

Matter

Prior Knowledge

The student has

1. measured length and area in the English and metric systems
2. measured time
3. added and subtracted with regrouping and renaming
4. used a calculator to find sums and differences
5. estimated sums and differences less than or equal to 100
6. formed arrays to show repeated addition as a model for multiplication
7. separated equivalent groups to show repeated subtraction as a model for division.

Mathematics, Science and Language Objectives

Mathematics

The student will

1. measure volume of gases, liquids and solids in metric and English systems to the $\frac{1}{2}$, $\frac{1}{10}$, $\frac{1}{100}$ units
2. measure weight of gases, liquids and solids in metric and English systems, to the $\frac{1}{2}$, $\frac{1}{10}$, $\frac{1}{100}$ units
3. estimate volume and weight
4. predict results of physical and/or chemical changes
5. find volume of given three-dimensional geometric shapes
6. find sums and differences with addends less than or equal to 500
7. use a calculator to find products of two-digit factors greater than or equal to 20
8. describe differences between objects to include weight and volume as descriptors
9. measure temperature
10. graph data
11. explore inverse operations.

Science

The student will

1. list three forms in which matter exists, i.e., solid, liquid, gas
2. list mass and volume as properties of matter
3. describe two changes through which matter undergoes
4. list at least three examples of a physical change
5. list at least three examples of a chemical change
6. describe composition of substances as mixtures, compounds or elements
7. describe elements as uniform compositions, and give three examples
8. describe compounds as uniform compositions, and give three examples

9. describe mixtures as nonuniform combinations, and give three examples
10. measure volume using a graduated cylinder in standard units of volume
11. measure weight using a scale
12. describe mass of objects using a balance and nonstandard units of weight.

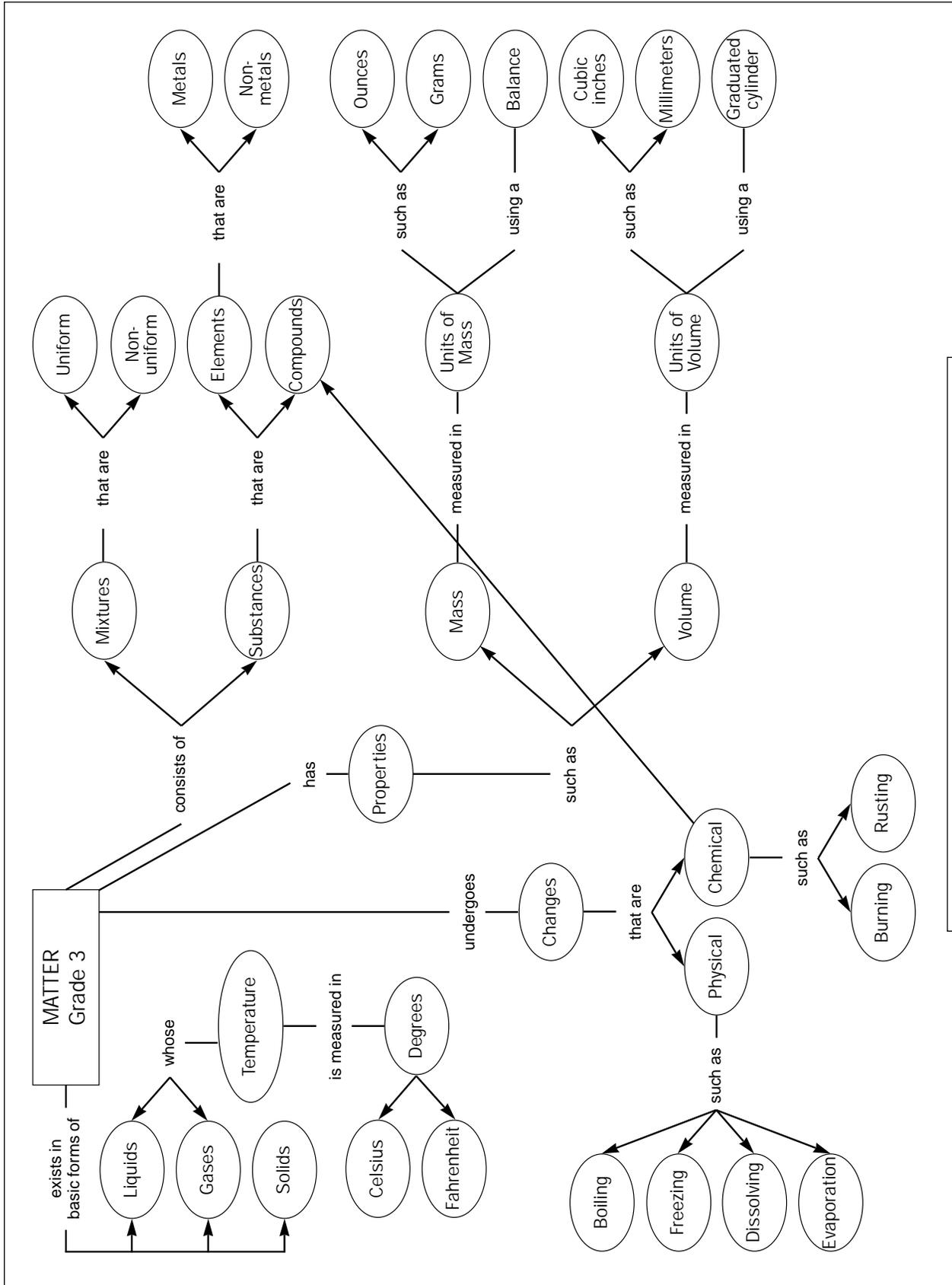
Language

The student will

1. engage in dialogue/discussion
2. record observations about unit activities in a journal
3. identify a main idea in a story
4. create stories using theme-related vocabulary
5. use description in writing
6. narrate events in writing
7. write complete sentences
8. give reasons to persuade
9. summarize
10. organize information/data in writing, charts and graphs.

V O C A B U L A R Y

matter materia	liquid líquido	solid sólido	gas gas	change cambio
evaporation evaporación	boil hervir	freeze congelar	burn quemar	rust oxidar
element elemento	compound combinación	mixture mezcla	uniform uniforme	nonuniform desigual
volume volumen	mass masa	balance balanza	grams gramos	graduated cylinder cilindro graduado
weight peso	space espacio	air tight sellado	physical físico	cook cocinar
property propiedad				



C O N C E P T W E B

Prior Preparation for Lesson 6

The teacher and students prepare the following materials and place them in the **Science Center**. The students make and record daily observations on a chart. See **Lesson 6** for a copy of the data chart. Reserve this chart with its data for use in **Lesson 8**.

Materials

several matches

rock

potato cut into several pieces and left uncovered; apple cut into several pieces and left uncovered

Two pieces of steel wool placed in two plastic bags; piece of wet steel wool placed into a plastic bag and sealed

cup of water

inflated balloon

Teacher Background Information ● ● ●

Everything in the universe is composed of matter or energy. Before students study matter, introduce the basic notion of what we mean by “matter”. Matter exists in its elemental form, such as carbon, mercury, iron, copper, gold, silver, etc., or in molecular form, such as water, wood, food, clothes, etc. Matter can also exist in the form of mixtures, such as air, which is a mixture of gases in their elemental form (nitrogen, oxygen) and in molecular form (carbon dioxide, water vapor). We call the most fundamental units of matter **atoms**. An atom is the smallest particle of matter that by itself can combine with other like or different particles, or atoms. **Elements** are groups or combinations of like atoms, while **molecules** are combinations of like or different atoms.

Matter has two essential properties — it has **mass** and it has **volume**, it occupies space. Mass is the amount of “stuff” something is made of. Mass has **inertia**, which is the resistance of matter to change in its state of rest or state of motion.

Sometimes mass is referred to as “weight”. Weight is a property of matter that changes, depending on where matter is weighed. Large bodies, such as the earth, the sun, the planets and the moon, have their own gravity that attracts anything that is close to them. When we weigh ourselves on earth, we are measuring the attraction of the earth on our body. Our weight does depend on how much “matter” we have, but it changes depending on where we weigh ourselves — on what is attracting our body. For example, our weight would be less if we weighed ourselves on the moon and more if we weighed ourselves on the sun! The mass of our bodies, the stuff we are made of, however, does not change.

All matter is either a solid, a liquid or a gas. Elements exist in any of these three forms — i.e. gold, mercury (liquid form of the element) and oxygen. Matter can change its form, but under normal processes, matter in its elemental form cannot be destroyed. Under a physical change, charcoal (element, carbon) remains a solid even when powdered. Water (in molecular form) has the unusual property of changing easily to any of the three states of matter. Students can see that when water becomes a gas it is invisible.

Substances can also exist as **mixtures**, in which each of the individual components maintains its properties. Milk is a mixture of substances that we can sepa-

rate into their original form. Cereals, like Fruit Loops or trail mix, are good examples of mixtures, since students can see and easily separate each of the individual components. When an egg breaks or is beaten, however, it is very difficult to see the original components and impossible to separate, but nevertheless this is a mixture because it was changed **physically only**. Breaking an object is one example of physical change.

Elements combine to form various substances in a process that is not only physical, but chemical also. When elements, such as carbon and hydrogen combine with oxygen, for instance, they burn and form **compounds**. Compounds are combinations of elements that have joined through chemical changes. When we cook an egg, for example, the nature of the egg changes. Cooking is an example of chemical change.

When matter changes from one form to another and back, as ice melting to form water and then water freezing back into ice, we have an example of two **inverse operations**.

The notion of inverse operations is a mathematical notion, also. For example, addition and subtraction are inverse operations, because one “undoes” the other. On the other hand, there are some operations that have no inverse operation, for example, cooking an egg. There are other operations that are their own inverses, for example, pressing the power button for “off “ and for “on” on a TV set.

L E S S O N F O C U S**■ LESSON 1*****Matter Is Everywhere******BIG IDEA***

Everything we see and touch is matter. We can describe relations between 2 measurements with a graph.

■ LESSON 2***How to Detect Matter******BIG IDEA***

If it is matter, it has mass. One way to describe mass is to weigh it and to say where in the universe we weighed it.

■ LESSON 3***Another Way to Detect Matter******BIG IDEA***

If it is matter, it occupies space. We can measure volume.

■ LESSON 4***What Is Matter?******BIG IDEA***

Everything in the universe is composed of atoms. Special combinations of atoms, called molecules, help us understand the properties of matter. A small number of elements can join to form many different combinations.

■ LESSON 5***Matter Changes in Appearance******BIG IDEA***

Matter can change its appearance through a physical change while its weight and volume remain the same. Inverse operations “undo” each other.

■ LESSON 6***A Substance Can Change in Mass******BIG IDEAS***

Matter can change in its mass through a chemical change. Weight and volume can change through chemical reactions.

■ LESSON 7***Compounds and Mixtures******BIG IDEA***

Compounds form through chemical change; mixtures are combinations that form through physical alterations only. There are similar mathematical operations; some operations have inverses, other have no inverses and some operations are their own inverses.

■ LESSON 8***Science: Counting and Measuring******BIG IDEA***

Science tries to answer questions about our world; often, we find the answers by counting, estimating and approximating.

OBJECTIVE GRID

Lessons	1	2	3	4	5	6	7	8
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Mathematics Objectives

- | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1. measure volume of gases , liquids and solids in metric and English systems to the 1/2, 1/10, 1/100 units | | | • | | | • | • | |
| 2. measure weight of gases, liquids and solids in metric and English systems, to the 1/2, 1/10, 1/100 units | | • | | | • | • | • | |
| 3. estimate volume and weight | | • | | | • | • | • | • |
| 4. predict results of physical and/or chemical changes | | | | | • | • | | |
| 5. find volume of given 3-dimensional geometric shapes | | | | • | | | | |
| 6. find sums and differences with addends less than or equal to 500 | • | • | | • | • | • | | • |
| 7. use a calculator to find products of 2-digit factors greater than or equal to 20 | | | | • | | | | |
| 8. describe differences between objects to include weight and volume as descriptors | | • | | | • | • | | |
| 9. measure temperature | • | | | | | | | |
| 10. graph data | • | | | • | | | | |
| 11. explore inverse operations. | | | | | • | | • | |

Science Objectives

- | | | | | | | | | |
|--|---|---|---|---|---|---|---|--|
| 1. list 3 forms in which matter exists, i.e., solid, liquid, gas | • | • | • | | • | • | • | |
| 2. list mass and volume as properties of matter | | • | • | • | • | • | • | |
| 3. describe 2 changes through which matter undergoes | | | | | • | | • | |
| 4. list at least 3 examples of a physical change | | | | | • | | • | |
| 5. list at least 3 examples of a chemical change | | | | | | • | • | |
| 6. describe composition of substances as mixtures, compounds or elements | • | | | • | • | • | • | |

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LESSON

1

Matter Is Everywhere

BIG IDEAS Everything that we see and touch is matter. We can describe relations between two measurements with a graph.

