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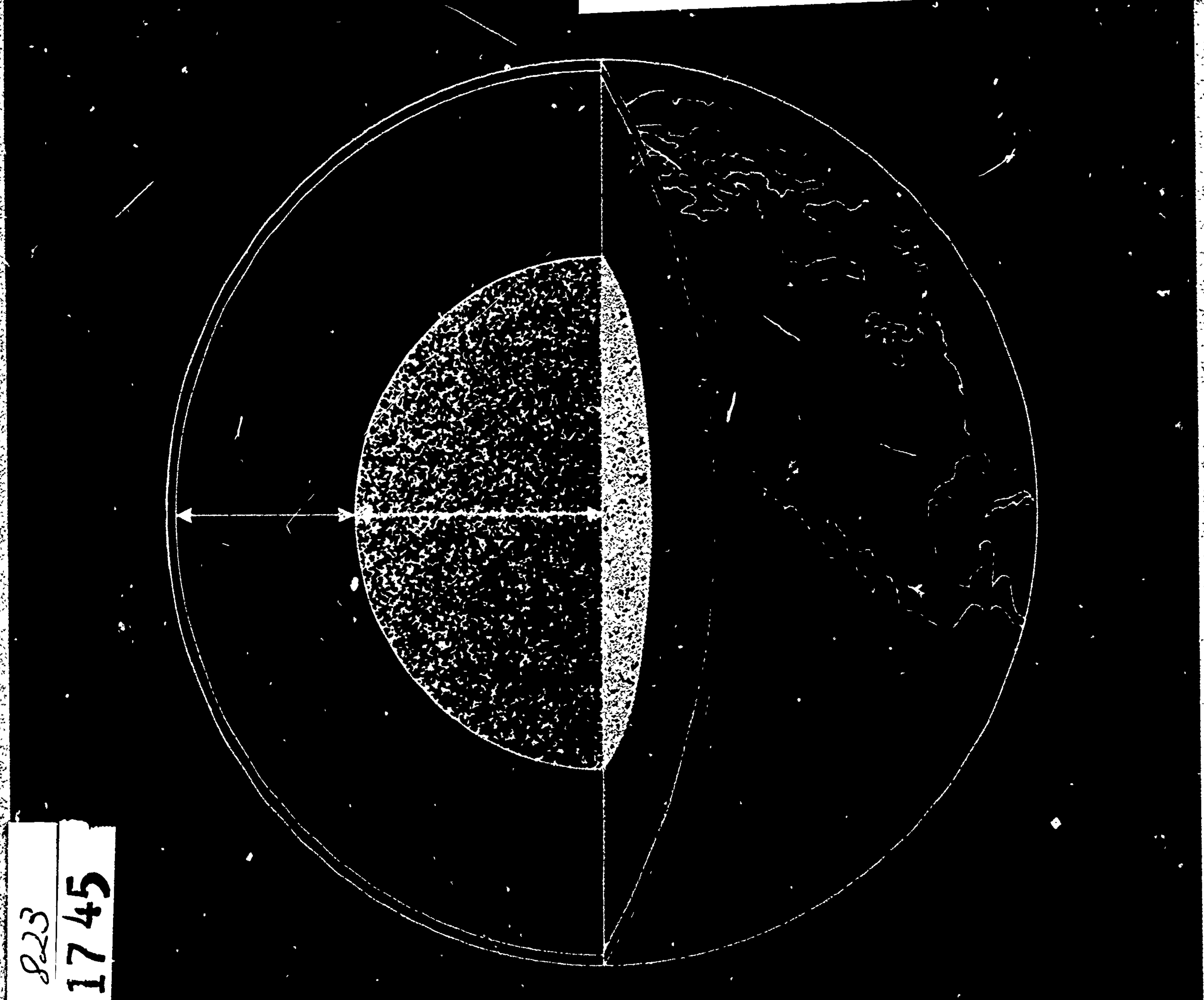
This is the second in a series of guidebooks written for elementary school teachers to help improve their science teaching. The book emphasizes processes of science and creativity as well as science content. The book is divided into three sections--the atmosphere, the lithosphere, and the hydrosphere. Each chapter begins with simple concepts, and leads to more complex concepts. (BC)

INVESTIGATING SCIENCE WITH CHILDREN / VOLUME 2

THE EARTH



National Science Teachers Association

INVESTIGATING SCIENCE WITH CHILDREN

VOLUME 2

THE EARTH

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INVESTIGATING SCIENCE WITH CHILDREN SERIES

Volume 1 LIVING THINGS

Volume 2 THE EARTH

Volume 3 ATOMS AND MOLECULES

Volume 4 MOTION

Volume 5 ENERGY IN WAVES

Volume 6 SPACE

The National Science Teachers Association is a department of the National Education Association (NEA) and an affiliate of the American Association for the Advancement of Science (AAAS).

