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SCIENCE MINI-UNIT
INTERMEDIATE

Properties and Behavior

Matter & Energy

Full-color Activity Poster!

- ✓ Hands-on Activities
- ✓ Balance Process & Content
- ✓ Use Readily Available Materials

Daniel J. Spe

Enhanced E-book

Matter and Energy

Properties and Behavior

"Matter" sounds like a pretty scientific thing, doesn't it? But really, "matter" is only a fancy word for "stuff." This book tries to bring scientific ideas down to that simple a level. Students learn the difference between mixtures and compounds using gumdrops. A thermometer is made out of a soda pop bottle, a straw, and some clay. Students explore how heat affects molecules by putting on a molecule "play."

These activities may not always come out the way you expect. Help students understand that they can learn a great deal from their mistakes or failures.

Hands-on science activities also provide a good opportunity for developing individual science journals which can become a part of your students' portfolios.

Table of Contents

Read through the whole book and try the activities yourself before doing the first activity with your students.

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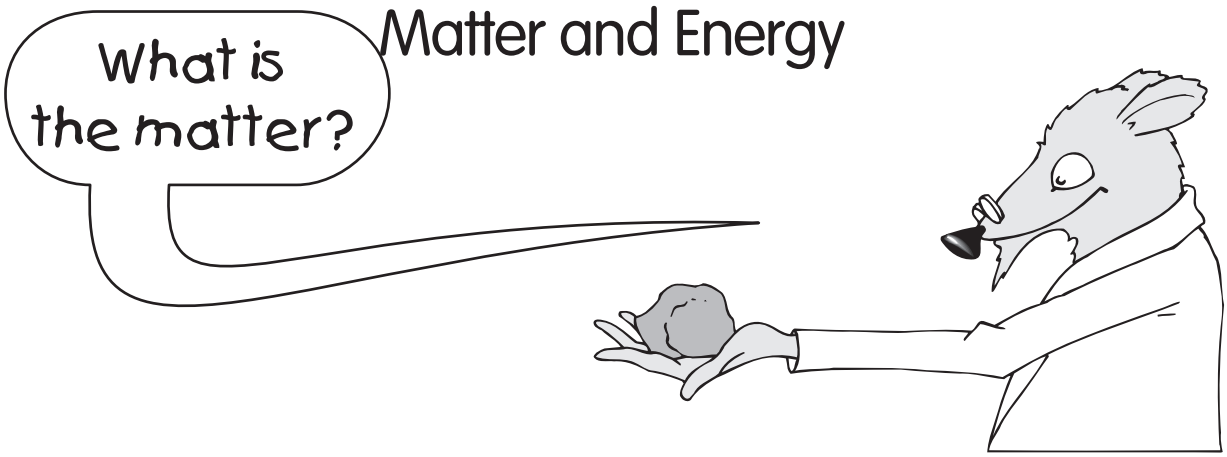
Matter and Energy



When students understand the basic concepts of what matter and energy are like and how they affect each other, it opens the gates to all kinds of fascinating discoveries. The activities in this book can provide a real turning point in your students' understanding of both science as a "subject" and of how science is a part of the everyday occurrences in their lives.

Materials You'll Need:

- pans or bowls
- pyrex containers
- paper cups
- water
- rocks
- flashlights
- water
- ice cubes
- hot plate
- thermometer
- safety goggles
- gumdrops
- toothpicks
- small bottles
- clear straws
- clay
- water coloring
- paper
- tape

optional:

- dry ice

Opening Activity

Write the following three headings on the board and have your students brainstorm for the names of items that will fit under each heading. Help them to sort items such as those listed here into the three categories:

Matter	Energy	Other
rocks	light	space
water	heat	vacuum
air	sound	

Some items will be named that will make you and your students wonder. Suggest to them that you need definitions for matter and energy to help you do your brainstorming and sorting accurately.

Matter can be thought of as *things*.

Energy can be thought of as *actions or forces*.

What's left is *nothing*.

Now invite your students to take a closer look at matter...

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For the teacher

What is Matter?

Years ago, matter was defined as "anything that has weight and takes up space." Referring to weight in the definition turned out to be a problem because something only has weight where there is gravity. Objects in an orbiting space station have no weight. Does that mean that they aren't matter anymore? No...they still have mass.

Saying that matter has "mass" rather than "weight" works pretty well with more advanced science students, but trying to teach the concept of mass can be pretty hard with younger learners. So, let's work with the second property of matter at this stage: **Matter is anything that takes up space**.

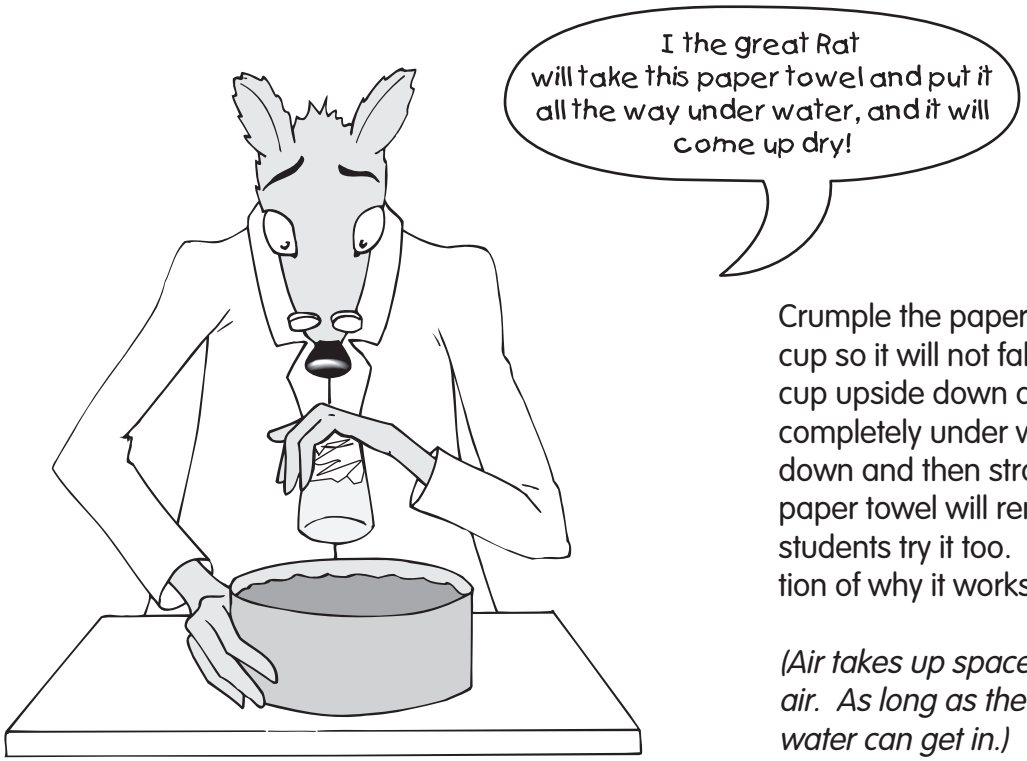
Activity: Are These Things Matter?

Each group will need the following materials plus a copy of the student record sheet on page 3.

- 1 pan or bowl
- 1 coffee-size paper cup
- 1 smaller-size paper cup
- water
- 1 rock that will fit into the larger cup
- 1 flashlight (could be shared between groups)
  (The light from the flashlight will not prove to be matter...light is energy.)