Whole Group Work

Materials

Large chart; bottle of strong-smelling perfume; marble, some other solid object; cup of Kool-aid; ice cube

At least three transparent glass tumblers of different sizes and odd shapes

Word tags: solid, liquid, gas, shape, form

Encountering the Idea

Begin this overview lesson with the question: What is the world made of? As students offer ideas, write them on a chalkboard for later use. If students do not mention air, ask if air should be on the list. What about water? What about our bodies? After the students have offered their suggestions, ask them how some of these things are alike.

Ask students what ice is. Yes, water. What is steam? Yes, that is water also. What is the difference between ice, water and steam? Yes, the temperature — steam is hot, but ice is cold. Water can be hot or cold. We can take the temperature of liquids and gases more easily than that of solids. We are going to explore these ideas more.

Exploring the Idea

Perfume

Before students go to the learning centers, begin this activity:

Students, look at this perfume bottle. I am going to take off the stopper and place the bottle here by the window. As soon as you smell the perfume, raise your hand and tell us that you can smell it and describe the smell. As soon as a student indicates she/he can smell the perfume and describe it, the teacher adds: Some people are holding up their hands. Do you smell the perfume? Why can you smell the perfume if it is far away from you? Who can give me some ideas? (The perfume is a liquid, but it has a smell; the smell is a vapor; a vapor is also a gas; a gas can go all over the room; it doesn't stay in one place.)

Who was able to smell the perfume first? Are you closer to the bottle? Did it take the perfume smell long to travel to the other side of the room? What helped the perfume travel from the bottle to the other side of the room? (Has no shape; won't stay in a container unless it is covered. It goes into the air that takes it everywhere.) Describe the properties of a gas.

If I don't want to smell the perfume, what do I do? (Put the cap on the bottle so the vapor won't go out.)

Kool-Aid

Look at this cup of Kool-Aid. Is Kool-Aid matter? Is it a solid or liquid? What shape is this liquid in? (The shape of the cup.) Now I'm going to pour it into these different tumblers.

What form or shape does it have? Yes, it takes the shape of the tumbler. What can we say about a liquid? (We can see it and feel it, but it doesn't have a definite shape.) What are some other examples of matter that is in liquid form?

Marbles

Look at this marble. This is a solid. Describe it. (Hard, heavy, definite shape, can see it, feel it.) What can we say about matter in the form of a solid? What are some other examples of matter that is in solid form?

Solids, Liquids, Gases

For this activity, we are going to look around the room, again, and see if we can list things that are either solid, liquid or gas. As we name these things, we'll put them up on this chart under the words: Solid, Liquid or Gas.

Things the world is made of

Solids (hard, heavy)	Liquids (have to have it in bottle)	Gases (can't see it)
rocks wood people paper pencils clock	water milk juice rain Kool-Aid	air oxygen carbon dioxide cooking gas

At the **Science Center**, the students complete **Activity** — Solids, Liquids and Gases.

At the **Mathematics Center**, the students complete **Activity** — Temperature. For review, students can do **Activity** — Using a Thermometer, from **Unit 2: Sun and Stars**.

Getting the Idea

Tell the students that everything we see and touch is **matter**. Our bodies are made of matter, the water we drink is made of matter, as is the air around us. (There is little that we can see and feel that is not matter.) Sometimes we can see matter and feel it, but sometimes we can't. Even if we cannot see it or feel it, as with air, it is still matter. Matter exists as a solid, a liquid or a gas.

How can you describe a solid? (It's hard; it's heavy; can't see through it; you can't go through it; you can feel it and see it; it has a specific shape.) **Note:** If a student names light as matter, you may respond that the world does receive light from the sun and that light is energy, but we will not study energy until a later unit.

How can you describe a liquid? (You have to put it in something; it doesn't have a specific form; it takes the form of its container; it doesn't have a shape.)

How can we describe a gas? (It goes everywhere; it doesn't have a shape; it doesn't stay in an uncovered container; sometimes you can't see it; it goes everywhere in the room.)

Organizing the Idea

1. Students write about matter in their journals — what it looks like, what it feels like.
2. Students draw a picture of matter; what does matter look like?
3. Students make a checklist of things to look for in matter to be able to say whether it is in solid, liquid or gas form.

Applying the Idea

Problem Solving

1. What is jello? Solid or liquid? For your answer, select either solid or liquid and convince your partner or your teacher of the answer you chose. Can both answers be correct? Why?
2. Is temperature related to the form that water is in? Explain.
3. Do you think that the temperature of matter is related to whether it is in solid, liquid or gas form? Why do you think that might be true?

Closure and Assessment

Paper and Pencil

1. A (gas) has no shape and sometimes we can't (see) it or (feel) it.
2. A solid is (heavy), has a (shape) and we can see it and (feel) it.
3. A (liquid) has no shape, but it takes the (form) of the container it's in.
4. How many forms does matter have? Name them and describe at least two properties of each.

List of Activities for this Lesson

- ▲ Solids, Liquids and Gases
- ▲ Temperature

ACTIVITY *Solids, Liquids and Gases*

Objective

Student says that matter exists as a solid, liquid or gas and can change from one form to the other.

Materials

Hammer; ice cubes; dish; thermometer; paper towel; charcoal briquette or small piece of coal

Procedures

1. Put the ice cube in the dish and the pieces of coal on the towel.
2. Examine and describe the charcoal and the ice cube. How are they alike? How are they different?
3. Crush the piece of charcoal with the hammer.
4. Examine the charcoal again. In what ways is it the same as it was before? How is it different? Is it a solid, liquid or gas?
5. Let the ice cube remain in the dish. Examine and describe it including its temperature after a few minutes, after an hour and after a day. Each time, decide whether it is a solid, a liquid or a gas.
6. After the last observation, again compare the charcoal and the ice cube. How did they respond differently when left undisturbed? Why do you think this happened?
7. Place the water from the melted ice cubes in a pan and heat it until it begins to boil and produces steam. Take the temperature of the steam. Describe the water in this form.

Problem Solving

1. What is the temperature of the piece of coal? How could you take its temperature?
2. What is the temperature of the water that has been left in the room for several hours, or several days? (It has the same temperature as the air in the room.)
3. What do you think that “at room temperature” means?

Getting the Idea

In this activity we saw that matter exists as a solid, a liquid or a gas. But we saw something else — matter can change its form from solid, to liquid, to gas and then back. Matter cannot be destroyed — only changed in form.

▲ ACTIVITY *Temperature*

Note

Conduct this activity **with the whole group**, the students working in pairs. The teacher **strictly monitors** the activity since it will require using boiling water. It is important that the teacher conduct the discussion as indicated.

BIG IDEAS We can measure the temperature of liquids in degrees Celsius or degrees Fahrenheit. We can show the relation between degrees Celsius and degrees Fahrenheit on a linear graph.

Materials

Hot plate to boil water; ice cubes to put into a cup of water

Graph paper, or a paper marked with a grid. On the grid paper draw a coordinate system such as the one in Fig. 3; label one axis degrees Celsius and the other degrees Fahrenheit.

One thermometer, marked in both Celsius and Fahrenheit units, for each student pair

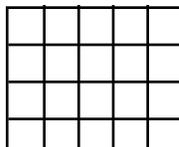
One thermometer for the classroom, marked in both Celsius and Fahrenheit units, to remain at room temperature for the entire activity and easily available to all the working groups

One thermometer, marked in both Celsius and Fahrenheit units; place outdoors early in the day, away from direct sunlight, for students to take the outdoor temperature

Procedures

1. Students examine the thermometers and describe them.
2. Students put the thermometer in boiling water and record the temperature to the nearest $1/2$ unit, using both scales.
3. Students put the thermometer in the freezing water and record the temperature to the nearest $1/2$ unit, using both scales. The students repeat their measurements two or three times, after allowing the thermometer to cool or warm depending on the observation they want to make.
4. Each student pair report their results and observations.
5. After students report their results, they discuss why there were differences in their observations, i.e. did everyone report that water boiled at exactly 100°C or 212° .

¹Draw a grid to graph a relation several times on a single sheet of paper and duplicate for students' use. Draw in the axes and the scale later.



	Celsius	Fahrenheit
Boiling water	100°	212°
Freezing water	0°	32°

Fig. 1**Discussion**

Why were the temperatures we observed and recorded not **exactly** the same? (Measurements are never exact.)

When you read the temperatures on the Celsius side of the thermometer and then on the Fahrenheit side of the thermometer, why are the readings (the numbers) different? Yes, because we are using two different scales.

Are both scales standard scales? Yes.

Compare the first Celsius reading with the first Fahrenheit reading.

Compare the second Celsius reading with the second Fahrenheit reading. What do you notice about the readings? (For each observation the Fahrenheit reading is larger than the Celsius reading.) Do you think this will always be true? Why?

1. Students record the room temperature using both scales to the nearest 1/2 unit. Was your prediction true? Was the Fahrenheit reading larger than the Celsius reading?
2. Students record the outdoors temperature and predict the relationship between the Celsius and Fahrenheit readings again.
3. Students state a rule about the temperature readings in Celsius and Fahrenheit. (The C reading will always be less than the F reading, or the F reading will always be greater than the C reading.)
4. Does this mean that the temperatures are different? No, the temperature is the same. What, **then**, is different? Yes, the size of the units is different.
5. We use the temperatures at which water freezes and at which it boils to make the two scales. Which unit is larger **in size**? Celsius is larger, so you need fewer units to go from freezing to boiling. Fahrenheit is smaller, so you have to have more units.

	Celsius	Fahrenheit
Room air	25°	78°
Outside air	10°	50°
Boiling water	100°	212°
Freezing water	0°	32°

Fig. 2

We can plot the relationship between the two temperature scales on a line graph using the four points (the origin) we found with the four thermometer readings.

6. On the coordinate system find the point $(0, 32)$ on the graph. Since the graph shows the Celsius scale represented on the horizontal axis, and the Fahrenheit on the vertical axis, remember to use the C reading to the right, and the F reading to the top. Find the points $(0,0)$, $(100, 212)$, $(10, 50)$, $(25, 28)$, $(0,32)$.
7. What do you get if you connect all four points in increasing order for C?
8. Because the graph of the C readings and the F reading forms a line, we say that the Celsius scale and the Fahrenheit scale have a **linear relation**.

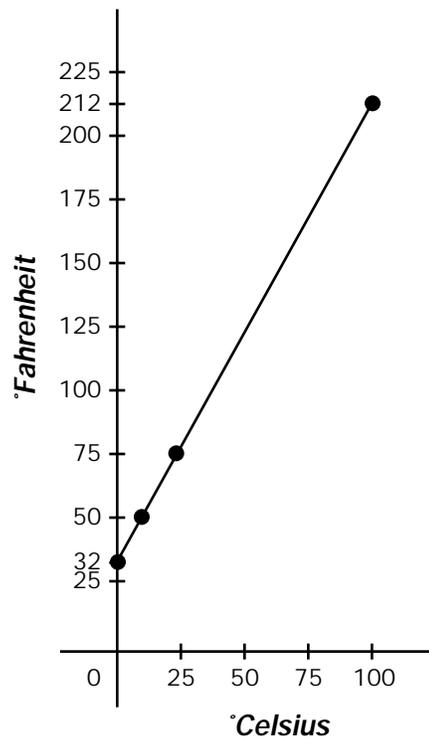


Fig. 3

Applying the Idea

You can use the graph we constructed above to find the temperature in degrees Celsius if you know it in degrees Fahrenheit. You can also do the inverse. Given the degrees Fahrenheit, you can find the degrees Celsius. Can you do it?

1. Suppose the outside temperature in the summer is 100° F. What is it in C? You can approximate your answers. Be sure you have a reason for your answer. Share it with other student groups.
2. Suppose the room temperature is 16° C. What is it F?
3. Just by looking at the graph can you tell that the F reading will always be greater than the C reading? Explain it to your teacher.

