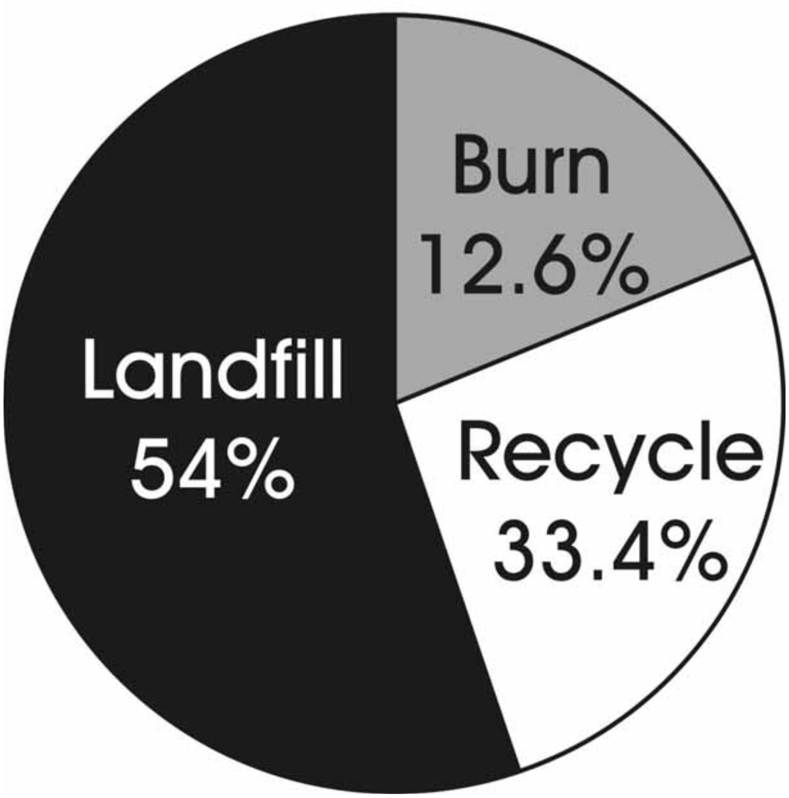
The Trash We Toss

What do we throw away most? Look at the graph on the right. Paper is the winner, by a long shot. Does that surprise you? Most people think plastics make up most of our trash. The amount of yard waste surprises a lot of people, too. And we throw away enough food to feed an army.

What happens to all that trash? It gets recycled, burned or put into landfills. Take a look at the graph below. As you can see, most of our trash goes into landfills. We recycle some and burn the rest. Mostly, we burn paper, yard wastes, plastics, and rubber in waste-to-energy plants to make electricity.



What Happens to Our Trash?



Are you surprised that we recycle only 30 percent of our trash? You shouldn't be. We've really come a long way in the last few years. In 1980, we recycled only 10 percent of our trash and, in 1990, only 17 percent. As we learn new ways to recycle trash, we recycle more and more.

Americans throw away more trash than people in any other country. In Japan, people throw away less than three pounds of trash a day. And Germans throw away only two pounds a day. Talk some trash with your family and friends. Find ways to reduce the amount of trash you throw away every day.

Activity: Are We Average Americans?

Purpose: To investigate the amount and types of trash that the students throw away over a three day period. *(You can extend the activity for as long as you would like and involve entire families. The more people participating and the longer you participate in the activity, the more reliable your results will be.)*

Materials: Small kitchen trash bags with ties—five per student

Five labels per student (for trash bags)

Scale to weigh the trash every day

Trash Recording Form—one per student

Procedure:

1. Begin the activity on a Monday. Explain to the students that they will be keeping track of all the trash they throw away for three days (Tuesday through Thursday). To do this, they will have three trash bags to keep with them at school, at home, and wherever else they go. Emphasize the importance of collecting all of the trash they generate, including a portion of the packaging for meals prepared at home.
2. Three bags (one for each day) will be for food waste and other biomass, such as plants and flowers.
3. One bag will be for recyclable trash—cans, paper, plastic bottles, etc. If the students have glass as trash at home, ask them to weigh it at home or estimate its weight. Students should not carry glass back and forth to school in a plastic bag.
4. The remaining bag will be for all other trash—broken crayons, pencil shavings, batteries, socks with holes, etc.
5. Students must put all of the trash they generate (except for glass) into the bags. The bags will be weighed every morning and the results recorded on the Recording Form. Warn the students, however, against placing dangerous or poisonous materials in their bags, including glass objects. Direct the students, instead, to make a note of those materials and estimate their weights.
6. After the trash has been recorded for three days, have the students calculate the results as shown on the Recording Form and compare their results to the average U.S. figures. Then, calculate the figures for the class as a whole, and compare the results.
7. Discuss possible reasons for variations from the average–yard wastes, for example–and the short length of time of the activity. Discuss the absence of large and durable objects, such as furniture and appliances, that are unlikely to be thrown away in a three day period.

TRASH RECORDING FORM

TRASH HOUND: ______________________________

	TUESDAY	WEDNESDAY	THURSDAY	TOTAL
FOOD WASTE				
RECYCLABLES TOTAL				
PAPER				
PLASTICS				
GLASS				
METALS				
OTHER WASTE				
TOTAL				

GRAND TOTAL

TO CALCULATE YOUR AVERAGE TRASH PER DAY, DIVIDE YOUR GRAND TOTAL BY THREE:

$$3\overline{)\quad\quad\quad}$$

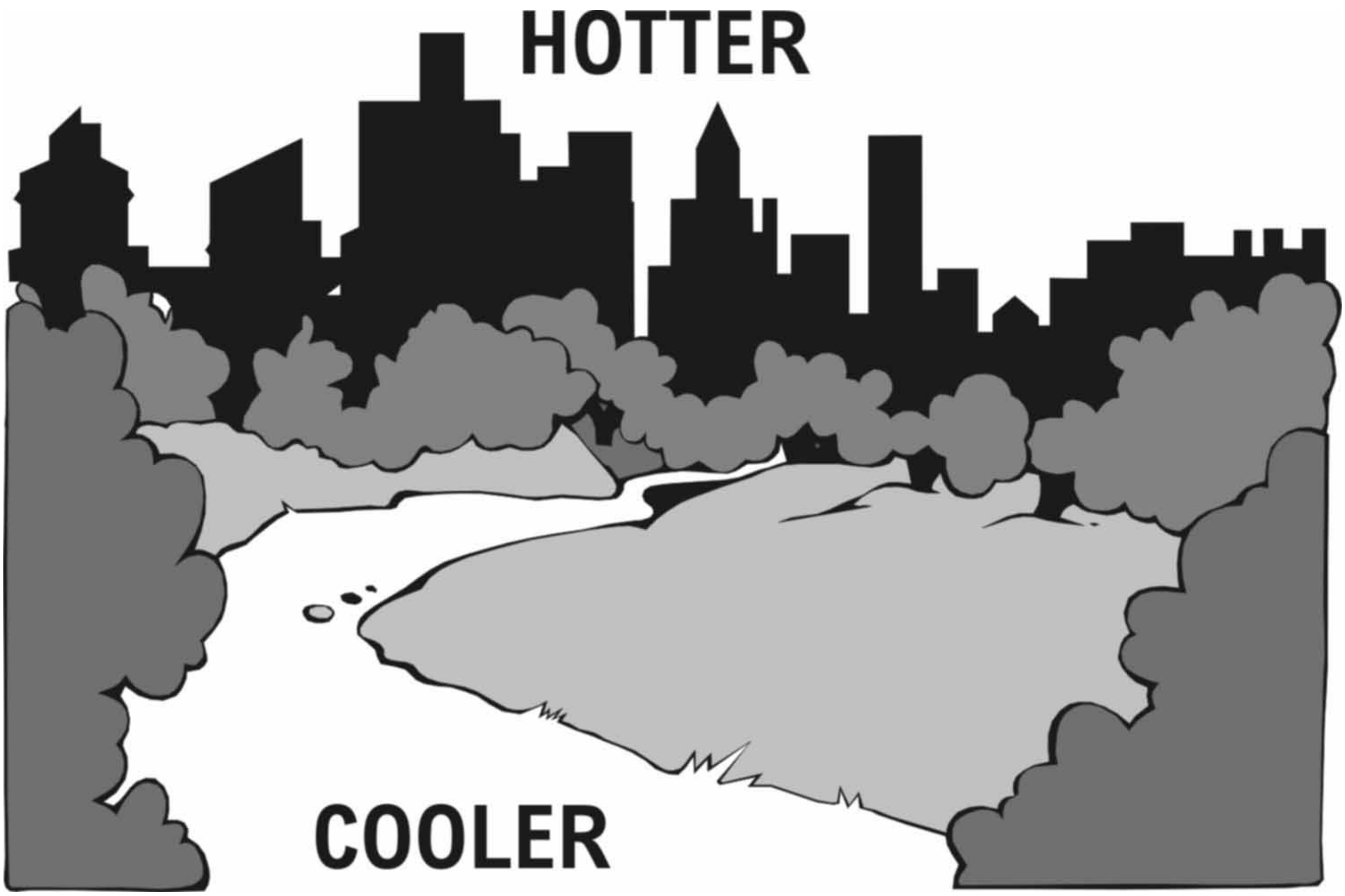
MY TRASH PER DAY WAS ____________________