Have your students follow the instructions on their copy of the student sheet. Before putting the materials away, discuss the results as a class. It will usually be harder for students to accept air and other gases as matter than to accept solids and liquids.

If your students are still not convinced that air is a form of matter after the experiment and discussion, use this demonstration as additional proof.



Crumple the paper towel inside a paper cup so it will not fall out. Turn the paper cup upside down and slowly push it completely under water. Go straight down and then straight back up. The paper towel will remain dry! Have the students try it too. Ask for an explanation of why it works.

(Air takes up space. The cup is full of air. As long as the cup is full of air no water can get in.)

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Name _____

Date _____

Are These Matter?

Student Record Sheet

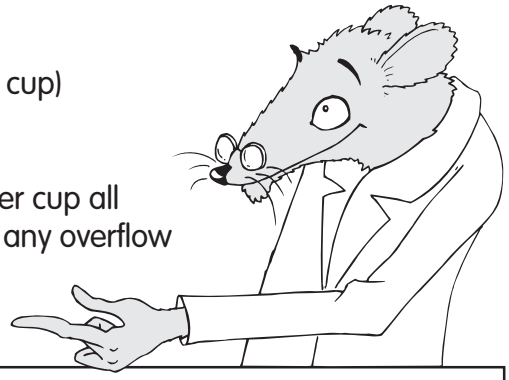
Matter is defined as anything that takes up space.

You will test four materials to see if they are matter.

Materials:

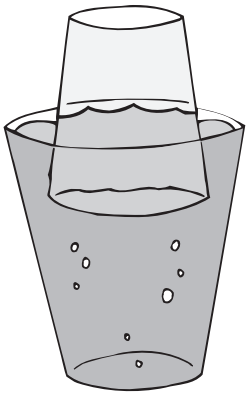
- 1 pan or bowl
- 1 large paper cup
- 1 small paper cup
- 1 rock (must fit in large paper cup)
- 1 flashlight
- water

Fill your bowl half full with water. Use the smaller cup to fill the larger cup all the way to the top with water. Set the large cup in the bowl so that any overflow will go into the bowl. You will use this set-up for all four tests.



Is air matter?

Air is a gas. Refill the large cup with water. Empty the small cup and turn it upside down and push it straight down into the larger cup. If air is matter (takes up space), the water will overflow.



Does air take up space?

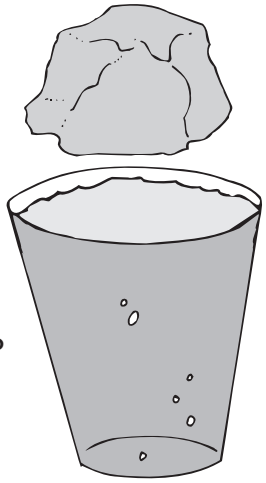
_____

Is water made of matter?

_____

Is a rock matter?

It is a solid. Carefully lower a rock into the water in the large cup. If a rock is matter (takes up space), the water will overflow.



Does the rock take up space?

_____

Is the rock made of matter?

_____

Is light matter?

Refill the large cup with water. Shine a flashlight into the large cup of water. Put as much light as you can into the cup. If light is matter (takes up space), the water in the large cup will overflow.

Does light take up space?

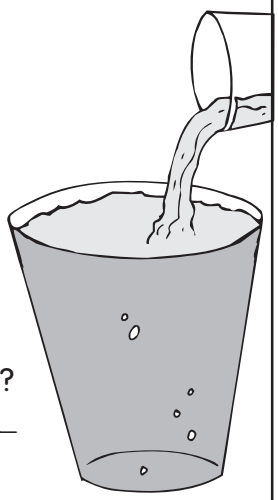
_____

Is light made of matter?

_____

Is water matter?

It is a liquid. Refill the large cup with water. Then use the small cup to pour more water into the large cup. If water is matter (takes up space), the water in the large cup will overflow.



Does the water take up space?

_____

Is the water made of matter?

_____

Which one of the four is not matter?_____

If it is not matter, what is it? _____

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Forms of Matter

Matter exists in three forms: **solid**, **liquid**, and **gas**. This activity will help your students sort out the properties of these three "states of matter." You will need a rock, a clear glass of water, and a plastic bag full of air.

Procedure:

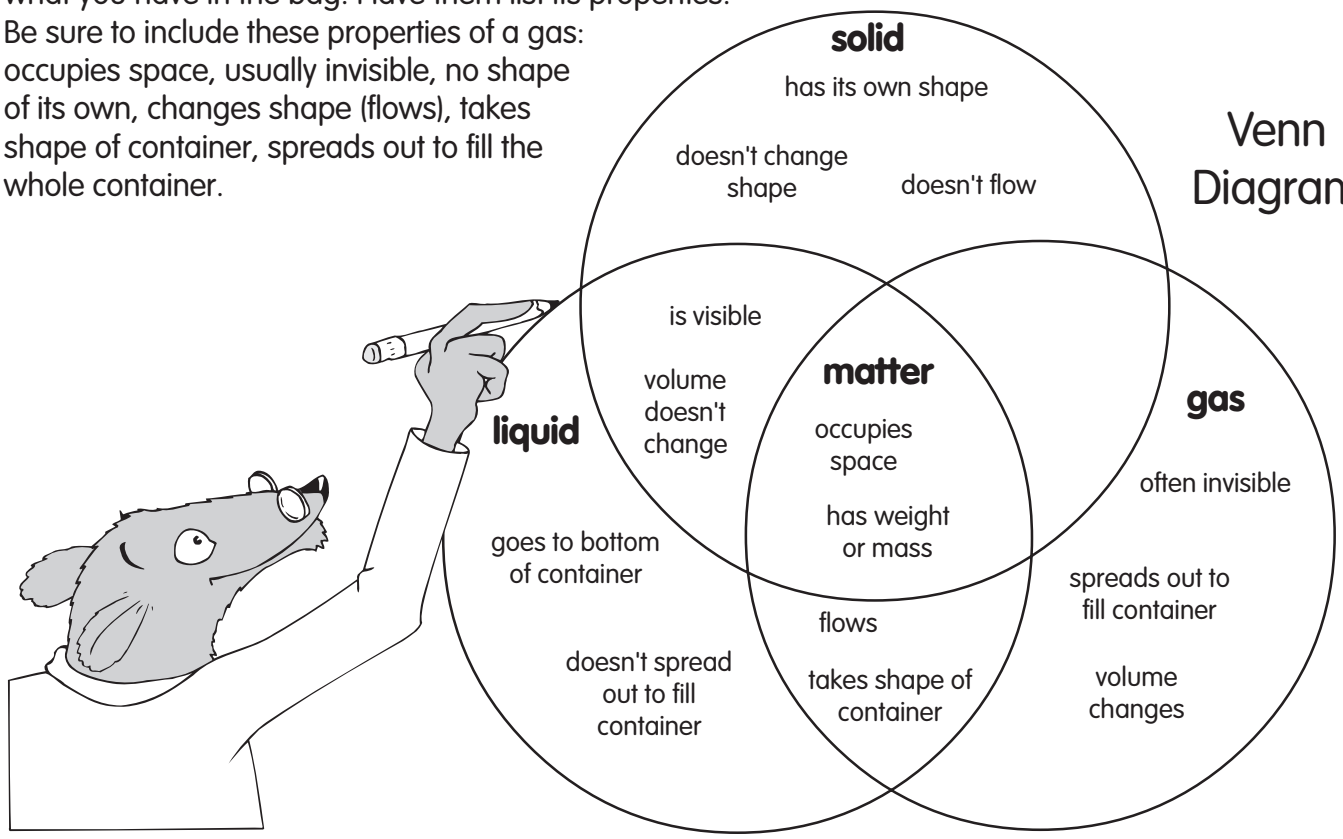
Draw a large Venn diagram as shown below on the board. Explain that you are going to use the diagram to show the properties that solids, liquids, and gases share and those that make them different. You may have your students fill in the diagram on page 5 as you discuss the forms of matter or use it later as an assessment tool.