LESSON

2

How to Detect Matter

BIG IDEAS If it is matter, it has mass. One way to describe mass is to weigh it and to say where in the universe we weighed it.

Whole Group Work**Materials**

For each student team

Place the following items in a box for student use: ping pong balls in a plastic bag; a marble; a paperweight or a large stone; several cotton balls in a plastic bag; two balloons

Balances to mass various objects, and nonstandard weights to mass the objects, such as washers and/or other objects

Several different pictures of astronauts in a space capsule floating inside the capsule

Gallon can or plastic bottle

Nail and hammer

Several rubber bands; small plastic bags with ties; balloons; sponges; water and Kool-Aid; cups; a meter stick; a 12-inch piece of string

Word tags: weight, mass, matter

Encountering the Idea

Ask the students to review the following: In what forms does matter exist? Matter exists as a **solid**, as a **liquid** or as a **gas**. We can usually see and feel matter when it is in the form of a solid or a liquid, but if it is a gas, we may not be able to see it, smell it or even feel it. If that is true, how do we know matter is there? (Pause for possible suggestions.) Write some of the suggestions on a chart or chalkboard for later consideration. We are going to perform some experiments in the **Science Center** that will help us discover answers to this question: If we can't see matter, feel it or smell it, how can we detect it?

Exploring the Idea

At the **Mathematics Center**, the students complete **Activity** — Water Weight.

At the **Science Center**, the students work in teams of four each.

- Using the balances, the students mass the following objects and record the number of washers or other objects used in balancing the objects: a marble; plastic bags filled with cotton balls; ping pong balls, a plastic bag partially filled with water and sealed with a tie to keep the water from spilling

After the students have had an opportunity to mass these objects, discuss what they observed and recorded.

- They balanced one mass, the ping pong balls, with another mass, the washers.
- The two masses “balanced” meaning that the two masses, one on each side, were equal.
- They found that solids (the balls, the cotton, the marble) have mass.
- They found that water (the water in the bag) has mass.

2. Ask students to find a method by which to mass air, using any of the materials available in the classroom. (Suggest they might look in the box for materials they might use.) As soon as a group thinks they have found a way to mass air, the students explain their idea to the class.

Getting the Idea

Complete the following sentences for the experiment on the weight of a liquid.

The weight of the _____ minus _____ of the _____ equals _____.

The weight of the _____ plus _____ of the _____ equals _____.

Answer the following question: Can we find the weight of all liquids in this manner? (Usually, yes, but there may be liquids that we can't handle as easily as water, or alcohol, milk, etc.)

One important property of matter is **mass**. Mass is the "stuff" things are made of. In these experiments we were able to see that **all matter has mass** when we picked up objects such as this marble or paperweight. It is not as easy when we pick up this ping pong ball or this cotton ball to feel that they are heavy. We need a balance to help us see that these things have weight.

We describe mass in matter by saying that it has weight. Weight tells us how much earth's gravity is pulling on something. If there were no gravity, then we would not weigh any amount, **but we would still have the same amount of mass**. Weight only describes how much gravity is pulling on matter, and it is a way of describing matter.

Does all matter have weight? How do we know? Do solids have weight? Do liquids? What can we say about air? (Air has weight, because air is matter.) Even though we can't see air, we know it is there because we can mass it, or we can weigh it. Gases have mass, and we can weigh them also.

What is the answer to our question: If we can't see matter, smell it or feel it, **how do we know it is there?** Write and illustrate the answer in your journals.

Organizing the Idea

The activities conducted during the exploration phase of the lesson include strategies for organizing the idea.

Applying the Idea

Answer these questions after studying the pictures of the astronauts inside the space capsule:

1. What would happen to you if there were no gravity on earth? (Float off into space; couldn't keep my feet on the ground; couldn't weigh myself; **but I would still have the same amount of mass.**)
2. Why do the astronauts float around the space capsule, turn upside down and sideways? (There is no gravity in outer space; the astronauts then have **no weight!** But, they **do have the same mass they had on earth.**)

Closure and Assessment

1. Students, working in small groups, state and/or illustrate their own definition of matter, mass and weight.
2. Students use these words to complete the following paragraph: mass, matter, weight, gravity, container, invisible, outer space.

All (matter) has (mass). Solids are (heavy), and (we can't see through them), are (hard) and have (mass). Liquids (have to be put in a container) and have (mass). Gases usually (can't be seen, are invisible), (have to be put in a container) and have (mass). Matter does not have weight when it is (in outer space where there is no gravity).

What can you say about weighing liquids and gases? (They cannot be weighed directly; we must use an indirect method to weigh them. We need to put both liquids and gases into containers; we need to place a gas, however, into a **closed** container.)

List of Activities for this Lesson

- ▲ Water Weight
- ▲ Finding the Weight of Solids, Liquids and Gases

▲ ACTIVITY Water Weight

Objective

Students use subtraction and addition to compare two quantities to find a difference.

Materials

At least two different liquids, paper cup, scale to weigh the cup, a sponge

Procedures

1. Weigh a cup without water, then weigh it again with water. Record the weights.
2. What is the difference in the weights? What does the difference show?
3. Weigh the sponge. Next, wet the sponge and shake some of the water off of it. Now, weigh it again. Record both weights of the sponge. What is the difference in the weights?
4. What can you say about matter in the form of liquids? (It has weight.)

Cup/Sponge	Water	Alcohol (or other liquid)
with		
without		
difference		

Getting the Idea

1. Why did we use subtraction in finding the weight of water (alcohol)?
2. Rewrite the subtraction sentence as an addition sentence.

3 ounces, weight of paper cup
7 ounces, weight of water
10 ounces, total weight of cup and water

3. Why can we rewrite the subtraction sentence as an addition sentence?
(Addition “undoes” subtraction and subtraction “undoes” addition.)
The weight of the _____ minus the weight of the _____
equals the weight of the _____.

Organizing the Idea

Write subtraction and addition sentences and draw illustrations that say what we did in this experiment.

ACTIVITY *Finding the Weight of Solids, Liquids and Gases*

BIG IDEAS We can weigh solids directly; we must place liquids and gases in containers to weigh them, using subtraction.

Materials

a rock; balloons; water in a container; scales for each student group
 a cup for water for each student group
 several cups available for student use, as needed

Procedures

1. Students find the weight of the rock. Ask students what they had to do to find the weight of the rock.
2. Show students the container with water (or some other liquid). Tell the students that their group assignment is to find the weight of the water. What is the problem that they must solve to find the weight of the water? (Students cannot weigh the water directly on the scale because it spills over. They have to weigh the water in a container.) Provide each group of students with a cup of water; they must find the weight of the water only.
3. The students, working in small groups, decide how to weigh the water in the cup assigned to them. After each group has had an opportunity to work on the problem, ask them to report the results to the class.

Getting the Idea

1. What was the problem that you had to solve before you could find the weight of the water? (How to contain the water.)
2. If you had to put the water into a container in order to weigh it, did that bring in a new problem? How did you solve that problem?
 Yes, you had to use subtraction. Why did we use the mathematics operation of subtraction?
 Yes, we use subtraction to find differences.

**(Container plus water) Sum - part (container) = difference (water),
 or
 Sum - one part = the other part**

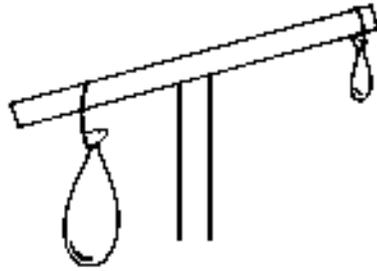
Applying the Idea

Tell the students that now that they have solved the problem of finding the weight of a liquid, they need to apply what they have learned to try to find the way to weigh a gas. For example, how can we weigh air?

Give them time to consider the solution. Hint: Air, since it is a gas, needs to be placed in a container. The problem is, how can you weigh the container without the air being inside it to begin with?

Let them brainstorm about what containers they could use. Hint: It doesn't have to be a glass container — it could be made of something else, like a balloon.

After the students have thought about using balloons to weigh air, let them explore in a manner similar to the one below.

**Materials**

Two meter sticks; two balloons; two six-inch pieces of string

Procedures

1. Have the students put one meter stick on the end of another meter stick to form a balance.
2. Attach one uninflated balloon on each end of the top stick with string. Place the meter stick with the balloons attached on the vertical stick and adjust until the two balloons balance. Mark the point of balance on the horizontal stick.
3. Inflate one balloon and replace it exactly where it was before.
4. Have students observe and describe what happened.

Discussion

What can we say is inside the balloon? (We blew air into it.)

Are the two balloons the same before and after the experiment? (No, one balloon has air, and it is heavier after we blew air into it.)

What happened to the meter stick? (Or what happened to the balance?) (The meter stick is leaning to the heavier side.)

What does it mean if the stick tilts down to one side? (The heavier balloon goes down.)

Which side is heavier? (The one with the inflated balloon.)

What can we say about air? (It has weight. A gas has weight.)

Why do you suppose we tied the other balloon with the string even though it did not have air in it? (The string has weight, and the two balloons have to be the same if we are going to compare them.)

Did we use subtraction in this method of finding the air's weight in the balloon?

LESSON

3

Another Way to Detect Matter

BIG IDEAS If it is matter, it occupies space. We can measure volume.

Whole Group Work**Materials**

An empty box, cubic centimeter cubes, one-inch cubes, or other units of volume; a graduated cylinder or a measuring cup in ounces and milliliters; a cup of Kool-Aid or juice; Ziplock Baggies and the Baggie box; a bowl half-filled with water; several dry, shriveled sponges; a transparent glass tumbler

Word tags: space, volume, capacity

Encountering the Idea

Introduce the relation between matter and volume by asking students to look at: the marble they weighed earlier; one of the centimeter cubes; the inflated balloon; the bowl with water in it. What do all these things have in common? Let the students suggest some ideas. (They are matter; they have mass that is shown as weight.) What other thing do they have in common? (Pause. Allow students to make suggestions.) Tell students that they will discover some answers to the question.

We are now going to perform some experiments in the **Science Center** that will help you answer the question: **What's another way to detect matter?**

Exploring the Idea

Let's look at this glass of Kool-Aid. If we pour it into a graduated cylinder, we see that the Kool-Aid takes up ___ milliliters (or ___ cubic centimeters) of space.

Here is another demonstration: I take this empty Baggie, open it, and swing it hard, and then without flattening it, close the zipper. The Baggie is now expanded, stretched, and when I squeeze it, it remains expanded. The Baggie now takes up more space. I can't put it back into its original box. It has gotten too big and takes up too much room.

Look at this box. We can fill this box with these cubes. We easily see that this box takes up ___ milliliters (or ___ cubic centimeters) of space or room.

At the **Mathematics Center**, students complete **Activity** — Volume of Solids, Liquids and Gases.

Getting the Idea

In order for scientist to discover answers to questions about matter, it is very important that they have the appropriate tools to help them make their observations. One such tool is the graduated cylinder. It is a cylinder in shape — round and three-dimensional. It is also narrow and long. Why do you think it's tall? (Pause for student suggestions.) It is tall to make the liquid rise high and give a

more accurate reading. The more narrow the tube, the more it looks like a “line” that could be measured with a measuring tape. The tube has marks in “grades” or steps for easy reading. It is an important tool for scientists.

Ask the students what solids, liquids and gases have in common. Let the students make suggestions. Yes, these things all take up space; they take up room; they have **capacity**, or **volume**. We say that the box has **capacity**. We can measure its **volume**, or the space it takes up, by using this standard cubic inch or this standard milliliter.

What’s another way to detect matter? Another way to detect matter is to note that it takes up room. What’s the other way? To note that it has mass and can be weighed.

Gases conform to the shape of a container and always fill it up completely. That is one difference between liquids and gases. Although liquids must be put into a container and they conform to the shape of the container, in other words take its shape, they don’t expand to cover the entire container. Gases also conform to the shape of the container, but the container must be **a closed container**, otherwise the gas will escape. The gas takes the shape of **the entire** container; gases keep expanding unless we close them off.

Organizing the Idea

1. Students write a paragraph and illustrate the property of matter we call volume.
2. Students explain how to find the volume of a solid, of a liquid and of a gas.