Heat Islands

Have you ever heard of a heat island? Chances are that you live in or near one. A heat island is an area, usually a city, that is hotter than the surrounding areas. What makes a heat island? Look at any large city and you will find all the ingredients. Cities are heat islands because they have lots of dark pavement. Many of the city buildings have flat roofs that are paved with black tar.

Why do people wear light clothing in the summer and dark clothing in the winter? Because white reflects light and black absorbs light. In the summer, you would be hotter in a black shirt than in a white shirt. The same principle is true for cities. The dark surfaces of the pavement and the roofs absorb light energy and convert it into heat. The heat is released into the surrounding air. On a hot day, the temperature on a black tar roof can be 90 degrees hotter than the air temperature. That means using a lot of air conditioning in those buildings to be comfortable.

What is it that heat islands don't have? They don't have lots of shade trees, bushes, and grass. You've probably noticed that it is cooler in the shade of the woods than on the sidewalk. But, did you know that trees and bushes do other things to keep things cool? Leaves release moisture by evaporation, cooling the air. And, because leaves cool down at night, they can absorb more heat from the air during the day, making the air feel cooler.

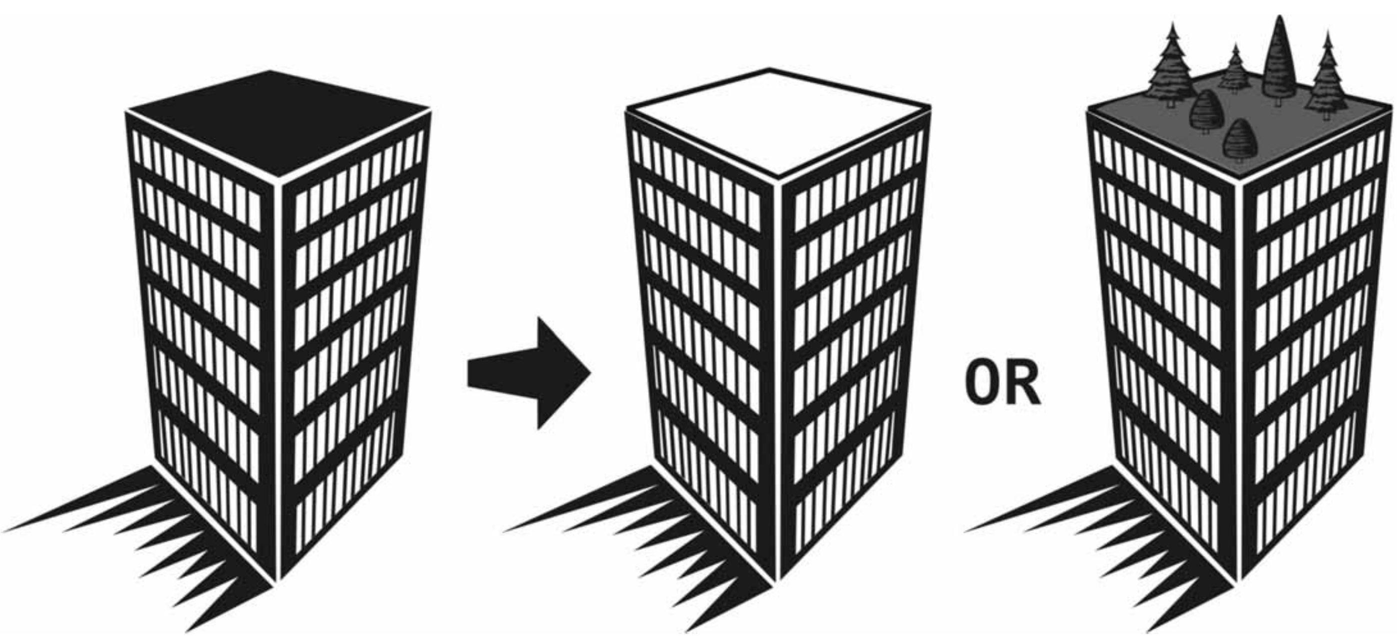


Scientists are thinking of ways to cool down the heat islands. Researchers at the Lawrence Berkeley National Laboratory have been using computer models to work on the problem. One of the things they recommend is that cities replace black tar roofs with lighter colored materials. That could save a city like Phoenix, Arizona, $40 million a year in energy costs. Even in cities where it gets cold in the winter, lighter roofs would save money.

The U.S. Department of Energy has been working with American Forests to encourage communities to plant trees in urban areas. The U.S. Environmental Protection Agency is sponsoring a pilot project to control the heat in heavily developed areas. Four of the cities—Houston, TX, Salt Lake City, UT, Baton Rouge, LA, and Sacramento, CA—have replaced dark roofs with lighter ones and have planted trees and shrubs in open spaces.