About the cover: The solid portion of the Earth, called the lithosphere, is divided into three concentric spheres. From the surface of the Earth to its center, the spheres are called the crust, the mantle, and the core.

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About the
INVESTIGATING SCIENCE WITH CHILDREN
Series

These six handbooks for the teaching of science in the elementary school have the distinguished sponsorship of two leading groups concerned with the improvement of science teaching: NSTA (The National Science Teachers Association) and NASA (The National Aeronautics and Space Administration). Initiated by NSTA, the series received technical and financial assistance from NASA. The six authors were carefully chosen by NSTA and NASA from among leading science educators in the United States and Canada. The series has been carefully planned, developed, and edited over a period of two years. It updates and replaces the widely successful SCIENCE TEACHING TODAY series by Dr. Guy Bruce, published by NSTA in 1950.

General approach and philosophy. As they planned this series of books, members of the writing team were concerned with the following questions: What are some things we can or should do to help teachers as they investigate the world of science with children? In what direction should we move? How can we incorporate into our writings the processes and content of science, the fostering of creativity in children, provisions for children's varying abilities?

The age and culture in which we live demand that children in the elementary schools have a variety of real science experiences that lead them to an understanding of the world about them. Through a variety of science experiences, each individual will come to understand and to use scientific processes and skills, as well as to acquire the specific science learnings that will help him live intelligently.

Since each book in the series is concerned with one area of science and moves from simple concepts to more complex ones within each chapter, *each* teacher, at any grade level, will find that *all* the books have materials that she can use in her teaching.

Question–discovery approach used. Throughout each book, questions are used in several different ways. At the beginning of each chapter is a list of questions that children of different ages might ask. Answers to these questions and others are found when the children become involved in doing the Activities of the specific chapter. Other questions, with answers containing the science information given in parentheses for the teacher, are included within each Activity to help teachers as they guide the children's learning. More questions are listed later, as open-end Activities to be used with those children who may wish to make further investigations.

Organization keyed to varying abilities. To provide for varying abilities of the children in a group and at different grade levels, as well as to make possible a developmental approach to concept formation, the Activities and learnings are purposely not "graded," but are designated by the following symbols: *x* for those Activities involving beginning learnings; *y* for those Activities requiring more skill and involving several learnings; and *z* for those Activities of considerable difficulty and involving more complex thought patterns. An introduction is included with each Activity, which is merely suggestive and which may give the teacher ideas helpful in challenging children's thinking.

Illustrations and format. All six of the volumes are filled with helpful illustrations that will help the teacher as she directs the children's participation in the Activities. A two-column format allows for easy reading and clear organization, for in-class presentation.

Summaries and references. Each chapter concludes with a summary of the main ideas developed by the author. Throughout each book, cross references are made to Activities and science content found in the other books of the series. At the end of each book there is a list of bibliographical references that contain additional science information.

Scientific accuracy assured. One of the concerns of the writing team was the scientific accuracy of the information appearing in each book. To insure such accuracy, leading scientists who are specialists in their respective fields were asked to read and review the content during the preparation of the manuscripts. Their names appear at the end of this section.

It is hoped that this series of books, INVESTIGATING SCIENCE WITH CHILDREN, will be helpful in providing opportunities for children to use many processes of inquiry —investigating, observing, problem-solving, hypothesizing, experimenting, thinking, checking, analyzing—as they try to find the *what, how,* and *why* of the world around them. There are no final answers in these books. Let the series be thought of as a challenge to teachers to further learning.

Acknowledgments. Many people have made this series possible. The authors and series editor wish to express their appreciation to Robert Carleton, Executive Secretary of the National Science Teachers Association, for his confidence in the project and for his many words of encouragement; to Frank Salamon, Specialist in Elementary Science, National Science Teachers Association, for his guidance through various stages of the project; to Everett Collin, Mattison L. Story, and George Gardner, Specialists, National Aeronautics and Space Administration Education Program, for their interest in the project and for their reading of the manuscripts; and to Lila J. Phillips, Editor for this series, Teachers Publishing Corporation, for her suggestions and aid in the preparation of the final manuscripts for publication.

To the following scientists, who read the manuscripts in their preliminary form for scientific accuracy, the authors and series editor are deeply indebted for their many helpful comments and reactions: Dr. M. G. Seeley, University of Arizona, Tucson, Arizona; Dr. Alexander Calandra, Washington University, St. Louis, Missouri; Dr. Albert R. Hibbs, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California; Dr. William Mathews III, Lamar State College of Technology, Lamar, Texas; and Dr. Barbara Collins, Geologist, Northridge, California.

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1

INTRODUCTION

"What do you mean when you talk about science? What is science?" Mrs. Arnold asked her fourth grade class these questions one day before starting a new science unit.

"Isn't science knowing about interesting things like bees and ants?" Janie volunteered.