Applying the Idea

Problem Solving

1. Of which form of matter — solid, liquid, or gas — is it the easiest to find the volume? Illustrate your answers, if you can.
2. Solve the following problem. Working in teams, design a **different** demonstration that will show that air takes up room; in other words that air, which is a gas, takes up space. Use any of the materials in this box to make your demonstration. (The following is one solution. The students may suggest different ones. If we blow up a balloon with air, we see that the balloon gets big and takes up space. If we release the opening of the balloon we can feel the air come out as the balloon deflates.)

Closure and Assessment

1. The first team who is ready will demonstrate to the class why they think that air has volume; they will tell you what materials they used for the demonstration and why. The other students listen and discuss whether they agree or not.
2. Matter exists in the form of a solid, a liquid or a gas. It is easy to see that matter takes up space when it is in the form of a solid or liquid. Discuss why it is more difficult to measure the volume of a liquid or a gas.
3. Two very important properties of matter are that matter has mass and that it occupies space, or in other words has volume. By these two properties, you can detect matter.

In these activities, we experimented with the properties of matter: matter has mass and it occupies space. Draw and write in your journals about matter.

List of Activities for this Lesson

- ▲ Volume of Solids, Liquids and Gases

▲ ACTIVITY *Volume of Solids, Liquids, and Gases*

Objective

Students see that they can measure the volume of a solid, liquid or gas.

Materials

For each student group:

A small box; a rough, irregular rock or some other object; any book; a chalkboard eraser

Enough centimeter cubes to completely fill the small box (the cubes must stack with no spaces between them)

Pieces of wood, such as unifix cubes, Cuisenaire rods or other materials that have the same volume and that can be placed into the small box so as to fill it

Procedures

Students can do the activity on three separate days, one part per day.

Part I: Solids

1. Ask the students to look at the piece of wood. Describe it. (Color, odor, takes up space, has mass, etc.) If students don't mention it, tell them that the piece of wood takes up room, takes up space, or has volume. Can we measure volume? How can I find the volume of this piece of wood? How can we measure volume? Allow students sufficient time to think about it and to offer suggestions. Hint: How do we measure length? (With units of length called "inches", "centimeters" or "feet".)
 How do we measure area? (With units of area called "square inches" or "square centimeters.")
 How do we measure volume? (With units of volume.)
 What can we use to measure the volume of this box? (Pause for suggestions.) I can take these smaller cubes and put them into the box until all the space in it is used up. By finding the number of cubes it took to fill the box, I will know its capacity, or volume. Centimeter blocks (or whatever unit of volume was used) can be the standard unit of volume to fill up the box because they take up room, have volume.
2. Your first assignment is to find the volume of the box. You can also find the volume of this chalkboard eraser, this book, and this rock. Record the information on this chart. The object is the solid of which you are measuring the volume; the method describes what you did to find the volume; and the volume you give in the units you used.

Object	Method Used	Volume (unit)

3. After completing the assignment, the students report to other groups or to the class.

4. What method did you use to find the volume of the shoe box? The eraser? The rock? Explain why you selected the different methods. (If the students are not able to find a reasonable estimate of the volume of the rock, leave this question unanswered until after the student have completed Part III of the activity. At that time someone may suggest placing the rock into a large measuring cup and using the rise in water volume as the measure of the volume of the rock.

Part II—Liquids

Materials

For each student group:

A graduated cylinder; a soda pop can

Three milk containers — 1/2 pint, 1/2 gallon and one-gallon

1. Students, look at this cup of water. Does the water take up space or room? Does it have volume? What is the volume of the water? How can we find the volume of a liquid? (Since a liquid takes the shape of its container and does not have a definite shape, we have to put it into a container before measuring its volume.)
2. What is the volume of the milk container? (1/2 gallon. How do you know? It says on the label.) And this one? (“One gallon” is on the label.). We say that a gallon is a standard unit of **liquid volume**. Examine the milk **container**. The container often shows the content in other standard units. What are they? (Liters and fluid ounces.)
3. Your assignment is to find the volume of the water in your cup. Find the volume of the milk you drink when you use the milk containers in the cafeteria. Find the volume of soda pop in the can. (Should be listed fl. oz. and ml.)
4. After completing the assignment, the students report to other groups or to the class.
5. What method did you use to find the volume of the milk carton? The can? Explain why you selected that method. Liquids take the shape of the container but gravity causes filling from the bottom up.
6. What units do we use to give the volume of a liquid? (Fluid ounce, pint, gallon, milliliter, liter, cubic centimeter.) Why do you suppose there are so many **different units** to say what the volume of a liquid is?

Part III—Gases

Materials

For each student group:

A measuring cup; a large container with water

1. Students, look at this empty measuring cup. What is its capacity? How much liquid can we put into it, if we fill it up to this mark at the top? Yes, one cup. On the other scale it reads ____ milliliters. What is inside the cup, now? Yes, air. But we can't see it. How do we know it is there?
2. We are going to use the large container that has water in it. Take the cup and submerge it into the water in the large container **without turning it sideways**. Describe to your team members what happens.
3. What is in the cup that prevents the water from filling the cup completely? Is it hard to keep the cup from turning sideways? Can you tell how much volume the air is occupying in the cup? Read it to your team members.

4. What can you say about the volume of a gas? (We can measure it.)
5. What units do we use to measure the volume of a gas? Are they the same as the units we use for liquids? All of them except the fluid ounces. Why do you think that we can measure the volume of a gas using the same units? (Since a gas does not have a definite shape, it needs to be put into a container, as does a liquid.)
6. How can you find the volume of this rock? (Can submerge it in the measuring cup and record the change in the volume of the water.)
7. In your journal, write your conclusions about the most important thing about measuring the volume of solids, liquids and gases.

Alternative to finding the volume of a gas.

Ask the students for suggestions for other ways to find the volume of a gas.

Remind them that a gas not only conforms to the shape of its container, it also **fills the container completely**; therefore the container must not only be a closed container, but it must be **airtight**.

1. Put water into a large measuring cup with water, but do not fill it. Record the volume of the water.
2. Blow air into a **small** balloon and submerge it completely into the measuring cup. (Students will have to decide how to submerge the balloon completely without putting their hands or some other object into the water. The students explain why they have to take this precaution.)
3. Read the change in the volume of the water.
4. The students may want to discuss whether the balloon itself affected the reading of the volume, and if so, what needs to be done about that.

LESSON

4

What Is Matter?

BIG IDEAS Everything in the universe is composed of atoms. Special combinations of atoms, called molecules, help us understand the properties of matter. A small number of different elements can join to form many different combinations.

Whole Group Work

Materials

Small piece of coal or charcoal

Small square of aluminum foil

Hammer

Have for demonstration pictures of a diamond, gold and silver jewelry, or pictures of objects made of brass, steel, copper

Word tags: atom, molecule, element, combination

Encountering the Idea

In our previous lessons we have talked about the forms that matter takes, for example, solids, liquids and gases. We also talked about matter having special properties — it has mass and we can weigh it, and it has volume, or takes up space. But have we actually said what matter is? This is one of the most important questions that scientists are trying to answer. What we think that matter is today has been handed down to us by scientists who have tried to find out about matter. In the following activities we are going to try to discover some new things about matter.

Exploring the Idea

Show students the piece of coal. Ask what it is. This is pure carbon, or coal. What happens if I hit it over and over with the hammer? Yes, it breaks into very small pieces. Is it still coal, or carbon? (It looks like it; breaking only changes its appearance.) How long do I have to hammer this coal until it is not coal anymore? Yes, that's right, you can't change it by just breaking it. What about this piece of aluminum foil? It is pure aluminum, and when I cut it into very small pieces is it still aluminum? Can you change the aluminum foil just by making it into small pieces? No.

Many hundreds of years ago, the Greeks asked the same question. Can we continue cutting the carbon into smaller and smaller pieces forever, or is there a very small piece that we can no longer cut into smaller pieces? The Greeks solved their problem like this: the smallest piece that matter can be cut into without changing the matter into something else, they called — and to this day we call — **an atom**. All matter, then, is made up of these small units that cannot be cut into smaller units using ordinary processes. A collection of the same kind of atoms is called an **element**. Groups of atoms, sometimes of the same kind and sometimes of different kinds of elements, that cling together like tiny magnets are called **molecules**.

Matter usually does not exist in its pure form as an element, like carbon or gold. Matter exists in the form of molecules. These particles that we have named, atoms and molecules, are so very small that we cannot see them, not even with a microscope. Thus, we group these molecules into the forms of matter we call solids, liquids and gases.

In the following activities we are going to try to discover some of the properties of molecules. The first activity will help us see that molecules are combinations of atoms, the second that molecules are in constant motion and the third that a small number of different types of atoms can combine to form many different combinations that are the molecules.

At the **Mathematics Center**, students do **Activity** — Molecules Combine.

At the **Science Center**, the students

1. do **Activity** — Sweet Molecules
2. do **Activity** — Molecule Can Move Through Solids
3. as a whole group do **Activity** — Molecule Speed, as below.

Materials

Two glasses of hot and cold water; food coloring; medicine dropper

Procedures

1. Get a glass of very cold water and one of very hot water (not boiling).
2. Put a drop of food coloring in each glass.
3. Students describe what happened.

Getting the Idea

We know some substances in their pure form such as carbon, coal, charcoal or graphite. Other substances that we usually see in their pure form as **elements** are diamonds, which are also carbon but in the form of crystals. Gold is another element. Usually, when we use gold for jewelry, it is not in its purest form because gold is very soft. It has to mix with other metals for it to be hard. We can see silver in its pure form, usually as jewelry. Other metals such as aluminum (foil), copper and zinc exist as elements. These are examples of matter in its element and in its solid form.

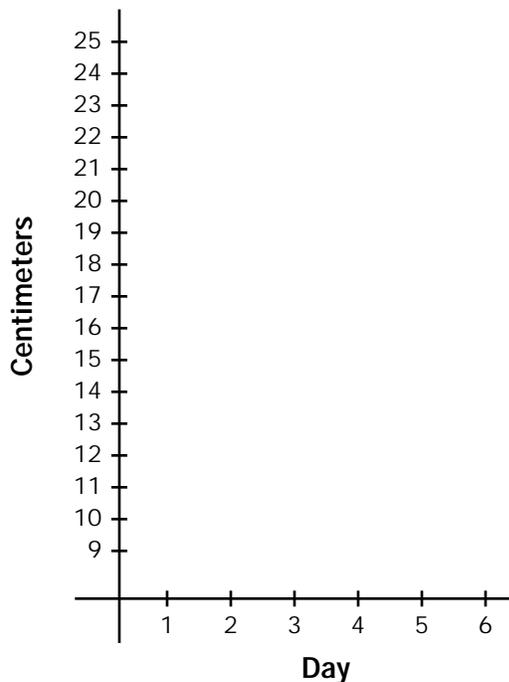
Matter also exists in a liquid form as an element, but this is very unusual. One metal, mercury, exists in its pure form as a liquid. It goes into its vapor state very easily and is very poisonous as a gas. We will not show that to you except in this mercury thermometer. The mercury is sealed into this tube and cannot escape.

Matter in the form of a gas exists as an element too. These gases are hard to see because they are usually colorless. Oxygen in the air is in its element form, as is nitrogen. However, carbon dioxide, which is included in the air we breathe out, is also a colorless and odorless gas, but it is not an element. It exists in the form of a **compound**. Compounds are **substances** composed of two or more elements that have joined as a result of a chemical change. Water, for example, is a compound composed of two gases — oxygen and hydrogen.

In one of our experiments we said that hot water molecules were moving faster than cold water molecules. How did we reach that conclusion? (Pause; allow students time to give opinions.) A drop of food coloring will mix much more rapidly in hot water than in cold water, because as liquids heat up the molecules in them move faster. The movement of the molecules “stirs” the water and causes the food coloring to mix at a faster rate. Water does not compress, but it will expand and contract due to changes in temperature.

Organizing the Idea

- To expand on the idea that molecules can move through solids, students make a chart showing the length of a string every time they measure the circumference of a balloon. From the chart they draw a graph.

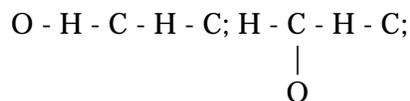


- Students make a drawing showing how atoms, elements and molecules are different from each other.