Explain that words used to describe something are called **properties** of that item. As you and your students discuss each of the following items, write the words and phrases on the chalkboard. When you have completed listing properties of the items, organize them into the appropriate sections of the Venn diagram you drew on the board.

Hold up the **rock** and ask students to describe its properties. Use questioning and discussion to be sure the list includes such properties of a solid as: occupies space, visible, has a shape of its own, doesn't change its shape, volume stays the same (if no temperature change).

Hold up the glass of **water** and ask your students to list its properties. Be sure to include these properties of a liquid: occupies space, visible (even if clear, you can tell it is there), changes shape (flows), takes the shape of its container, goes to bottom of the container, doesn't spread out to fill the whole container, volume stays the same (if no temperature change).

Hold up a plastic bag filled with **air**. Ask your students what you have in the bag. Have them list its properties. Be sure to include these properties of a gas: occupies space, usually invisible, no shape of its own, changes shape (flows), takes shape of container, spreads out to fill the whole container.



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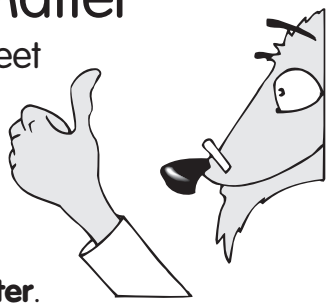
Name _____

Date _____

Three States of Matter

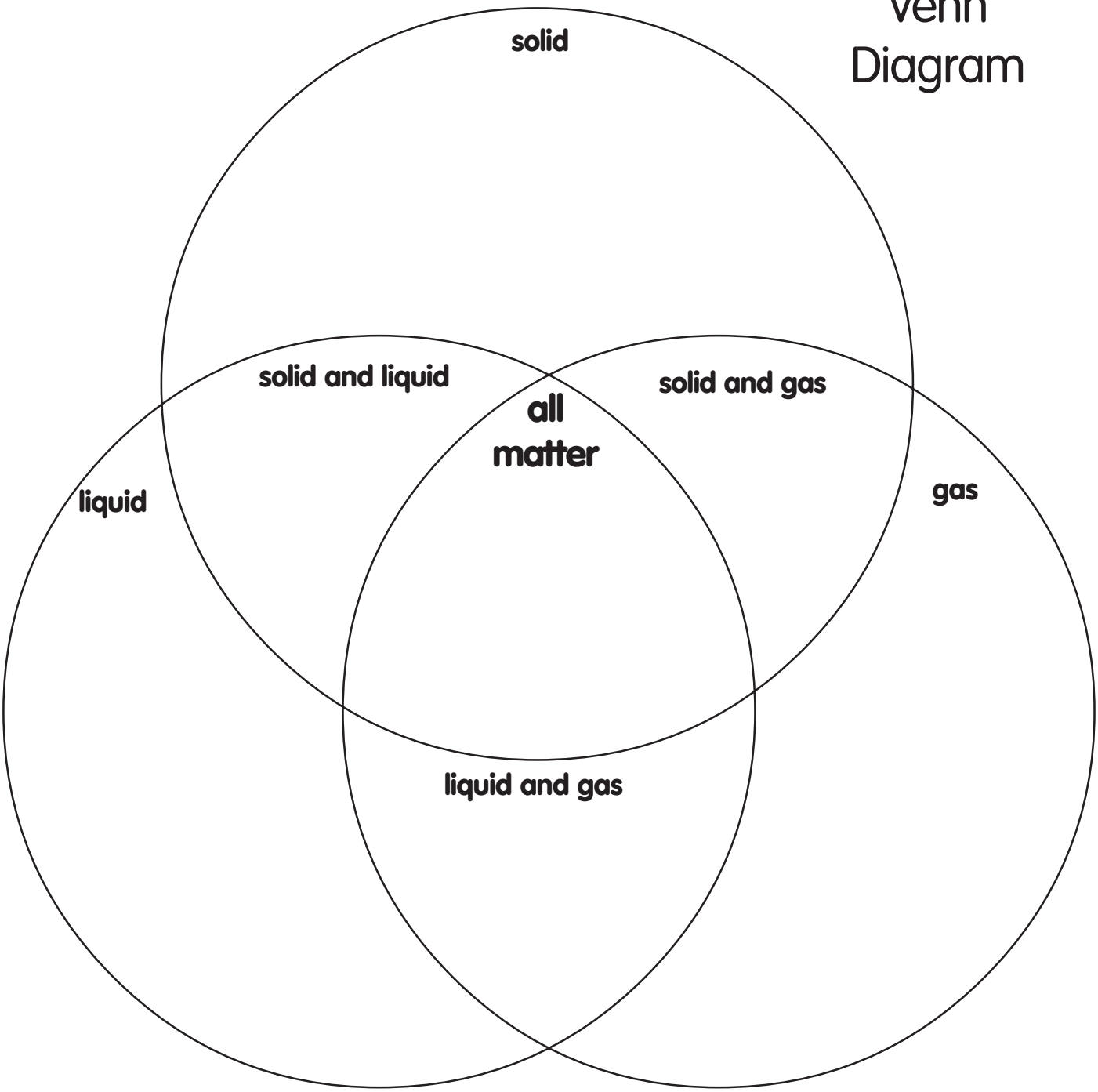
Student Record Sheet



You know that matter has three forms: **solid**, **liquid**, and **gas**.
Use what you learn during the class discussion about the properties of solids, liquids, and gases to fill in this Venn diagram.

Write characteristics that all three forms share in the middle where it says **matter**.
Write characteristics that two forms share in the space where the two forms overlap.
Write characteristics that fit only one form in its space.

Venn Diagram



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Solid, Liquid, or Gas

Now that your students have learned the properties of solids, liquids, and gases, do the following activity to extend their understanding. Put the following list of materials on the board. Ask your students to label each item as a solid, liquid, or gas. They will need to pay close attention or they may be fooled.

rock	milk	nitrogen	iron	alcohol	plastic
copper	mercury	nickel	oxygen	water	helium

As the sorting proceeds, some of your students will probably see that there can be a problem labeling some of the materials. You may hear questions such as these:

"Isn't there such a thing as melted rock? Like in a volcano?"

"Isn't water a solid when you freeze it?"

"How about alcohol? Doesn't it evaporate to become a gas?"