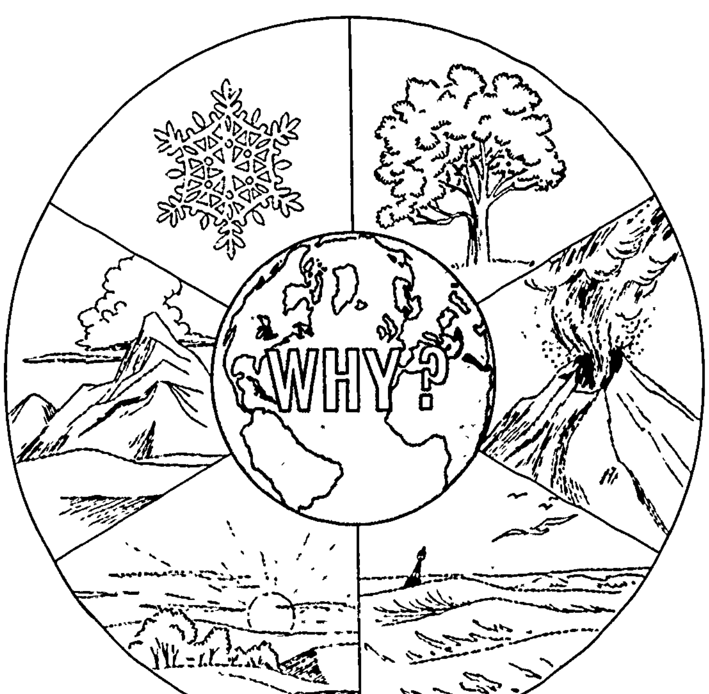
"That could be part of it," answered Mrs. Arnold. "Are there any other ideas?"

"I think science is discovering things. You know, like cutting up animals to see what's inside them," said Jack.

"Discovery is certainly an important part of science," said Mrs. Arnold, "but it's a particular kind of discovery. Let me ask you another question. Would you call the early explorers who discovered the Americas scientists?"

The children responded by saying, "No, I don't think you'd call them scientists." "I guess discovering isn't exactly what science is." "Maybe you have to discover certain kinds of things."

"Now you're getting closer to the real answer," said Mrs. Arnold. "What kind of things do scientists discover or find out?"



"One thing scientists do is discover cures for diseases."

"Yes, that's right. Any other ideas?"

"My uncle's a scientist and he is trying to find out about outer space," Mary ventured.

"Scientists also work with chemicals and discover new things," said Bill.

This discussion might occur in any classroom. Mrs. Arnold was introducing the concept of science and scientific thinking to her class. She correctly realized that science is more than learning a collection of facts taken out of a book. It is a way of thinking, a way of discovering the answers to problems. It also includes the development of concepts and ideas.

"We've already said that science is trying to find answers to problems," continued Mrs. Arnold. "How do you suppose a scientist finds a problem?"

"That shouldn't be very hard," spoke up Richard. "You could just ask 'why' about anything around you—'Why is the sky blue?' or 'Why does it snow in the winter?' "

"Yes, to find a problem all you have to do is look around you and then be curious. But now that you have a problem," said Mrs. Arnold, "how would you go about finding the answer? You look as though you might have an idea, Jane."

"I've always heard that scientists make experiments. Maybe these come in here somehow."

"Yes, Jane, you're right. Scientists perform experiments to answer their problems. Suppose you want to know what the shape of the Earth is. First you must make a guess and then test it with an experiment. What kind of a guess could you make?"

"Well, you could guess that it was flat like a table," Sally said.

"But that's crazy," spoke up Bill, "our geography book says it's round."

"Yes," said Mrs. Arnold, "but we didn't always know it was round. Suppose you lived in the time of Columbus and didn't know the shape of the Earth. How would you find out what it was? You must first make a guess and test it. Your guess might be right and it might be wrong. But this is the only way of finding the right answer.

"Suppose you did guess that the Earth was flat, like a table. What kind of experiment would you make to test your guess?"

"I know what you could do," spoke up John. "If it was like a table, you would be able to travel to the edge and look over it."

"Yes, you should be able to. What exactly would you do to test your guess?"

"I guess I'd take a boat or a train and keep going in a straight line until I reached the edge."

"And, if you never reached the edge, then what?" asked Mrs. Arnold.

"Then I guess I'd decide the Earth wasn't flat."

"Exactly," said Mrs. Arnold. "But now there's one more thing to the scientific method that we haven't mentioned as yet. What happens when you have finished your experiment and find that your guess was correct?"

"Well, you know the answer to what you asked in the first place."

"And now what do the scientists do?" asked Mrs. Arnold.

"Maybe they make laws or something about what they found out."

Mrs. Arnold was pleased with the responses of her class in their discussion of scientific methods. She wanted to help her children develop those skills and abilities necessary to approach problems scientifically. With a series of planned Activities, she hoped to stimulate their interest and ability to question, to make intelligent guesses, and then to test them. By using such a method she could introduce important scientific concepts.