Applying the Idea

- If you wanted something, like jello, to dissolve rapidly in water, what would you do to the water you were going to make it in? Explain why. (Heat for jello to dissolve faster or stir quickly, or both.)
- You have two atoms of carbon, two of hydrogen and one of oxygen. Make as many **different** molecules as you can using **all** five of the atoms at the same time. Make the molecules with gumdrops to check yourself.

H - C - C - H - O; H - C - C - H; C - H - H - C - O; C - H - H - C; H - C - H - C - O;



- Check with your partner to see if she/he had different ones.

List of Activities for this Lesson

- ▲ Molecules Combine
- ▲ Sweet Molecules
- ▲ Molecules Can Move Through Solids

▲ ACTIVITY Molecules Combine

Objective

Given a set of elements, the student counts all possible combinations of the members of the set.

Materials

Felt or cardboard cutouts of ice cream cones and ice cream scoops; gumdrops

Procedures

1. Janie works in an ice cream store. The flavors sold are {vanilla, chocolate}. Although there are only two flavors the store sells, how many possible combinations can Janie make from these two flavors, alone, for a double-scoop cone? (Remember, some people might like a double vanilla or double chocolate.) Use the ice cream cutouts to help you solve the problem. Record your results on a chart. (3.)
2. The store introduced a new flavor: strawberry. How many combinations can Janie now make for a double-dip cone? Use the cutouts to help you see the solution. ((v,v) (v,c) (v, s) (c,c) (c,s) (s,s).) (**Hint:** Try using gumdrops to show the ice cream cones and then count them.)
3. The store is having an ice cream sale and is reducing the price of a triple-dip (three scoops) cone. How many combinations of a triple-dip cone can Janie make? Let's let a vanilla, vanilla, chocolate cone be the same as a vanilla, chocolate, vanilla cone. In other words, the order in which you put the scoops on is not important — just the number of scoops of each flavor.
 ((v, v, v) (c, c, c) (s, s, s)
 (v, v, c) (v,v, s)
 (c, c, v) (c, c, s)
 (s, s, v) (s, s, c)
 (v, c, s)
4. The store now begins to offer 31 flavors to its customers. The customers can ask for a single, a double or a triple-dip cone. Can you make a guess about how many different combinations there can be? How did you come up with this estimate?
5. Instead of making combinations of flavors for ice cream cones, you are going to make combinations of different elements to make molecules. How many **different molecules** could you make if you had two different elements {krypton, selenium} and combined them two atoms at a time? Remember, molecules can form from combinations of the same element, as well as from different elements.
6. How many **different molecules** do you estimate you could make if you had three different elements and could combine them in groups of two molecules and then three molecules? Select three colors of gumdrops and make some molecules and count them. Combine your information with the rest of your group's information and report to the class.

Discussion

What can you say about this idea: A small number of different elements can combine to form many, many different kinds of molecules.

▲ ACTIVITY Sweet Molecules

Objective

Students construct molecules of common compounds with color-coded gumdrops (or some other colored, soft candy).

Materials

Package of different-color gumdrops; toothpicks; baking cups; a copy of the color chart.

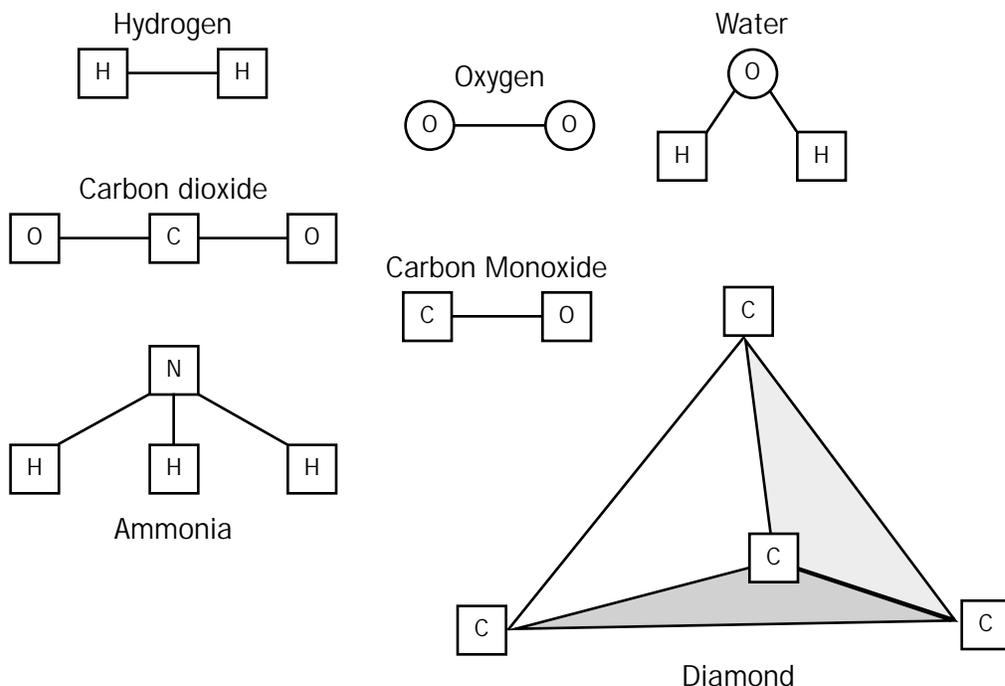
- 30 gumdrops or other colored candy (at least five different colors); class has determined and assigned colors for each element
- 30 toothpicks
- Copy of the chart depicting molecules of water, oxygen, hydrogen, ammonia, carbon dioxide, carbon monoxide
- five to six paper cups (baking cups)

Procedures

- Students receive the gumdrops, sort them by color and put them in the labeled paper cups.
- Using the candies, the students construct each of the molecules shown on the chart depicting molecules of water, etc..
- Once they construct the molecules, the students copy the models into their journals, coloring the atoms with the assigned color.

Symbol	Color	Atom
H	red	Hydrogen
O	white	Oxygen
C	_____	Carbon
N	_____	Nitrogen
Ca	_____	Calcium

- Have students describe the molecules, saying how many red atoms and how many white atoms make a molecule of water.



Getting the Idea

1. You made some representations of molecules in this activity; what do the different pieces of candy represent? (Each gumdrop represents an atom. The different colors of the gumdrops help us see how many **different elements** go into each molecule.)
2. What do the toothpicks represent? (We said that molecules are groups of atoms that hold together like little magnets that hold to each other. The toothpicks represent the magnetic forces that keep the atoms together, thus forming the molecule. Without these magnetic forces, the molecules would fly apart.)
2. How many different types of atoms make one molecule of hydrogen? (Only one type — both of the atoms that make up that molecule are hydrogen atoms.)
3. Describe the molecule of water. (Has three atoms, and two kinds of elements — hydrogen and oxygen only.)
4. What is the difference between the molecules of carbon dioxide and carbon monoxide? What is the difference between these two gases in real life? (Humans breathe out carbon dioxide and also breathe in carbon dioxide with the regular air we breathe. Carbon dioxide exists in regular air in only a small percent. But carbon monoxide, on the other hand, is a very deadly gas. Humans cannot breathe it for more than a few minutes and live.)

ACTIVITY *Molecules Can Move Through Solids*

Objective

Materials

Balloon; string; marker; paper and pencil

Procedures

1. Blow up a balloon and tie it.
2. Measure the size of the balloon by wrapping the string around the balloon along its largest circumference at the largest point. Mark and record the length of the string.
3. Place the balloon where it will not be disturbed. Try to keep it away from heaters or drafts and record the size of the balloon twice a day, in the morning and in the afternoon.
4. At the end of three days, describe your observations.
5. Explain any changes you noted to the class.

Getting the Idea

After three days, ask students what their observations have been and what their interpretation is of the data.

Note: You might check to see that the balloon is tied tightly so air cannot leak through the opening. You can do this by submerging it in water to check for air bubbles. As the balloon sits, air molecules actually permeate the balloon walls, and it will lose air slowly even though air is not escaping by any observable means. For the duration of this activity the air temperature should remain as constant as possible. If air temperature changes, the balloon will expand or contract (in warmer and cooler air, respectively) and that will nullify the results.

LESSON

5

Matter Changes in Appearance

BIG IDEAS Matter can change its appearance through a physical change while its weight and volume remain the same. Inverse operations “undo” each other.

Whole Group Work

Materials

Ice cube; potato cut into several pieces; broken glass bottle; empty can of hair spray

Word tags: change, physical, permanent, temporary, form, appearance, operation, inverse

Encountering the Idea

We have been studying about matter for several days now. We know that matter exists in three forms — liquid, gas and solid — and that it has mass and takes up space. Now, we are going to explore another question: What can we **do** to matter? Can we change it? This is one of the most important questions that scientists have asked. Many hundreds of years ago, **alchemists** were some of the early scientists. They were looking for ways to change matter. For example, they wanted to change iron, copper or lead, which can be easily found, to gold. Their efforts helped science take its early steps. We are going to explore these questions: What can we **do** to matter? And, can we change matter?

Look at this apple. I’m going to cut the apple into small pieces. Take one of these pieces. What does it look like? What does it smell like? What does it taste like? What is it? Yes, it is apple. What is the only thing that has changed about the apple? Yes, only its size, its shape, or form. We can take the pieces and put them together again, like a puzzle, and it will look like an apple again.

In this little demonstration we saw that we can change matter. What did we change in the apple — its shape, its appearance, its form. When matter changes, in what ways does it change? We know that matter has two important properties. What are they? Yes, matter has mass that we can try to change. What experiments do you think we could design to help us see how matter changes? (Pause for suggestions and, if feasible, try some of them.)

Exploring the Idea

Let’s look at this ice cube. Is it a solid or a liquid? Yes, it’s a solid. What is ice? Yes, it is water, but we said that water is a liquid. So what is it — solid or liquid? Can anyone explain this to the class? Yes, when water gets very cold it freezes, and when the ice gets warmer it melts into a liquid, but it is still water. What happens when we heat the water? Yes, it turns into steam. But, is it still water? How do you know? Yes, it is still water because the steam, or water vapor, will condense back into water. In this type of change from ice to water to steam and

then back to water, the change is not permanent. We can go back and forth changing from one to the other. **In what ways does matter change?**

At the **Science Center**, the students complete **Activity** — Mass and Physical Change.

At the **Mathematics Center**, the students complete **Activity** — Inverse Operations.

Getting the Idea

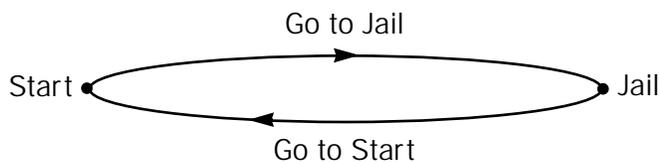
Matter can undergo change. Matter can change its form. That means that matter can change its **appearance**. This is called a **physical change**. For example, we can break a piece of glass, but each piece is still a smaller piece of glass. We can cut up an apple, but each piece is still a smaller piece of apple. Only its size or form changes.

Are physical changes permanent? Explain this to the class. (When ice turns to water and then freezes again, the changes from ice to water and back are not permanent changes. If you break a piece of glass, however, it is a physical change, but unless you have a glass factory, you won't be able to put the pieces back together exactly as they were before. This means that we can't say if a change is a physical change just by looking at whether that change is permanent or not.)

We use mass and volume to demonstrate that physical changes only change the **appearance of** matter and not its mass. We were able to see in an activity that mass, as described by the weight of the rocks after they were broken, remains the same.

We can use the idea of **inverse operations** in mathematics to think about events that follow each other in such a way that performing one operation after the other takes us back to the place where we started. two very important inverse operations are addition and subtraction, as we learned in **Lesson 2**.

We can show the results of performing inverse operations — “Go to Jail/Go to Start” one after the other — by thinking about them as a map. One step followed by the other takes you to the point where you began.



Organizing the Idea

Write a paragraph about and/or illustrate physical change of matter in your journal.

Applying the Idea

1. Suppose you are a carpenter and bought some wood to make a bookshelf. The bookshelf will have six shelves. Each shelf is 15 inches wide and six feet long. You calculate you will need 36 feet of 15-inch wide wood planks. You telephone in your order, and the company sends you three 15-inch wide wood planks that are 12 feet long each. Can you make the bookshelf with these pieces of wood? If so, how? Show a picture of the bookshelf and label the dimensions. (three planks 12 feet long are the same as six shelves six feet

long; cutting the planks into smaller pieces is only a physical change and you have the same amount (mass) of wood that you ordered.)