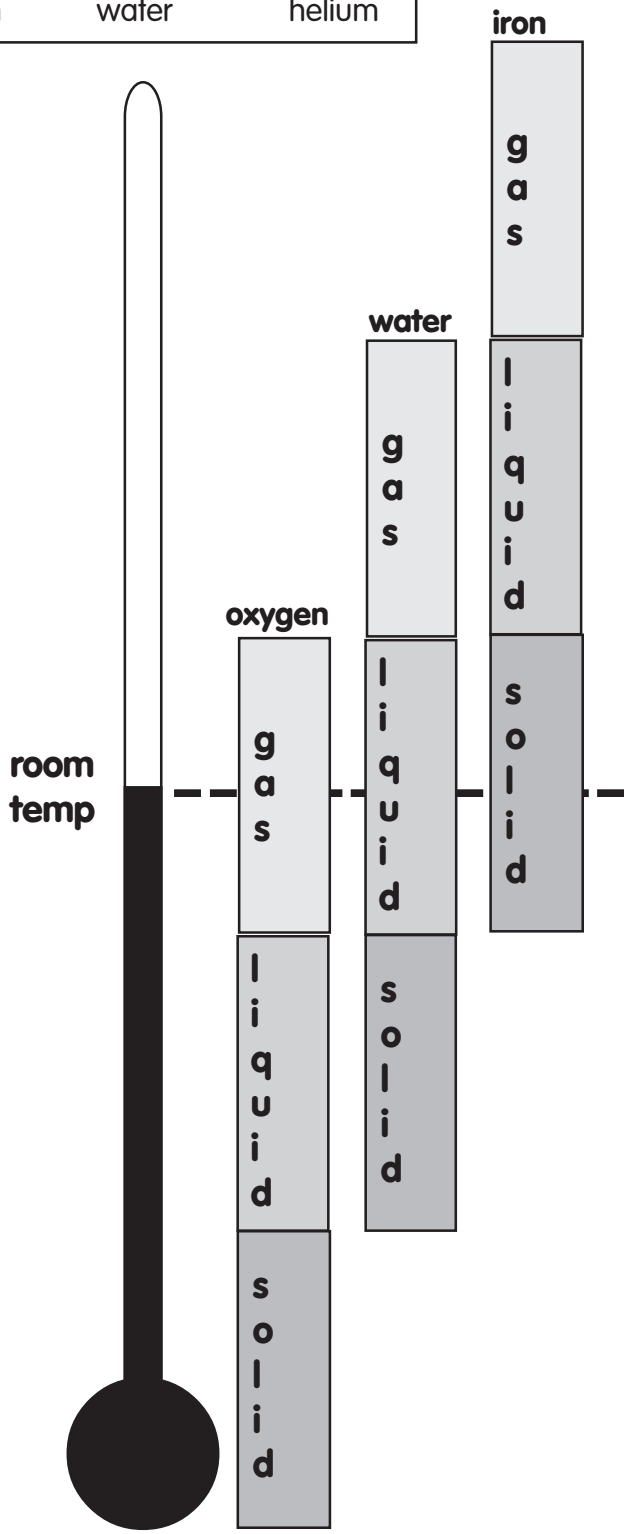
Encourage these questions. They show that your students understand that any particular matter can exist in more than one state. It depends on how much heat energy it contains. Temperature makes the difference.

At "room temperature," iron is a solid, water is a liquid, and oxygen is a gas. If you cool the oxygen enough, it turns into a liquid. Liquid oxygen is used for rocket flights.

If you heat iron, it turns into a liquid. That's how iron can be poured into a mold so it will cool and harden into a particular shape.

Make a sketch of the thermometer at the right on the chalkboard for your students to see. It will help to show how each of these materials can exist as a solid, liquid, or gas. It also shows that, at room temperature, the iron is solid, the water is liquid, and the oxygen is gas.

Erase and re-color the "liquid" in the thermometer to show changes in temperature. Ask your students to tell you what state each material is in at higher and lower temperatures.



Changing States of Matter

Demonstration #1:

Let nature take its course.

Materials: ice cubes, clear plastic cups, and record sheets (see page 8)
Give each student or group of students an ice cube and clear plastic cup. Have them put the ice cube in a cup. Do this at the beginning of the school day. Have students observe the ice cube each hour and record what has happened. At the end of the day, conduct a discussion of what they have seen. Ask students to explain what they think has happened.

Demonstration #2:

Speed up the action.

Materials: ice cubes, hot plate, clear pyrex container, long heavy-duty thermometer with calibrations below freezing and above boiling temperature, safety goggles, and copies of the student record sheet (see page 8).

Put some ice cubes in a clear pyrex container. Stir carefully with the thermometer until there is enough water to cover the bulb of the thermometer. Announce the temperature and have your students write it in the correct place on their record sheets. Put on your safety goggles. Have students close enough to observe what is happening, but out of "splash" range.

Heat and stir the ice cubes until they have all melted. Announce the temperature again. Have students record the temperature. Heat the water and announce the changes in temperature each time it goes up 5 degrees. When the water begins to boil, announce the temperature for students to write on their record sheets.

Discuss the terms which apply to each state of matter and the change which has occurred (**gas**, **liquid**, **solid**, **condensation**, **evaporation**, **freezing**, **melting**). Have your students write these in the correct places on their record sheets.

As you go through this activity, your temperature readings may be off slightly. You may choose to round them to the number you would get with more precise conditions, using distilled water and a more accurate thermometer. The purpose of your demonstration is to get across these concepts:

Activity #2:
Watch as the teacher adds heat energy to a container of ice cubes.
Record the temperatures and terms that correspond to the descriptions below:

1. Water changes between a solid and a liquid at ____**0**____ °C
2. Water changes between a liquid and a gas at ____**100**____ °C
3. Water in the form of steam is a ____**gas**____
4. At room temperature, water is a ____**liquid**____
5. Water in the form of ice is a ____**solid**____
6. Changing from a gas to a liquid is called ____**condensation**____
7. Changing from a liquid to a gas is called ____**evaporation**____
8. Changing from a liquid to a solid is called ____**freezing**____
9. Changing from a solid to a liquid is called ____**melting**____

Name _____

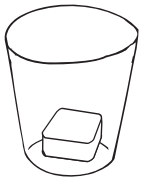
Date _____

Water: Solid, Liquid, and Gas

Student Record Sheet

Activity #1:

Put an ice cube in a clear cup. Once an hour record what you see happening.