The Activities in this book are designed to present children with useful experiences in earth science. These Activities will introduce important concepts about the nature of the Earth and the processes that are continually shaping and changing it.

WHAT IS THE EARTH MADE OF?

Children usually think of the Earth as just the solid rock and soil they stand on, but the Earth is made of much more. The rock layer that extends through the Earth makes up a huge ball or sphere called the *lithosphere*. The Earth also has a water layer which covers parts of the rock layer and is known as the *hydrosphere*. An air layer, which surrounds the Earth, is also shaped like a sphere and is called the *atmosphere*. These three spheres, the lithosphere, the hydrosphere, and the atmosphere, make up the Earth.

To demonstrate that the Earth is made up of these three spheres and to discover the nature of each sphere, you may want your children to carry on some or all of the following preliminary Activities. The first of these Activities will develop the concept of density as an aid to an understanding of the three spheres. Density is a relationship between weight and volume. If two objects have the same volume, the object that is heavier has a greater density. For example, a cubic foot of water weighs 62.5 pounds; a cubic foot of iron weighs 490 pounds. Iron, then, would have a much greater density than water. Density is usually expressed in weight per unit volume, such as pounds per cubic foot.

ACTIVITY 1 (x,y,z)

DISCOVERING THE MEANING OF DENSITY

Purpose: To introduce the meaning of density

Concept to be developed: The density of an object is expressed as its weight per unit volume.

Materials needed:

Small wad of cotton
Cork stopper
Wood block
Small piece of iron
Piece of glass
Small stone
Piece of plastic
Piece of aluminum

INTRODUCTION: Place several different kinds of objects on the table and have the children decide which one takes up the greatest amount of space (which has the greatest volume), which has the least volume, and whether any are almost equal in volume.

When the children understand what volume is, have them compare two objects of similar volume —but obviously different weights. Why is one heavier than the other? *(Because it is made of a denser material.)** Density is a measure of weight

* For a further discussion of weight, see *Motion*, by Lois Dunn (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

per unit volume. When two objects have the same volume, the heavier object has the greater density.

Let the class test all the various objects for density by weighing and measuring them. Have the class determine which are the most dense and which are the least dense.

Learnings: (x) The volume of an object is the amount of space that it occupies. (y,z) Density is the weight per unit volume. If two objects have the same volume, the heavier object is the more dense.

ACTIVITY 2 (x,y,z)

MIXING SUBSTANCES OF DIFFERENT DENSITIES

Purpose: To show why the atmosphere, the hydrosphere, and the lithosphere assumed their respective positions

Concept to be developed: The relative densities of freely moving objects determine their relative positions.

Materials needed:

Olive jar with a cap
Water
Pebbles

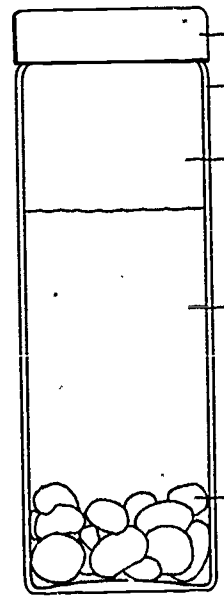
INTRODUCTION: Discuss with the children the meaning of the words solid, liquid, *and* gas. *Make a list on the chalkboard of all the things they know that are solid, liquid, and gas. Ask the class, "What parts of the Earth are solid? What parts liquid? What parts gas?" (Relate your children's answers to the three spheres of the Earth—the solid lithosphere, the liquid hydrosphere, and the gaseous atmosphere.)*

Now ask your children if liquids and gases have densities. (Yes.) *Why?* (Because they take up space and have weight.)

Have the children think of ways to tell whether a liquid or a gas has the greater density. (Liquids are more dense than gases.) *How will two substances that have different densities and are free to move behave when mixed together? Suggest that the children perform the following Activity to discover the answer.*

Have a child fill the olive jar half full of water and screw on the top. Shake the bottle and observe what happens. What happened to the water? *(Bubbles of air were in the water and they could be seen rising to the surface.)* What is above the water? *(Air.)* Why did the bubbles go up? *(They floated up because they were lighter, or less dense, than the water.)*

Next add a few pebbles to the jar. Cover and shake again. What did the children observe this time? *(The bubbles went up to the top and the*



pebbles sank down to the bottom of the jar.) Why did the pebbles sink to the bottom? *(They were heavier, or more dense, than the water.)*

Lead the children to apply what they observed in this jar to the Earth and its three layers or spheres. Which sphere do the pebbles represent? *(The rock layer, or lithosphere.)* Which sphere does the water represent? *(The water layer, or hydrosphere.)* Which sphere does the air represent? *(The air layer, or atmosphere.)*

Learnings: (x) Gases, liquids, and solids all have densities. (x) Heavier objects, or objects of greater density, sink beneath lighter objects, or objects of lesser density. (x,y) It is the relative density of freely moving objects that determines their relative positions. (x,y) The Earth's rock layer, or lithosphere, has the greatest density and is below the hydrosphere, or water layer, and the atmosphere, or gas layer. Gases rise to the top, as they are the least dense.