2. Read the warning label on a can of spray paint or hair spray. Why do you think the label says that you should not dispose of the can by putting it in a fire. What do you think would happen if you did? Why do you think that would happen?

Closure and Assessment

Problem Solving

At the **Science Center**, take several pieces of banana and smash them with a fork. Write and complete these sentences:

Smashing pieces of banana with a fork is an example of _____ change. My reasons for saying this are: _____ .

Burning a match (is, or is not) an example of a physical change. My reasons for saying this are: _____ .

Report to the class and explain your reasons.

List of Activities for this Lesson

- ▲ Mass and Physical Change
- ▲ Inverse Operations

ACTIVITY *Mass and Physical Change*

Objective

The student observes and can say that the mass of an object doesn't change in a physical change.

Materials

Rock; hammer; large piece of ice or several ice cubes; scale

Procedures

1. Weigh the rock and record its weight.
2. Break the rock into several pieces.
3. Again, record the weight, being sure to weigh all the pieces.
4. Place the ice cubes in a pan and weigh them. Record the weight. Keep a lid on the pan. If you weigh the pan with the lid on, keep the lid on whenever you weigh the pan again.
5. Let the ice melt and then weigh the pan with the water in it, again.

Discussion

1. What happened when we crushed the rock? Did its appearance change? Did it change color? Did it smell any different? (The only way the rock changed was that instead of keeping it all in one piece, we broke it into many smaller pieces, but that was all that changed.)
2. Did its mass change? How do you know? (The pieces all weighed the same as the rock did before it was crushed.)
3. What happened when the ice melted? Did the color change? Did the shape change? Did the odor change? (The only way the ice changed was that it changed its form from solid to liquid.)
4. Did the mass of the ice change? (No, the water weighed the same as the ice.)
5. When you weighed the ice and then weighed the water from the melted ice, why didn't you weigh the pan separately? (Since we weighed both the ice and the water **in the same pan** the weight of the pan was not important.)
6. Why did you put a lid on the pan when you melted the ice? (To make sure that the water did not evaporate before we had a chance to weigh it.)
7. What conclusions can we draw from this experiment? How can we summarize this experiment?

▲ ACTIVITY *Inverse Operations*

Objective

The student understands the concept of inverse operation so that

1. given an operation that has an inverse, the student can give its inverse
2. given an operation, the student can say if it has no inverse and can explain why.

Materials

Lamp that lights by turning a knob to the right and that turns off the same way
A rusted knife or a rusted scouring pad

Procedures

1. Turn on the light in the classroom and say: I'm performing the operation "turn on the light" by flicking the switch up. How can I "undo" what I did? (Pause for the students to have opportunity to think and respond.) How can I get the classroom to be as it was before? Yes, I can perform the operation "turn off the light" by flicking the switch down. The actions "turn on the light" and "turn off the light" we call **inverse operations**. One operation — "turn off the light" undoes what the other one does — "turn on the light." If I start with one operation, I can go back to where I started by performing its inverse operation.
 - Close the door and say: I'm performing the operation "close the door." What is its inverse operation? Yes, "open the door" is its inverse; it takes the door back to where it was originally.
 - Inhale and say: I'm inhaling. What is the inverse of inhaling? Yes, letting your breath out, or exhaling.
 - Give other examples such as putting on your shoe and taking off your shoe.
 - Students give their own examples. They explain how an operation followed by its inverse takes them back to where they originally started.
2. Turn on the lamp by turning the knob to the right and say: I'm performing the operation "turn on the light" by turning the round knob to the right. How can I "undo" what I did? (Pause and let the students examine the knob before they attempt to answer.) Do you turn off the lamp by turning the knob to the left, since you turned the lamp on by turning to the right? No, that unscrews the bulb, so what do you do? Yes, you have to turn the knob to the right again, to turn off the light. On this lamp, what is the inverse operation of "turn the knob to the right"? Yes, it is the same — turn the knob to the right. What can you say about this operation? Yes, it is its own inverse. Are there other operations that are their own inverses?
 - The power on/power off button on television sets and VCRs.
 - Can the students think of other operations that are their own inverses? They can give new examples to the class whenever they come across them.
3. Tell the students you are going to give them a new example. They are to try to think of what this nursery rhyme tells them about operations.

Humpty Dumpty sat on a wall.

Humpty Dumpty had a great fall.

All the King's horses and all the King's men,

Couldn't put Humpty Dumpty back together again.

What does this rhyme tell us? Yes, that there are some operations that have no inverse — you can't get back to the place where you originally started. Let's look at some other examples of operations that have no inverse operation.

- Burn a match. Ask students if “burning a match” has an inverse operation.
- Take a small bottle and break it. Does “break a bottle” have an inverse operation? The students may want to discuss the notion that you could glue the pieces back together; but would that be putting the bottle back to its original condition?

Application

1. Place four ice cubes in a pan; heat the pan only until the ice melts. Ask: What is the inverse of “melting ice”? Yes, freezing water. What is the inverse of “freezing water”? Yes, melting ice. How are these two operations related? (Inverse operations.)
2. Dissolve salt in water. Ask: What is the inverse operation of dissolving salt in water? Yes, getting the salt back, but how? (Heat the water until it evaporates, leaving the salt in the pan.)
3. Show the students the rusted scouring pad. Ask: What can we do to “undo” the process of rusting? We can't reverse it. Rusting is also called an irreversible process — it has no inverse.

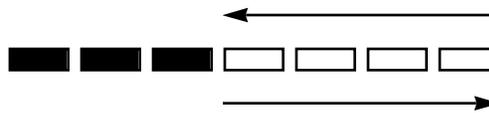
Assessment

Students say whether a given operation has an inverse and, if so, what it is. If the operation does not have an inverse, say why.

1. Climb up a mountain/ climb down a mountain.
2. Scratch my head.
3. Be a baby.
4. Write with a pencil/erase it.
5. Go to school/go home.
6. Say something (you can't un-say it).
7. Adding four to a number/subtracting four from the sum.

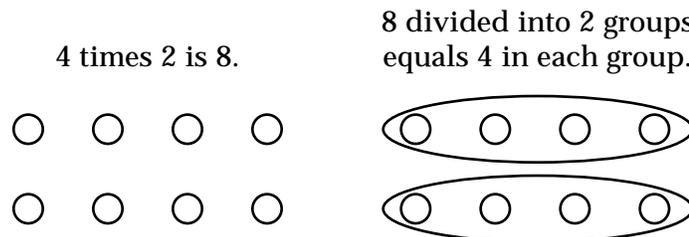
ex. 3 (the number) $+ 4 = 7$; $7 - 4 = 3$ (back to the original number)

You can show this relation with locking cubes:



8. Multiplying a number by two/dividing the product by two.
ex. 4 (the number) $\times 2 = 8$; $8 \div 2 = 4$ (back to the original number)

You can show this relation with arrays:



9. Finding a number greater than a given number has no inverse.

ex. Using the counting numbers, you start with five; nine is greater than five. If you start with the result nine, how do you get back to the original five? If you select “finding a number that is less than nine” then eight, seven, six, five, four, three, two, one and zero are also less than nine. Which one will you pick? Since the rule “finding a number less than nine” does not say which of the numbers that are all less than nine has to be selected, there is no way to get back to the number five.

LESSON

6

A Substance Can Change in Mass

BIG IDEAS Matter can change in its mass through a chemical change. Weight and volume can change through chemical reactions.

Whole Group Work

Materials

Several matches; a rock; a candle; an inflated balloon; an apple and a potato; three pieces of steel wool; small plastic bags; measuring cup; glass of water

Advance Preparation

Four days before beginning the lesson:

1. Cut an apple and a potato into several pieces, place on a plate and leave uncovered in the **Science Center**.
2. Put one piece of steel wool in a plastic bag, put three tablespoons of water in the bag, seal the bag and place in the **Science Center**.
3. Put another piece of steel wool in a bag, put three tablespoons of water in the bag but leave the bag unopened.
4. Put the third piece of steel wool in the **Science Center** where it won't get wet or be disturbed.
5. Measure the circumference of the balloon every day and record it.
6. Fill the measuring cup with one cup of water. Measure its volume every day and record it.
7. Place the rock in the **Science Center**.

Encountering the Idea

In the lesson we just finished, we learned that matter can change its form — that is, it can change how it looks, but it continues being what it was originally. Let's name some examples: ice turns to water or steam and back; we can cut an apple into pieces and it is still an apple. Now, I want you to look at this match. I light the match and what happens? Is this a physical change? How do you know? We had this question as a problem-solving assignment. Let's let the groups report on their answers.

Yes, those of you who said that burning a match is **not** a physical change are correct. What happened to the match? Did it look the same, feel the same, smell the same after it burned? No. What happened to it? That is what we are going to investigate in the following activities.

Exploring the Idea

A few days ago, we put this piece of steel wool into this bag with a little bit of water in it **but left the bag open**. We left it here for several days in the **Science Center**. In the other bag, we put other piece of steel wool, but we did not put water in it. We left this piece of steel wool dry. We put this apple on this plate

and left it uncovered for a few days. We did the same thing with this potato. The inflated balloon has been hanging here for several days, and we measured its circumference. We put this rock here in this corner. Your assignment is to come by every day and see if you notice a difference in each of these items. What is happening to them? As you come by to see what is happening to these items, make a chart of what you see and write a description in your journal of what you think is going on. If you want to add other items to test for change, you may do so, but add them to the chart to make sure that you record all your observations.

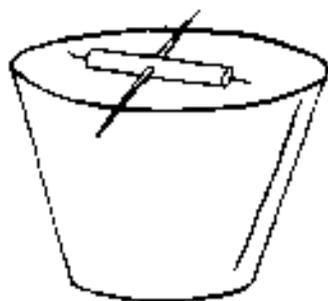
Before you go to the learning centers, let's complete this **Activity** — Burning A Candle, as below.

Materials

Candle or long taper; match; toothpicks; water glasses

Procedures

1. Prepare a candle so you may light the wick at both ends.
2. Stick round toothpicks into the candle and balance it on the water glasses as shown in the illustration. It doesn't have to balance perfectly.
3. Light both ends of the candle. Observe for several minutes. Describe what happens.



4. Using what you know about matter and how matter changes, explain how this happens.

Students complete **Activity** — Chemical Changes.

Getting the Idea

A burning match is an example of matter changing from a solid piece of wood to a gas — to smoke, and to ashes — other solids. A burned match is different from the match we started with. If we watch closely as the match burns, we can see some liquid close to the flame. This liquid is part of the match that has vaporized because it got so hot that it turned to liquid before it turned to smoke. This change of a burning match to vapor and then to ashes is called a chemical change. When matter goes through a **chemical change**, we have no way, using ordinary processes, to change it back to what it was before the change. In this example, there is no way we can capture the vapor and put it back into the ashes to make a wooden match again.

We studied other examples of chemical changes. What happened to the dry steel wool? Nothing — no change. Why did the wet steel wool change? What was the only difference in the two pieces of steel wool? One piece of steel wool was wet and placed in a baggie and sealed. It got no air. The other piece of steel wool

was wet, placed in a baggie, but left unsealed — open. It got air. The iron in the open baggie rusted. Rust is a substance made of iron and oxygen. Rust molecules have atoms of iron and of oxygen, with water molecules attached. When these elements — iron, oxygen and water — come together, a chemical change takes place — iron turns to rust.

All of you have had an opportunity to observe the changes in the potato, the apple, the steel wool, the balloon and the water. Why do you think that some of these changes are physical, while others are chemical? (The potato and the apple rotted; they got green or they changed color; they are not the same anymore. The wool rusted and became flaky. The water only evaporated. The balloon didn't change; it is still a balloon; it just got limp.)

Rotting and rusting are examples of chemical change. Evaporation is a physical change. Matter, however, **can change** its form and its attributes in ways that are permanent. We see this happening all the time. We can find evidence that a chemical change has occurred from one or a combination of the following: a change in mass, shown by a change in weight; heat is generated (the burning match); the color of the substance changes (apple and potato); a gas is generated (bubbles when mystery powder (baking soda) and mystery liquid (vinegar) were combined); the substance changes in nature (the egg white became elastic, and Elmer's Glue and liquid starch became Silly Putty).