Time:	**What has happened to the ice:**
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Activity #2:

Watch as the teacher adds heat energy to a container of ice cubes.
Record the temperatures and terms that correspond to the descriptions below:

1. Water changes between a solid and a liquid at _____ °C
2. Water changes between a liquid and a gas at _____ °C
3. Water in the form of steam is a _____
4. At room temperature, water is a _____
5. Water in the form of ice is a _____
6. Changing from a gas to a liquid is called _____
7. Changing from a liquid to a gas is called _____
8. Changing from a liquid to a solid is called _____
9. Changing from a solid to a liquid is called _____

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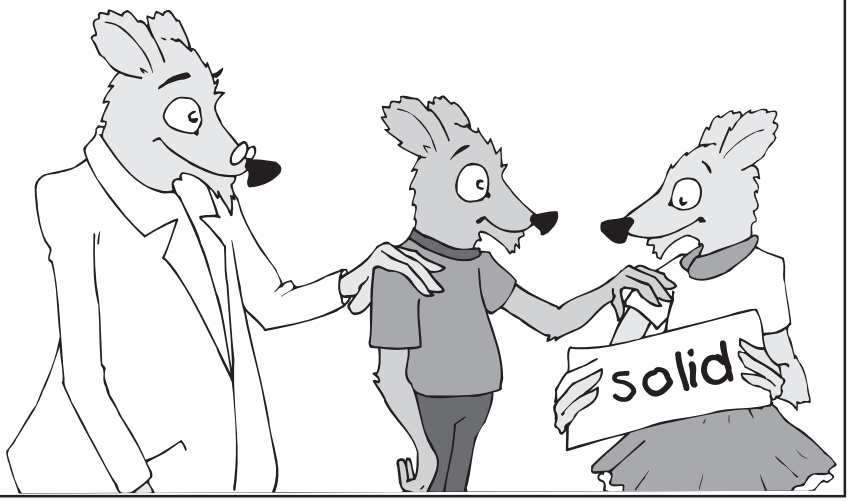
Energy Makes the Difference

A Dramatization

An excellent way to help your students better understand how matter acts is to have them dramatize the states of matter and how they change with the addition or removal of energy. Explain to your students that they are to follow your instructions exactly. Practice a signal for them to "freeze" when you need to get their attention. After each part of the dramatization discuss what has occurred.



Form Solid Ice

Tell your students that they are going to pretend to be tiny particles of water called "molecules", as the water changes its state of matter. Clear a large area in the classroom or use an empty cafeteria or gym. Have students stand in a random arrangement, holding at least one other student by the elbow. Everybody must be connected. They can move a little, but no one can disconnect, leave the group, or change positions with another "particle." They have formed solid ice.

Add Heat Energy

Explain that they are now going to act out two changes as you "turn up the heat." They will begin to wiggle a bit, but not too much. They are also to begin loosening their grip. Rather than hanging on to elbows, students slide their grip out to hold each others' wrists. Now the group takes up more space. The solid ice has expanded, but it is still a solid.

Change to Liquid Water

Pretend to increase the temperature some more saying the "temperatures" out loud, 30° C below zero ...20° below....10° below...etc. Students are to wiggle a little more each time the temperature goes up, but without overdoing it. When you reach 0° C, they let go of each other, but don't spread further apart. Since they don't have a solid connection, they can move around and change positions, but they always have to be within an arm's length of the other "particles." Now they are liquid water.

Change to Water Vapor (A Gas)

Start "adding heat" again. Say the temperatures out loud as before , 70°C...80°C....90°C... as the "molecules" wiggle a little more and spread out a little more with each number. They still need to stay within close range of each other as they flow around. Explain that when you announce 100°C (the boiling/evaporation point), they will start to dance around and spread out all over the room. Above 100°C they have become a gas. They are no longer connected to each other and can move more quickly, and spread out as far as the container (classroom) allows. Caution them not to overdo it.

Cool Back Down Again

Begin calling out temperatures, going *down* by 10° each time. Keep asking, "What should you molecules be doing now?" Students should begin slowing down to a wiggle and coming closer to each other without hanging on. When you get down to 0°C, they take hold of each other once again. Below O°C, they have returned to a solid, holding each other's elbows and moving only a very little bit.

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Taking a Closer Look

• Atoms are the tiny building blocks of all matter. It would take two hundred million atoms in a row to make a line 1" (2.5 cm) long.

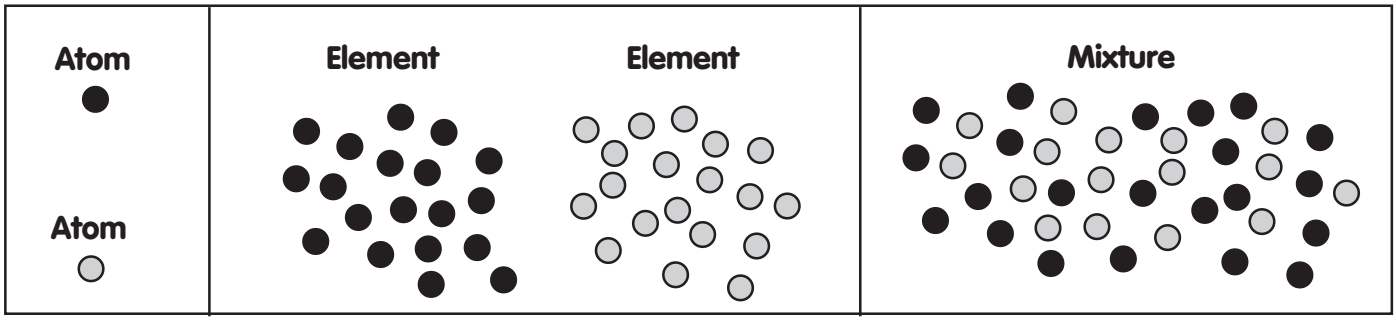
As you explain the following concepts, have your students use colored gumdrops and toothpicks to demonstrate that they understand the differences between **elements**, **mixtures**, **compounds**, **atoms**, and **molecules**. Reproduce the student record sheet (see page 11) for students to use as you conduct this activity.

• When a material is made of **atoms that are all the same**, the material is called an **element**.

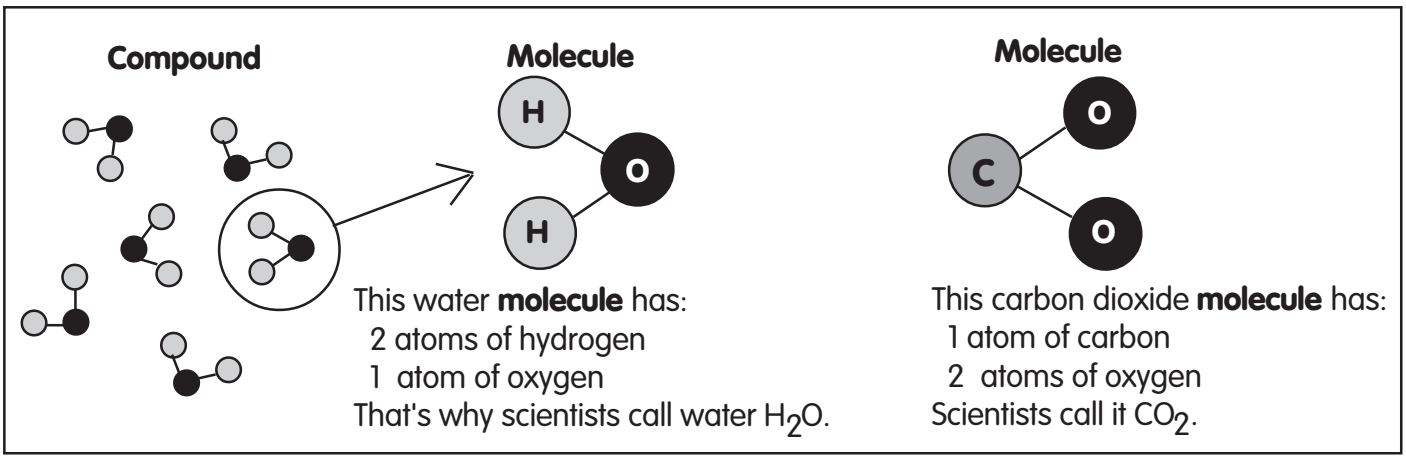
Solid at room temperature	**Liquid** at room temperature	**Gas** at room temperature
example: carbon, silver	example: mercury	example: nitrogen, oxygen

Mercury is the only common element that is a liquid at room temperature.