ACTIVITY 3 (x,y,z)

COMPARING TWO SOLIDS OF DIFFERENT DENSITY

Purpose: To show why the Earth's core, mantle, and crust assumed their respective positions

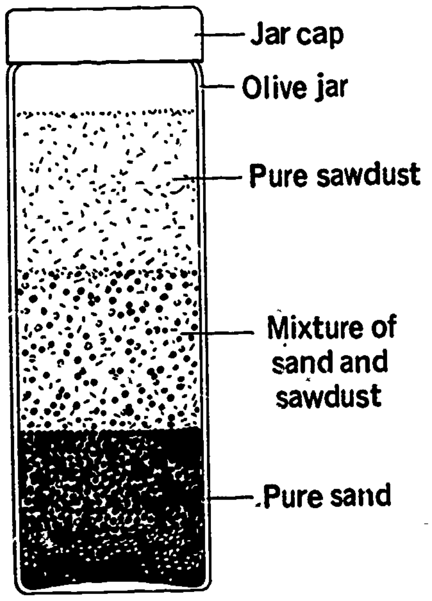
Concept to be developed: When certain solids are free to move, the more dense solid will settle below the less dense solid.

Materials needed:

Olive jar (big enough to hold more than two cups of liquid)
1 cup sand
1 cup sawdust
Spring scale

INTRODUCTION: Show the children the cup of sand and the cup of sawdust and have them note that the two have the same volume (since they *occupy identical amounts of space). Ask the children which they think will have the greater density and why. Have them test their ideas.*

Have several children weigh the cup of sand and the cup of sawdust and record the weights. Which is heavier? *(The sand.)* Put both the sand and the sawdust into the olive jar, screw on the cap, and shake the jar vigorously up and down. Have the children observe which material settles to the bottom in larger amounts. *(The sand.)* Why does the sand settle to the bottom and the sawdust come to the top? *(The sand weighs more per unit volume; the sand is denser and is pulled down with a greater gravitational force.)*



Relate their observations to the solid part of the Earth. The solid part of the Earth, the lithosphere, is also divided into spheres of differing densities. The central core consists of very dense material. Surrounding this is a less dense mantle; on the outer surface is the crust, the least dense. With which layers of the lithosphere, or solid Earth, do the sand and sawdust compare? *(The sand might be compared with the denser mantle or central core, and the sawdust might be compared with the less dense crust.)*

Learnings: (x) When certain solids are free to move, the denser solid settles below the less dense solid. (x,y) The Earth's rock layer, or lithosphere, also consists of layers with the least dense layer on the surface and the most dense layer in the center, or core.

ACTIVITY 4 (x,y,z)

MAKING A CLAY MODEL OF THE EARTH

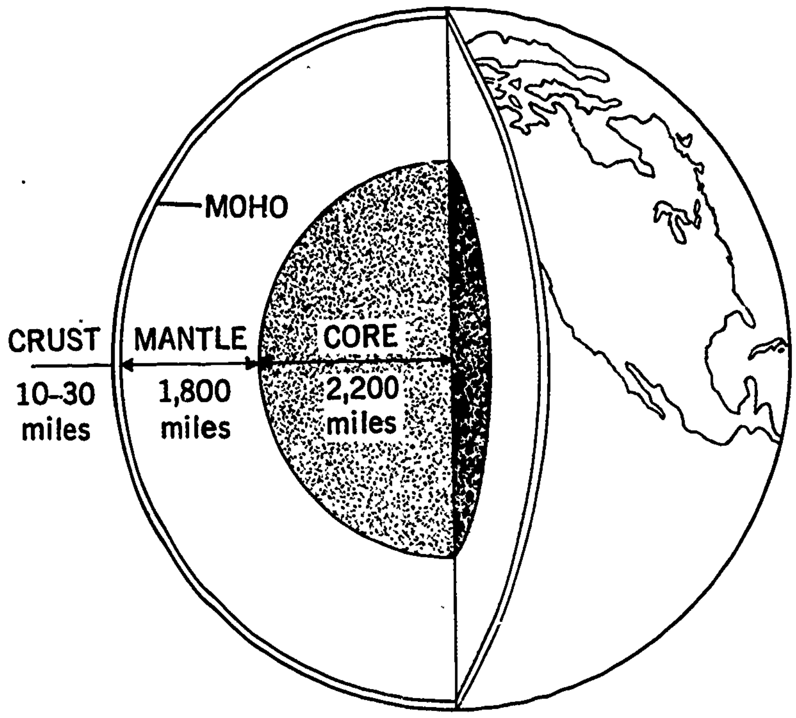
Purpose: To illustrate the structure of the lithosphere

Concept to be developed: The lithosphere consists of three layers: the core, the mantle, and the crust.