Organizing the Idea

1. Make a chart to help you record observations about changes in matter. This chart is designed to help you decide whether the change was a physical or chemical change. You may want to weigh the items you are investigating. What would a change in weight suggest?
2. After you have completed the chart on your observations of change, make a chart listing the differences between physical and chemical changes, as you observe them.

Physical or Chemical Changes?

potato					
apple					
steel wool (dry, placed anywhere)					
steel wool (wet, uncovered baggie)					
steel wool (wet, sealed baggie)					
cup of water					
rock					
inflated balloon					
	Day 1	Day 2	Day 3	Day 4	Day 5

Applying the Idea

1. **Activity** — Secret Message, as below.

Materials

Small jar; white paper; milk (only a few drops); lamp with light bulb; toothpick; lemon juice

Procedures

- Dip the toothpick into the lemon juice and use it as a pen to write a message on the paper. Let the juice dry.
- What happened to your message?
- Hold the paper close to a burning lightbulb. Describe what absorbed heat from the lightbulb. What can you say about this?
- Repeat with milk.

Teacher Information

As the liquid dries, the residue blends with the paper and becomes invisible. When we apply heat, a chemical change takes place in the residue, turning it dark and making it easily visible against the white paper.

2. Read about alchemy in a reference book. Answer this question: Have scientists been successful in changing lead into gold?

Closure and Assessment

Problem Solving

1. Does a physical change always go along with a chemical change?
2. Does a chemical change always go along with a physical change?
Demonstrate and explain your answers to the class.

List of Activities for this Lesson

- ▲ Chemical Change

ACTIVITY *Chemical Change*

Objective

Student gives an example of a chemical change and gives two reasons for saying that it is a chemical change.

Activity — Dissolve the Egg

Materials

One hardboiled egg; one fresh egg; 600 ml vinegar

Procedures

Soak a hardboiled egg overnight in 300 ml of vinegar (also soak a fresh egg in 300 ml of vinegar). The egg shell will completely dissolve into the vinegar leaving:

1. fresh egg — yolk and white surrounded totally by a thin membrane
2. boiled egg — white becomes rubbery and can bounce.

Activity — Silly Putty

Materials

One cup prepared (store-bought) liquid starch and one cup Elmer's Glue.

Procedures

Pour both liquids in a large Zip-lock bag (one qt. or larger). Make sure to close the bag securely. Knead the mixture thoroughly. Pour off watery liquid and discard. Wow! Silly Putty.

You can pull it slow and it stretches; pull it hard and it breaks. Press it on comics to copy the print. Make exciting models. Keep it stored in the bag to keep it fresh and soft.

Activity — Mysterious Reaction Baking Soda & Vinegar

Materials

Mystery Liquid = Vinegar (50 ml); 500 ml beaker; baking soda

Mystery Powder = Baking Soda

Procedures

(Do not tell the students that they are working with vinegar and baking soda — let them discover it.)

Observe mystery powder and mystery liquid.

Put 50 ml of vinegar in a 400ml beaker, drop one gram baking soda into liquid. What happened? Where did the bubbles come from? Was this a physical or chemical change?

LESSON

7

Compounds and Mixtures

BIG IDEAS Compounds form through chemical change; mixtures are combinations that form through physical alterations only. There are similar mathematical operations; some operations have inverses, others have no inverses and some operations are their own inverses.

Whole Group Work

Materials

Have in a box for demonstration:

- picture of a diamond; gold and silver jewelry or pictures of the jewelry;
- objects made of brass, steel, copper; labeled container with water; plastic, ceramic, glass objects; bread; fruit; one plastic bag of **Lucky Charms** cereal; trail Mix; Rice Krispies

Additional materials listed below

Encountering the Idea

Combine the following ingredients as you talk to the students. Some of these combinations the class has already made and discussed; but in this lesson the class will identify the combinations as being either compounds or mixtures, depending on whether the combinations are undergoing a physical or chemical change.

- baking soda and vinegar
- Elmer's Glue and liquid starch
- egg and vinegar
- milk and pudding
- bits of rock and bits of grass
- trail mix with Rice Krispies or some other cereal

Make each of the combinations above. After making each combination, ask the students: What happened when I mixed the _____ with the _____? What was the result? The students make observations and examine the results.

Exploring the Idea

Review the concepts of physical and chemical change before the students go to the learning centers. Light a match, then ask students to describe what they see as the match burns. Review the possible results of chemical changes: change in color; production of light, heat, gas or liquid that was not there before and not the result of melting, as with the ice/water activity; change in mass.

Students complete **Activity** — What Are Mixtures and Solutions?

Getting the Idea

Review the notions of the composition of matter. The smallest units matter exists in are called **atoms**. When matter exists in a combination of two or more elements, it is called a **compound** or a **mixture**.

Every object in the universe is composed of matter, either as a pure element or as a compound or a mixture. Elements combine to form compounds or to form mixtures. When a mixture forms, it is the result of a physical change — the individual components or parts that went into the mixture are often visible. The individual parts maintain all of their original properties, and we can separate them into their original form with relatively little effort, for example, trail mix. Look at this bag of **Lucky Charms** cereal. This is a mixture. In a mixture, you can sometimes see the different parts. It has marshmallows, stars, cereal. If you spill it on a table, you can separate all the different pieces out. This is not true of water, for example. You cannot easily separate the oxygen and hydrogen gases of which it is made.

A solution is also a mixture. If you dissolve sugar in water, this is a physical change. You can always evaporate the water and get the sugar back. In the case of solutions, you can't see the different parts like you can in **Lucky Charms**.

On the other hand, when two or more elements combine to form a compound, an exchange of energy occurs. At times, heat is given off. Light and gas are also products of the union of elements to form compounds. An explosion, for example, is the byproduct of the formation of new substances, as when dynamite is detonated.

Organizing the Idea

1. The students tabulate on a chart their observations of the combinations made earlier. They discuss how the original substances looked before and after the class combined them.

Substances	Type of changes	Description: (Before & After) Compound/Mix
Baking soda & vinegar		
Elmer's Glue and liquid starch		
Egg & vinegar		
Milk & pudding		
Bits of rock & grass		
Trail mix with Rice Krispies		

2. We are going to classify each object in this box in two ways—first, if it is a solid, liquid or a gas, and then we are going to guess to see if it is an element, a compound, or a mixture. When you finish, show and explain your work to the teacher. When all the groups have had an opportunity to classify these materials, we will discuss them.

Form	Substances		Mixture
	Element	Compound	
Solid	carbon silver, gold copper	wood, bread glass plastic	steel brass trail mix
Liquid	mercury	water alcohol	milk Kool-Aid
Gas	oxygen helium nitrogen ozone	carbon dioxide carbon monoxide	air scents natural gas cooking

Applying the Idea

Problem Solving

How do you get salt out of pepper?

Materials

For each student team:

a plastic bag with one teaspoon of pepper mixed with 1/2 cup salt

Procedures

Working in teams, the students design as many activities as they can to solve the problem of removing the pepper from the salt. There is no one correct answer to the problem. After they have solved the problem, they explain to the class. Then they write the activity in their journals.

Closure and Assessment

1. Dissolve some salt in a cup of water; describe what happened. Tell me if there was a chemical or a physical change with the salt and water. Tell me your reasons.
2. If you think it was a physical change, what can you do to get the salt back?
3. Make a chart or state a rule to explain how elements, compounds, mixtures and solutions are alike, and how they are different.

List of Activities for this Lesson

- ▲ What Are Mixtures and Solutions?

ACTIVITY *What Are Mixtures and Solutions?*

Objective

Students say that a solution is a mixture, but in liquid form.

Materials

Two glass jars; paper clips; spoons; toothpicks; sugar; bits of paper; water; paper and pencil; marbles or small rocks; bottle of soda pop

Procedures

1. Fill each jar about half full of water.
2. Put the marbles, paper clips, toothpicks and bits of paper in one jar and a spoonful of sugar in the other jar.
3. Stir both jars and observe what happens to the materials in the water.
4. Shake the bottle of soda pop.
5. Compare the results in the three containers.
6. Try other substances in water, such as sand, Jello or powdered chocolate.

Teacher Information

A mixture consists of two or more substance that retain their separate identities when mixed together. Solutions result when the substance mixed in a liquid seems to become part of the liquid. A solution is really a special kind of mixture — one in which the particles are all molecular in size.

Discussion

1. What are marbles made of? (Molecules.)
2. What is water made of? (Molecules of water.)
3. Explain why some things dissolve and some do not. (Clips, sugar.) Why did gas come out of the soda pop?

LESSON

8

Science: Counting and Measuring

BIG IDEA Science tries to answer questions about our world; often, we find the answers by counting, estimating and approximating.

Whole Group Work

Encountering the Idea

Begin by telling students that in this unit we have studied about matter. People who study about matter — what it is, what its properties are — are called scientists. Scientists ask questions not only about matter but about many other things about our world and the way it works. Scientists look for answers to these questions by collecting data in ways that are similar to the ways we have collected data.

How have we collected data? As students respond, write answers on the chalkboard. Yes, we collect data by **counting** and by **measuring**. What kinds of things have we counted? In taking surveys, for example, we count the number of people in the class who like different kinds of ice cream to see which is the class favorite. As another example, in studying nature, we count the number of body parts, three, and the number of legs, six, insects have, and we are able to compare them with spiders that are arachnids, that have only two body parts but have eight legs. (Students give examples of other things they have counted to collect data for experiments.)

We count things we can see; but suppose we are scientists and need to count something that is very small, for example, the number of cells in the human body. We can't count them because we can't see the cells that are very small. What can we do? This is one of the questions we are going to explore.

Let's talk about the other method we use to collect data. We said we measure things. We have measured the length of objects; we have measured the temperature of water and its weight. All of these measurements are data also. However, in order to measure something, weight for example, we need to use an instrument, such as a scale, and a standard unit of weight, such as an ounce, gram or pound. To measure the temperature of water, we need a thermometer and a unit of temperature such as degrees Fahrenheit or degrees Celsius. To measure the length of a box, we need a ruler and a unit of length such as an inch, centimeter or foot.

In addition to needing these instruments for measurement, we also need to know how to use these instruments. How do scientists make sure they use their instruments correctly? Have you had to learn to use a ruler? A thermometer? Yes, we have to develop these skills to collect data that is reliable, that we can trust. We will work in the **Science and Mathematics Centers** to explore some of these ideas.

Exploring the Idea

At the **Mathematics** and **Science Centers**, the students

1. complete **Activity** — How Many Beans?
2. complete **Activity** — Linear and Square Measure.

Getting the Idea

What do you think scientists do if they cannot actually count or measure something in order to collect data to answer a question? Yes, they estimate! We do the same thing; if we can't actually count something, we try to estimate the number. To **estimate** means to make a guess by using clues that help us get as close as we can to the actual number we are looking for. When you estimated the number of beans in the jar, what clues did you look for to help you guess a number?

The first time you guessed? (Just guessed, tried counting some of them, looked at the size of the jar, etc.)

The second time you made a guess? (Guessed again; if the beans were bigger, then I guessed fewer beans, had more experience in estimating beans in a jar, and my guesses were closer.)

The third time?

Sometimes scientists have to estimate also. For example, astronomers tell us that the distance from the earth to the sun is 93 million miles. How do they know? They don't; scientists have estimated the distance using different clues — just like you did. Since astronauts have traveled to the moon, they have been able to measure the distance from earth to the moon. They know now that the clues they were using to estimate distance in space were valid — that the clues they used were really helping them measure distance in space.

Let's think about some of the data we have collected in the experiment on chemical change. Look at our data chart. On the chart we show that the potato and the apple got wrinkled, turned brown, smelled bad and rotted, or just dried up. Is there any way we can measure **how much** the potato rotted? Can we measure how bad it smelled? Why can't we measure that? We don't have an instrument or a standard unit to measure how much food rots or smells. We can only estimate that each day the potato looked more rotten and smelled worse than the day before.

What about the water? Could we measure the amount of change? Could we tell how much water evaporated each day? Yes, because we put the water in a measuring cup and could read the scale to see how much was left. What else could we measure in that experiment? After students have given the question some thought, ask: Could we measure how much air escaped from the balloon? Yes, because we measured the circumference of the balloon every day.

What about the rock? Did it change in appearance? Did its mass change? How do you know?

Organizing the Idea

1. The students make a chart listing things that they can count and those things that they cannot count and have to estimate.