Chicago, Illinois is trying something different. It is installing roof gardens. The city has planted two oak trees and other plants on the roof of City Hall. To see how the project works, the city is comparing the temperatures at City Hall with those of a nearby building with a black tar roof. Research shows that one tree can have the same cooling effect as an air-conditioning unit designed to cool a 1,500 square-foot apartment. If you add other trees and shrubs, and put them on hundreds of rooftops all over a city, researchers think temperatures at a city's core could be lowered by as much as five degrees.

In Chicago, the city expects the roof garden on top of City Hall to save about $3,000 to $4,000 in heating and cooling costs each year. Not only will the city save money, but the environment will also be improved. Cooler temperatures will mean less demand for electricity. The trees and plants will also help reduce air pollution.



Activity: Cool Off That Heat Island

Question: Which will cool a building better—changing its black roof to white or adding a roof garden?

Materials: Three identical cardboard boxes—about 18” x 18” x 18”

Three thermometers

Black and white paint

A bag of potting soil

Several small plants

Aluminum foil

Procedure:

1. Paint the top of one box black
2. Paint the top of one box white
3. Make a shallow pan with the foil to hold about an inch of potting soil. Plant a garden on top of the third box.
4. Place the three boxes in a sunny spot with a thermometer inside each one.
5. Keep a record for a week of the temperature inside the three boxes. Check the temperature at 10 a.m. and 2:00 p.m. each day and make a note of the weather.

Results: Make a graph of the results of your experiment.

Conclusion: Which cooled better—painting the roof white or planting a roof garden?

RECORDING FORM

	CONTROL (BLACK)		VARIABLE 1 (WHITE)		VARIABLE 2 (PLANTS)	
	AM TEMP	PM	AM TEMP	PM	AM TEMP	PM
DAY 1						
NOTES						
DAY 2						
NOTES						
DAY 3						
NOTES						
DAY 4						
NOTES						
DAY 5						
NOTES						
DAY 6						
NOTES						
DAY 7						
NOTES						

EXPLORING 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:

Please fax or mail to:

NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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