Materials needed:

Modeling clay or wallpaper cleaner
Tempera paints

To illustrate the zones of the solid earth, the children may want to make a clay model. Have them roll some modeling clay or wallpaper cleaner into a sphere, cut out sections as illustrated, and paint the various layers with tempera paint.



The thin outer layer represents the *solid crust,* thought to be about 10 to 30 miles thick. The central section represents the *inner core* of the Earth. The area in between represents the mantle. The mantle is about 1,800 miles thick; the core is about 2,200 miles thick. These zones might be labeled with stickers on toothpicks stuck into the clay.

The clay model of the Earth can be further elaborated by painting the hydrosphere (on the portion of the model that has not been cut away) blue. The children might also wish to show the atmosphere on the model by supporting a sheet of cellophane or transparent plastic above the crust with toothpicks. If they do this, they can make the atmosphere appear more realistic by simulating clouds with puffs of absorbent cotton.

Some of the children may have heard of the Moho, the division between the outer crust and the mantle. Scientists are planning to drill down to the Moho to see what kind of rock composes the mantle, and some of the children may want to find information about the Mohole project.

Learnings: (x) The solid Earth consists of three layers: the crust, the mantle, and the central core. The outer crust is very thin when compared with the other rock layers of the Earth. (x,y) The Mohole project is the attempt to drill through the Earth's crust to reach the mantle. Scientists would like to know more about the nature of the rock in the mantle.

SUMMARY AND LOOKING AHEAD

We have seen that science is a method of thinking. It involves, first of all, curiosity and observation. A scientist observes the world about him and asks, Why? He next formulates possible answers to his problems, and these are known as hypotheses. A scientist must next perform experiments to test his hypothesis. When he accumulates enough facts to prove his hypothesis correct, he formulates a theory and finally, after enough evidence has been gathered, a law.

This book is designed to develop scientific thinking in children. Activities are designed to develop important concepts and give meaningful experiences to the children.

The main topic of the book is the Earth. One chapter will cover each of the three spheres of the Earth: the solid lithosphere; the water, or hydrosphere; and the gaseous atmosphere. The next three chapters show how these three spheres are continually interacting and how they help to shape the surface of the land. The last chapter will illustrate some of the processes and forces at work in changing and shaping the Earth's surface. Children will find the answers to such questions as "Why do we have hills and valleys?" "What made the mountains?" "Where did the sand come from on the beach?" "What is a glacier?" "What do fossils tell us?" and "Why does the desert look so different from other areas?"

2

INVESTIGATING THE LITHOSPHERE

What kind of rock is this?

Why are some rocks smooth and others rough?

What is the difference between a rock and a mineral?

How can I grow my own crystals?

Where do soils come from?

Why are some soils black and others red?

What is the white stuff that farmers put on soil?

These are some of the questions your children may have asked about rocks, minerals, and soil. The Activities in this chapter will deal with these and many other questions your children may have asked. The topics will be concerned with the lithosphere, the rock phase of the Earth. The Earth's crust is the upper layer of the lithosphere. Since the crust is the only part of the lithosphere that we can see, it is this part that will be studied. For these investigations, much of the laboratory and materials will be furnished by the out-of-doors. Discovering the nature of the Earth's crust can be a fascinating study in science and should provide many activities of interest for your children.

HOW CAN MINERALS BE IDENTIFIED?

The solid crust of the Earth is made up of many different kinds of rocks, which, in turn, are composed of minerals. Rocks may contain one or more minerals. Since the number and kinds of minerals differ in each type of rock, no two types are identical.

Minerals, on the other hand, are relatively constant in composition. They are naturally occurring elements or inorganic compounds. An element is a substance that cannot be broken down into simpler substances by ordinary chemical means. A compound consists of two or more elements chemically combined. An inorganic compound is a compound formed from a non-living source.*

* For a further discussion of elements and compounds, see *Atoms and Molecules*, by Seymour Trieger (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

To clarify further the difference between minerals and rocks, think of a pudding or fruitcake made with a variety of fruits and nuts. The pudding or cake represents the rock, while the raisins, currants, and figs represent the various minerals that compose the rocks.

Minerals can be identified by their physical and chemical characteristics. The more common characteristics include streak, luster, color, cleavage, fracture, hardness, specific gravity, reaction to acids, and crystalline formation. Other properties that can be tested include magnetic properties, taste, melting point, and heat conductivity.