• When a material is made of **different kinds of atoms**, but the atoms are not in definite proportions and are not hooked to each other, the material is called a **mixture**. Air is a mixture of two gases: nitrogen and oxygen. Bronze is a mixture of two solids: copper and tin.



• When a material is made of **different kinds of atoms**, but the atoms are in definite proportions and are hooked to each other, the material is called a **compound**. Each group of atoms in a compound is called a **molecule**.



This water **molecule** has:
2 atoms of hydrogen
1 atom of oxygen
That's why scientists call water H_2O.

This carbon dioxide **molecule** has:
1 atom of carbon
2 atoms of oxygen
Scientists call it CO_2.

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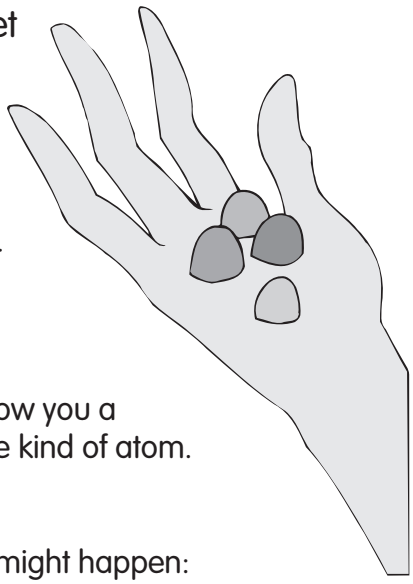
Name _____

Date _____

Different Kinds of Matter

Student Record Sheet



Atoms
Matter is made up of tiny particals called atoms. You and your partner will be using a gumdrop to represent an atom as you do these tasks.

Elements
Elements are materials that are made of all one kind of atom. Pick a color of gumdrop to represent oxygen atoms. Show your partner a handful of "oxygen." Oxygen is an element.

Pick a different color to represent hydrogen atoms. Have your partner show you a handful of "hydrogen." Hydrogen is also an element. It is made of all one kind of atom.

Mixtures and Compounds
When you put two elements together, there are two different things that might happen:

If the two different kinds of atoms just mix together in no special arrangement and the atoms are all separate, the result is called a **mixture**. Use your gumdrops to show your partner a mixture of hydrogen and oxygen. Draw a picture of that mixture.	If the two different kinds of atoms combine with each other to form something new, the result is called a **compound**. The atoms combine in definite combinations (Two atoms of hydrogen combine with one atom of oxygen to make one molecule of water). Have your partner make a few **molecules** of "water" using gumdrops and toothpicks. Draw a picture of one water molecule:

Review: Demonstrate what you have learned by drawing a picture of each of these.

atom	element	mixture	molecule	compound

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Changes in Matter

Physical Changes

When two chemicals are mixed together and their atoms don't hook together into molecules, only a physical change has taken place. The mixture might be softer or harder than before or change color a little, but it is still only a physical change.

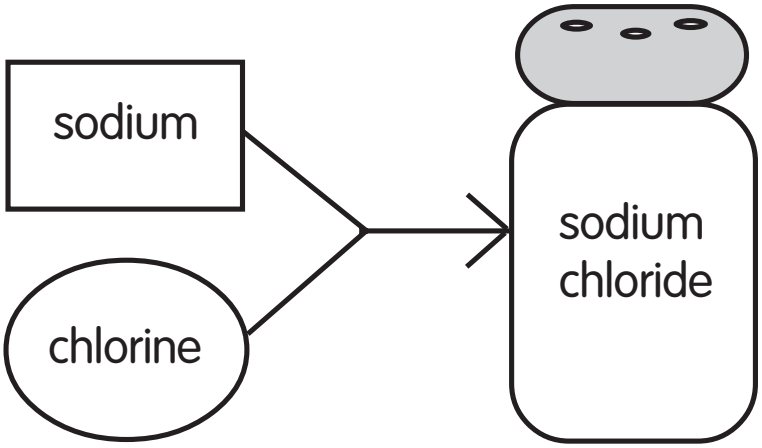
Chemical Changes

When you put two chemicals together and their atoms do hook together to make molecules, a chemical change takes place. Scientists call this a chemical change. The resulting compound is something completely different from the chemicals that went together to make it.

Example # 1:

If you combine this dangerous metal that has to be stored away from oxygen so it won't explode.....

...with this poisonous gas that has been used as a weapon in several wars.....



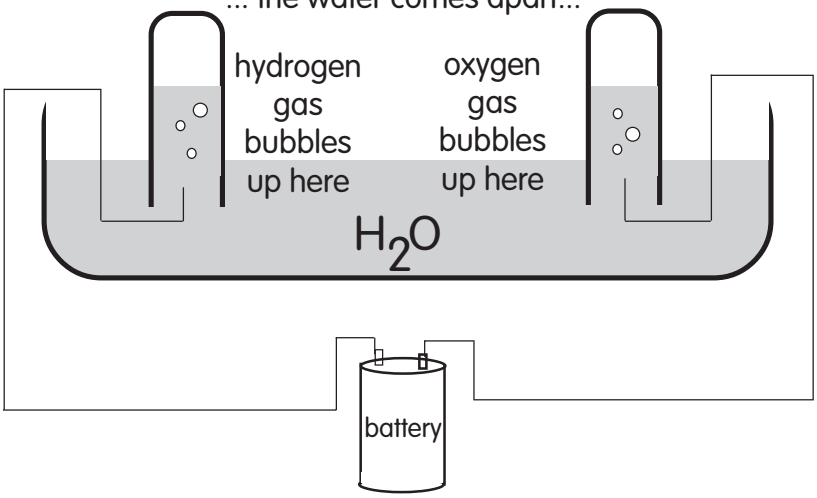
...it turns into the salt that you shake onto your steak and french fries!

Example #2:

Chemical changes aren't only caused by putting chemicals together. Sometimes they happen when chemicals come apart. (If you know how to do electrolysis safely and have access to the proper equipment, demonstrate this for your students.)

If you pass an electric current through regular drinking water...

... the water comes apart...