Can be Counted	Have to be Estimated
Students enrolled in our school	Students enrolled in 3rd grade in the U.S.
The number of times I have been absent from school	Number of molecules in a grain of sand
Number of elements in a compound; ex. table salt has 2 — sodium and chlorine	Number of stars in the Milky Way
The amount of money I have in my savings bank	How much the earth weighs

2. The students write and/or illustrate the difference between counting, estimating and approximating.

Applying the Idea

Problem Solving

What is the population of the United States? Look in a reference book in your school library to read about the “census”. What is it? How is it done? Is the population of the United States an estimate? Is it an approximation? Report your ideas to your group and then to your class.

Closure and Assessment

Assess each of the activities included in the lesson for student level of participation and degree of completion.

List of Activities for this Lesson

- ▲ How Many Beans?
- ▲ Linear and Square Measure



ACTIVITY

How Many Beans?

Objective

Students give an example of an estimate, an approximation and an actual count.

Materials

Three jars (two-cup capacity) labeled as “1,” “2,” and “3,” filled with beans of different sizes (pinto, navy, large lima beans)

Three charts to record the beans estimated and then counted

Procedures

1. How many beans are there in Jar 1? Do you think there are 1000? (Pause for responses.) What about 500? Well, then, if you still think that is too many, what is your best guess? Each student, working alone, makes an estimate.
2. Students, working in groups, share their individual estimates with the group and develop a strategy to get “as close” to the actual number as possible. They make a group estimate and record the estimates on a chart. Each group explains why they used a particular strategy.

Discussion

- What do we mean when we make a “best guess”. When I asked if you thought there were 100 beans, you said that was too high. You also said that 500 was also too high. Why did you think that? Then you made a “best guess,” which we also call an **estimate**.
- Did you change your guess after you heard other people’s estimates and their reasons for making those estimates? Why?
- Some groups counted 173 beans, one group counted 171 and another counted 193. Can this be right? Why? What do we do? Yes, maybe the correct count is 173 because three groups got that number. Let’s recount. Now that we agree that there are 173 beans, let’s examine the strategies that may have been more effective — the strategies that got “closer” to the actual count.

Jar 1 (Pinto beans)

	1	2	3	4	5
Estimate					
Approximation					
Count					

Students work in groups with Jars 2 and 3.

3. Here is Jar 2 with the same volume but different size beans. Let’s write down some estimates. Why did you estimate a greater (smaller) number? Because the beans were smaller (bigger).
4. Students work in groups to develop a strategy to get “as close to” the actual count as they can.
5. Students count the beans.
6. Repeat the steps with Jar 3.

Discussion

- The first number you guessed we call an “estimate”. Notice that the differences among these estimates was large.
- The next number you found when you tried to get “as close to” the actual count as possible. This time you used a strategy. It appears that some strategies worked better than others; some helped you get a closer count.
- The second time that you guessed, that you estimated the number of beans, did your guesses show that you considered the size of the beans and the capacity, or size, of the jars? Did you change your strategy to get a better approximation? Why?
- The third time you guessed, or estimated, did you make your best guess in a different way? Why? How about the approximation?

Assessment

1. What is the most important difference between an estimate and an approximation? (An estimate is made on general standards or clues, such as appearance, apparent size or past or personal experience; an approximation is also a guess, but we make it by using measurements, which are also clues, or by actual counting.)
2. When would you use an estimate? (When you have only a general ideas of the measurement.)
3. When would you use an approximation? (When you can use measuring instruments.)
4. When would you count? (When things are separate like beans, chairs, people, and when the numbers are small enough that you can count—otherwise you estimate.)

▲ ACTIVITY *Linear and Square Measure*

Objective

The students measure lines or areas to the nearest subunit of the measuring instrument they use.

Materials

- Copy of the figures to measure for each student
- Tape to measure in inches, subdivided into eighths
- Tape to measure in centimeters
- Inch-square grid and centimeter-square grid, each on a transparency

Procedures

Part 1

1. Students measure the length of the lines shown below, recording the inches and 1/8th inches and also recording the number of centimeters and 1/10th centimeters, or millimeters.
2. After the students have measured the lines, they discuss problems they had in measuring the lines, if any.

Discussion

1. Did you have a problem measuring line D with the inch unit? Why?
2. Did you have to “round” your measurement to the nearest 1/8 inch or to the nearest millimeter (mm.)?
3. When you were measuring the lines were you able to “get closer to” the “exact end of the line” with the inch and eighths of an inch marks or with the centimeter and tenths of a centimeter (also called a millimeter) marks? Why?
4. Look for two objects in your classroom and measure their lengths. Record the lengths in inches and eighths of an inch and in centimeters and millimeters.
5. Make a rule about when to use inches and when to use centimeters.



Line	Inches 1/8 in.	Centimeters 1/10 cm. (mm.)
A		
B		
C		
D		

Part 2

1. Using the transparencies of the grids in square inches and square centimeters, the students measure the areas of the figures shown below, recording the area in square inches and in square centimeters.

2. After the students have measured the lines, they discuss problems they had in measuring the lines, if any.

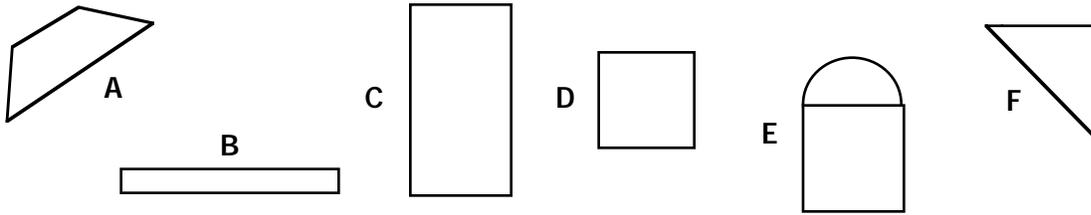
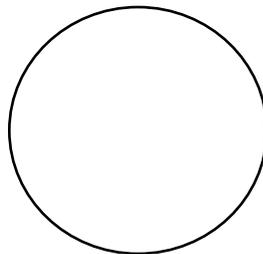
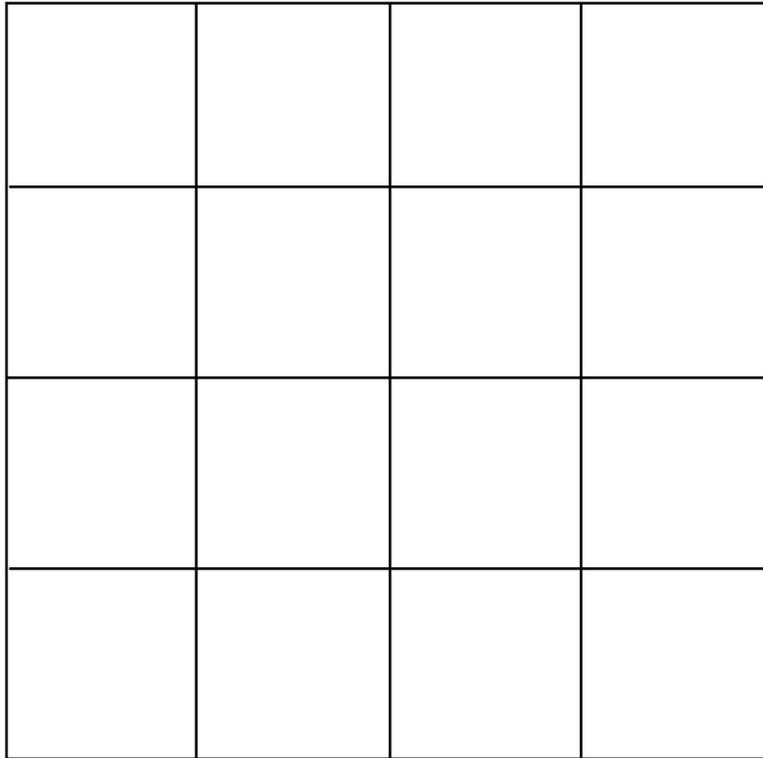
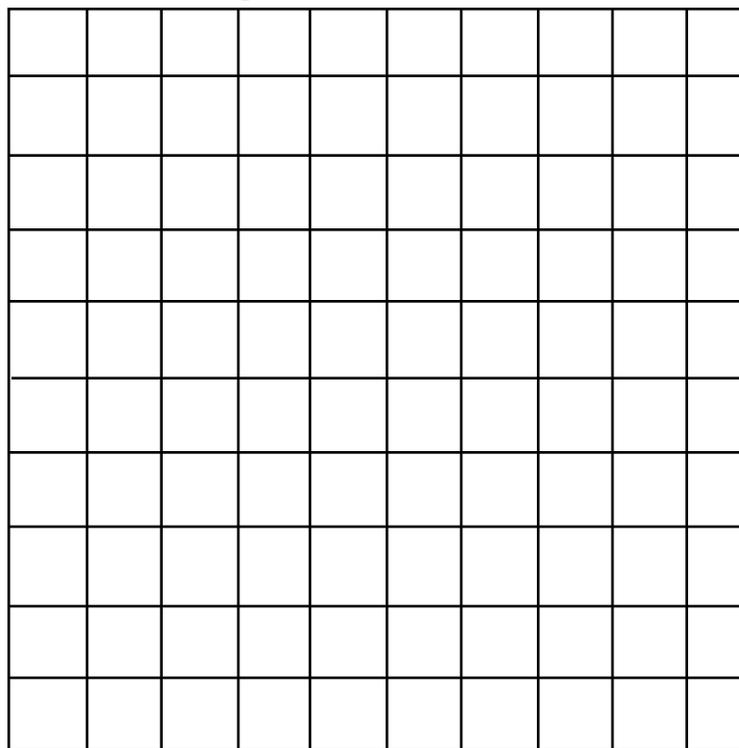


Figure	Square Inches	Square Centimeters
A		
B		
C		
D		
E		
F		

Discussion

1. Did you have a problem measuring figure B with the square inch unit? Why?
2. Did you have to “round” your measurement to the nearest square inch or to the nearest square centimeter? Why?
3. When you were measuring the figures were you able to “get closer to” the “exact area” with the square inch or with the square centimeter? Why?
4. Look for two objects in your classroom and measure their areas. Record the areas in square inches and in square centimeters.
5. Make a rule about when to use square inches and when to use square centimeters.
6. Suppose we marked the square centimeter grid into square millimeters. Could you get “closer” to the exact area of figure E? Why?
7. What is the closest you can get to measuring the area of this figure:



Square Inch Grid**Square Centimeter Grid**

UNIT ASSESSMENT

1. Is temperature related to the form that water is in? Explain.
2. Do you think the temperature of matter relates to whether it is in a solid, liquid or gas form? Why do you think that might be true?
3. Look at the chart you completed in **Lesson 6** on Physical and/or Chemical Changes. Did the cup of water change its weight during the days you observed it? Does a change in weight of the water mean that the water changed? (No, since the water evaporated, the cup of water would weigh less, but the water changed only in form.)
4. How can you keep the tools to fix your house or car — like screwdrivers, hammers and other steel tools — from rusting?
5. How can you keep fruits and vegetables from rotting?

Annotated Children's Books

Ardley, N. (1984). *Making things move*. New York: Franklin Watts.

The properties of friction, inertia, and gravity are explored.

Branley, F. M. (1972). *Weight and weightlessness*. New York: Crowell Collier Press, Division of Macmillan Publishing Co., Inc.

This book provides everyday examples of gravity and weightlessness.

Gramatky, H. (1939). *Little toot*. New York: G. P. Putnam's Sons.

This is a colorful, illustrated story about a tugboat and his adventures on the river where he lived.

Laithwaite, E. (1986). *Force: The power behind movement*. New York: Franklin Watts.

The principles of force are explained by demonstrating its applications.

Mitgutsch, A. (1985). *From swamp to coal*. Minneapolis, MN: Carolrhoda Books.

Much information is simply explained in this account of how coal is formed.

Walpole, B. (1987). *Fun with science: Movement*. New York: Franklin Watts.

An introduction to movement enhanced by photos and illustrations.

White, J. R. (1987). *The hidden world of forces*. New York: Dodd, Mead & Company.

Discusses some of the forces at work in the universe, such as electromagnetism, gravitation, surface tension, and frictions.

Whyman, K. (1986). *Forces in action*. New York: Gloucester Press.

Such forces as elasticity, gravity, and friction are explained in a simple pictorial approach.