The following Activities indicate how your children may use some of these properties to identify minerals. Before they begin the Activities on minerals, it is suggested that a series of minerals be purchased from "rock-hounds" or collections sold in stores. Some of the more important minerals to obtain include the following:

apatite	hematite
quartz (pink, white)	magnetite
feldspar (pink, white)	limonite
calcite (blue, white)	talc
mica (black, white)	asbestos
graphite	halite (rock salt)
galena	kaolinite
pyrite	fluorite (green, purple, white)
sulfur	
jasper	gypsum
chalcopyrite	malachite
azurite	

ACTIVITY 5 (x,y)

IDENTIFYING MINERALS BY STREAK

Purpose: To show that many minerals leave characteristic colored streaks when rubbed across a white surface

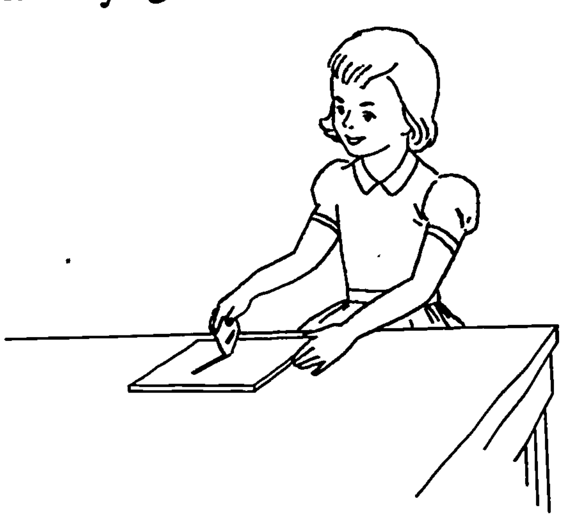
Concept to be developed: The streak test is one of the tests used in identifying minerals.

Materials needed:

Unglazed porcelain tile (1 piece for every 3 children if possible)
Files
Samples of different minerals

INTRODUCTION: Have a display of different mineral specimens on a table in front of the children. As you hold each specimen up, let the children tell what they can observe about it just from looking at it. Point out that this is one of the ways scientists use to identify minerals. Then tell them that they will discover another way in the following Activity.

Have one child rub a sample of pyrite or chalcopyrite across the unglazed porcelain tile. What do the children see on the tile? *(A greenish-black mark that has been made by the mineral.)* Point out that this method of testing is called a streak test and is one way of identifying certain minerals. (Streak refers to the powder a mineral leaves when rubbed on a rough surface. The color of the powder is often different from the color of the mineral itself. This difference in color is one means of identifying minerals.)



You may want the children to make their own discoveries of streak by rubbing the other minerals you have obtained on the unglazed pieces of porcelain tile. Have the children work in small groups. What do they discover? *(Some minerals leave no apparent streak; others leave streaks of a particular color.)* The streak or color of the powder may also be obtained by powdering the mineral with a file. Some children might want to use this way of discovering the streak left by their mineral samples. In some cases, minerals will appear to leave no streak and will scratch the tile instead. These minerals are harder than the tile and will not be powdered in this manner.

Have the children make their own list of the minerals, to include the minerals' external color and streak. Have them note which minerals have a distinctive enough difference between external color and streak to help in identification. The following table illustrates what your children can discover:

Minerals	External Color	Streak
apatite	blue-green	white
calcite	blue or white	white
chalcopyrite	brass yellow	greenish black
fluorite	green, purple, white	white
galena	lead gray	lead gray
hematite	steel gray, red-brown	brownish red
limonite	brown	ocher yellow
talc	gray or green	white
magnetite	black	black
malachite	bright green	pale green
pyrite	pale brass yellow	greenish black

From their findings, the children should be able to answer such questions as "What is the most common color of the streak?" *(White.)* "Would a white streak be a conclusive test for identification?" *(No, too many minerals have a white streak.)* "Do you note any streaks that seem to be a distinctive color and are different from the external color of the mineral?" *(Yes, the streak of hematite and limonite particularly.)* "Can these streaks be used for identification?" *(Yes, this is one of the chief tests for hematite and limonite.)*

Learnings: (x) The color of the powder or streak of a mineral is not always the same as the external color of the mineral. (x,y) A streak test is one means of identifying minerals. In most cases it must be used with other tests, since many minerals leave the same color streak. A few minerals, however, leave a very distinctive and characteristic streak, which identifies them.

ACTIVITY 6 (x,y)

IDENTIFYING MINERALS BY LUSTER

Purpose: To show that luster is a characteristic that aids in the identification of minerals

Concept to be developed: The luster of a mineral is a measure of the way it reflects light.

Materials needed:

Samples of different minerals

INTRODUCTION: This Activity will help children to discover another way to test mineral samples. This way to identify minerals is by means of their luster. *Explain that luster refers to the way minerals reflect light. Ask the children to name some minerals that have a very shiny, metallic look. These minerals are said to have a* metallic *luster. (Such minerals are* *usually compounds of a metal and sulfur, called* sulfides, *or a metal and oxygen, called* oxides.*) Minerals with a metallic luster are said to be* opaque *since they do not let any light pass through them. Write the terms* metallic *and* opaque *on the chalkboard. Brass, bronze, aluminum, and silver have this metallic luster. Pyrite and galena are good examples of minerals with a metallic luster. Other kinds of lusters include* adamantine *(brilliant or flashing),* vitreous *(glassy),* resinous *or* waxy, pearly, satiny, silky, *and* dull.