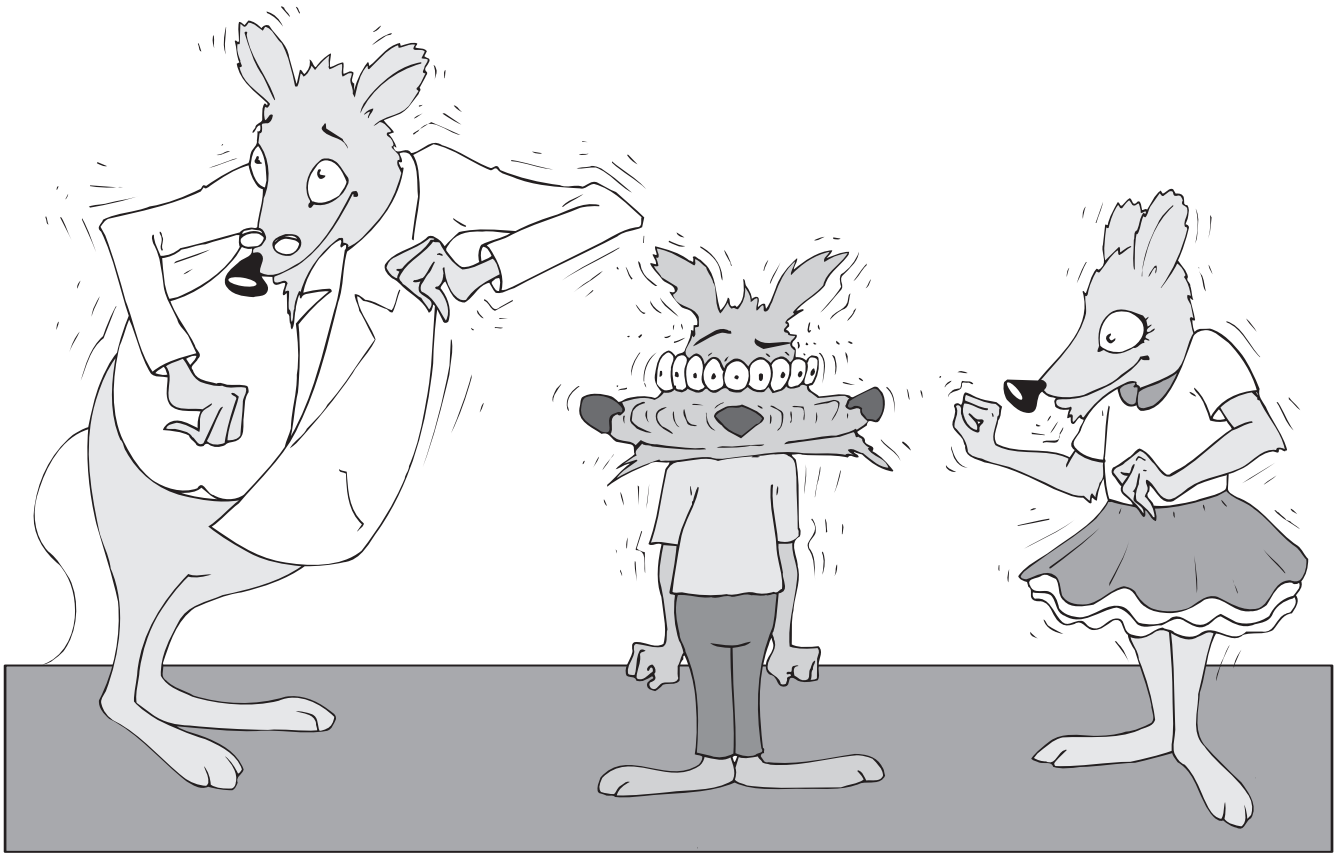


... until the water is all gone.

When matter changes, energy is either used or released.
Matter and energy work hand in hand.

Energy Affects Matter

A Dramatization



It's time for your students to portray molecules again. In the first dramatization, they showed the difference between solids, liquids, and gases. This time, your human "molecules" will help show that energy isn't matter; it is how matter acts.

Have your students stand around the room randomly, close together, but without holding on to each other. Remind them not to get carried away with their acting so they can concentrate on understanding the concepts. Practice your signal for getting the class to "freeze" when you need to regain their attention.

Explain that heat isn't matter, it is energy. Heat is the vibration (wiggling) of molecules. Your students are going to pass "heat" from student to student the same way that molecules pass heat from molecule to molecule.

You, the teacher, start to vibrate. Just wiggle as you walk toward the nearest student. When you start bumping (gently) against that student, he or she begins to wiggle too. Other students can only begin to wiggle when the "molecule" right next to them wiggles and gently bumps them. Slowly, the wiggling of molecules (that's what heat is) passes through the group.

Try it again with the student in the middle of the group being the first to wiggle. You want to show that the heat will spread in all directions.

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Heat Transference

There are several ways heat is passed from one molecule to the next.

1. Conduction
Remind students that molecules can pass heat from one to the next, but only if the molecules are close together. Ask, "Which state of matter do you think is most likely to carry heat this way?" (Solids.) This method of transferring heat is called **conduction**. Demonstrate this with a chalkboard eraser (representing heat) by having it passed from child to child moving it from the front of the classroom to the back. Ask your students to try and think of other ways you might get the eraser (representing heat) to the back of the classroom. Act out each way moving the eraser ("heat") again.

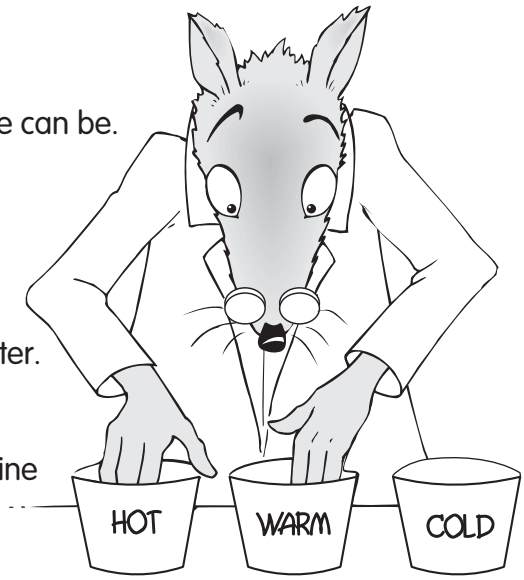
2. Convection
The eraser could be carried to the back of the room. A solid can't do this because the molecules have to stay put. For a molecule to carry heat, it has to "flow" to the back of the room, and other molecules have to be able to get out of the way. Liquids can act that way, and so can gases. This is called **convection**. Act out this way by having a "molecule" carry the eraser to the back of the room by flowing with it.

3. Radiation
The erasor could be thrown to the back of the room. To do this, the molecules have to be spread out enough for the eraser to get through. Solids and liquids have their molecules too close together. This only works with gases, or even better through empty space. Heat gets to the Earth from the sun through space by **radiation**.

Fooling Your Senses with Heat

We think that we can tell how hot something is just by feeling it. This activity helps to show how unreliable our sense of temperature can be.

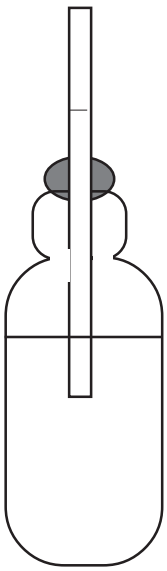
Put out three containers of water: one with hot water (caution: not too hot), one with warm water, and one with cold water. Have students take turns putting one hand in the cold and the other in the hot at the same time. After a minute have them take their hands out and put both hands at the same time into the warm water. The hand that was in the cold will feel the warm water as hot. The hand that was in the hot will feel the warm water as cold. This activity points up the need for a more objective way to determine temperatures. Ask your students to come up with ideas of how to test temperature accurately. (We need a thermometer.)



Make a Simple Thermometer

Review how a thermometer works. (Most thermometers are a hollow glass tube with mercury or alcohol in it. Things expand when they heat up, and mercury and alcohol expand easily, so they go up and down the tube as the temperature goes up and down.) Then have students make a simple thermometer following the directions on page 15.

Make a Thermometer



Thermometers work because heat causes the liquid in the tube to expand.

This simple thermometer measures temperature using colored water as the liquid.

Materials per group:

- clear plastic or glass bottle (8 to 16 oz)
- clear drinking straw
- clay
- water
- paper
- food coloring
- tape
- commercial thermometer
- containers of water at different temperatures

Steps to Follow:

1. Fill your bottle 3/4 full with cold water. Add a little food coloring.

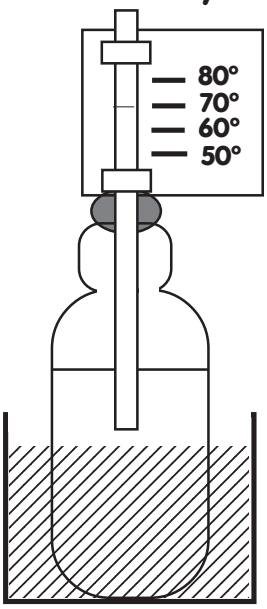
2. Put the straw into the bottle so the bottom of the straw is a little way under water. Use your clay as a bottle stopper. Make an airtight seal.

3. Look to see how high up in the straw the water has reached.

4. Put the bottom of the bottle into warm water. What happens to the water in the straw? _____

5. Put the bottom of the bottle into cold water. What happens to the water in the straw? _____

Extension Activity:



You can see how your homemade thermometer shows changes in temperature. To tell exactly how hot things are, you need to **calibrate** your thermometer.

Attach a piece of paper to the straw with tape.

Use the commercial thermometer to determine the temperature of one of the water samples.

Put your own thermometer into the same sample. Mark a line on the paper to show how high your colored water went. Write the temperature from the commercial thermometer next to that line.

Do the same thing with the other water samples until you have several temperatures marked on your own thermometer. Using those temperatures as a guide, you will be able to write in 40°, 50°, 60°, and so forth at the appropriate places on the paper. This will only be approximate, but you will get the idea of how its calibration works.

There are two different standards for measuring temperature. On some thermometers you will see °C, on others it will be °F, and on some you'll see both. What do the "C" and the "F" stand for? What's the difference between the two systems? Decide which markings you wish to use with your thermometer.

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Show What You Know

Name _____

Date _____

Connect the terms to the descriptions with lines.
Do the easiest ones first.

matter	matter that has a shape of its own
energy	any material that takes up space
solid	matter that flows without taking up a lot more space
liquid	something that isn't matter but affects what matter does
gas	type of small unit from which all matter is made
atom	changing from a liquid to a gas
element	matter that spreads out to take up the available space
mixture	matter made of just one kind of atom
evaporating	more than one kind of atom together but not combined
melting	heat travelling through a solid
conduction	changing from a solid to a liquid
molecule	changing from a gas to a liquid
condensing	a group of atoms combined into a unit
compound	heat flowing along with a liquid or gas
freezing	a material made of molecules rather than separate atoms
convection	changing from a liquid to a solid
radiation	a measure of how hot a material is
heat	heat going through space between molecules
temperature	energy stored in matter in the form of molecular vibration

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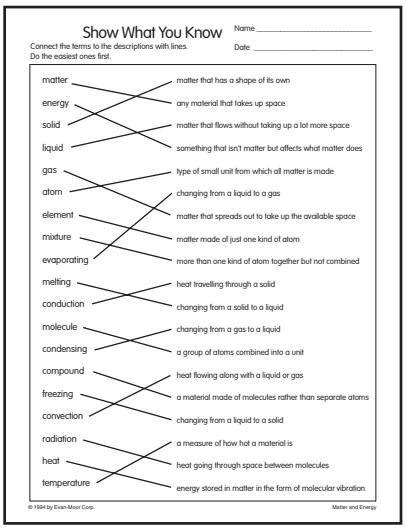
Assessing Understanding can be Fun

On the right are the answers to the quiz on page 16.



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Copy and cut out the word cards below for use with the poster game. This game combines elements of activities such as "Charades" and "Pictionary" to make a fun assessment activity. You will be able to confirm understanding and detect areas needing further explanation by watching as students play this game.

Matter	
Solid	Energy
Gas	Liquid
Element	Atom
Evaporating	Mixture
Conduction	Melting
Condensing	Molecule
Freezing	Compound
Radiation	Convection
Temperature	Heat

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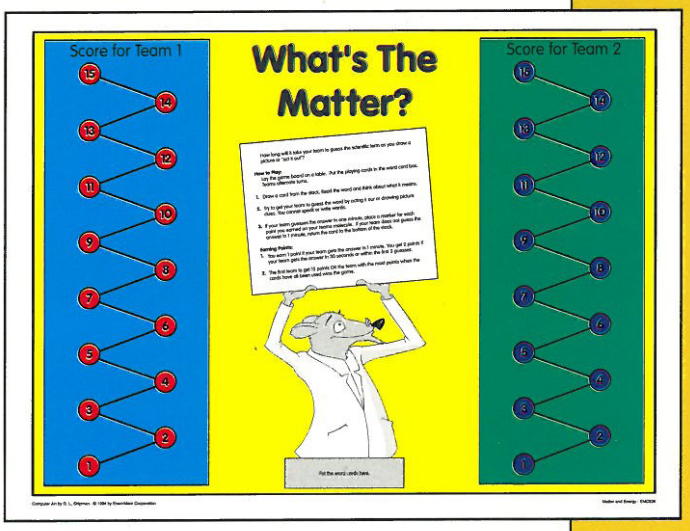
Use your science posters

- to motivate interest in learning about matter and energy
- to develop or review concepts and vocabulary
- as a science center activity

Poster 1
What's the Matter?

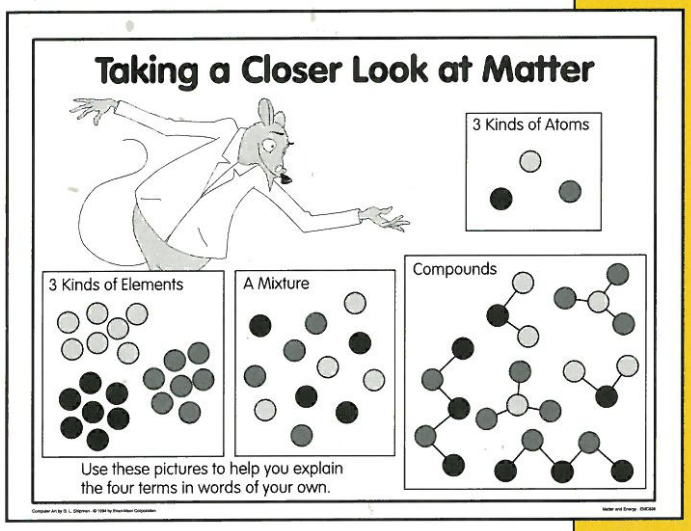
Prepare a set of playing cards by reproducing page 17 on cardstock. Place the cards face down on the appropriate box of the gameboard. Provide small objects in two different colors or shapes to use as markers. Complete game rules are shown on the gameboard.

A player draws a card. He/She reads the word on the card, then draws or acts out clues. Team members try to guess the term in as short a time as possible. Points are kept by covering "atoms" of the teams "molecule." The first team to complete their molecule wins.



Poster 2
Taking a Closer Look at Matter

This poster contains simple illustrations and definitions of atoms, elements, mixtures and compounds. Use it as you introduce or review these concepts.To use as an assessment tool cover up the definitions and ask your students to explain each term in their own words.



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