Have the children make a luster guide by first using common materials. Hold up samples of common materials and let the children describe the way each one reflects light. Develop the meaning of the word *luster*. For example, a dime would have a metallic luster. Ice would be described as glassy. Soil or clay would be called dull.

Next, let the children work with their minerals and determine the type of luster for each one. They may wish to add this list to the previous one on streak so that they now have two characteristics for each mineral.

The partial table of lusters below may be a guide for luster determinations.

Luster	Mineral
metallic	galena, pyrite, chalcopyrite, some hematite
adamantine	diamond, corundum, gems (ruby, emerald)
vitreous	transparent quartz, calcite
resinous	sulfur
pearly	talc
satiny	asbestos
dull	kaolinite

In observing the luster of the minerals, the children may have noted that some of the minerals transmit light or let it pass through. Explain to them that such minerals are called *transparent*, in contrast to those which do not allow any light to pass through them and are thus called *opaque*. Write the two terms on the chalkboard for review.

Learnings: (x,y) Minerals reflect light in different ways. This results in the property called luster, which may be used to identify minerals. Frequently minerals are classified as having a metallic or a nonmetallic luster. (x) If a mineral transmits light, it is called transparent; minerals that let no light pass through are called opaque.

ACTIVITY 7 (x,y)

IDENTIFYING MINERALS BY COLOR

Purpose: To show that the external color of a mineral is sometimes a means of identification

Concept to be developed: The color of a mineral is a result of the light that is reflected from the surface; this color, however, may be affected by impurities in the mineral.

Materials needed:

Samples of different minerals

INTRODUCTION: Children are only generally aware that minerals have different colors. *This Activity will help them to discover that color is another means of identifying minerals.*

Remind the children that minerals often have characteristic colors. Explain briefly why: the color of the mineral is determined by the light that is reflected, or bounced back, from the mineral to the eye. (This color may be different from the color of the transmitted light, the light that passes through the mineral.) But point out that the color of a mineral is not always constant and may be caused by certain impurities within the mineral. For example, copper impurities often produce a green or blue color. Iron impurities often produce a yellow, red, or brown color.

Have the children observe and record the colors of the various minerals you have obtained. For those minerals that have more than one color, such as quartz, it will be helpful to have samples of at least two different colors.

The children may want to list separately those minerals that have a variety of colors. Can the color test be used to identify these minerals? *(No.)* Do any minerals have characteristic colors that might be used for identification? *(Yes. Sulfur, azurite, malachite, jasper, pyrite, and galena are examples of these.)*

The following list will suggest how your class might record the different colors.

Minerals with a Constant Color

sulfur	yellow
malachite	green
azurite	blue
jasper	red
graphite	lead gray
galena	lead gray
pyrite	brass yellow
chalcopyrite	brass yellow
kaolin	white

Minerals with More Than One Color

fluorite	green, purple, blue, white
quartz	pink, white, gray
mica	colorless, pink, black
calcite	blue, white

Learnings: (y) The color of a mineral is a result of the light that is reflected from the surface. This color may be affected by impurities in the mineral. (x) The color of a mineral may be useful in identification. It cannot be used alone, however, since many minerals have more than one color.

ACTIVITY 8 (y,z)

IDENTIFYING MINERALS BY CLEAVAGE

Purpose: To show how cleavage may aid in the identification of some minerals

Concept to be developed: Cleavage is the tendency of some minerals to break along smooth, parallel planes.

Materials needed:

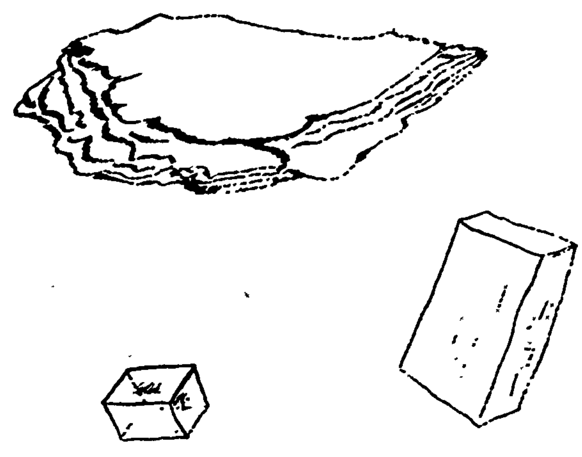
Magnifying glass
Hammer
Knife
Samples of different minerals

INTRODUCTION: Explain to the children that one of the most important properties for identification of a mineral is cleavage. *Write this term on the chalkboard. Tell them the definition: cleavage refers to the tendency of some minerals to break along certain parallel planes. Minerals having cleavage will show one or more directions of cleavage when fractured. Because the cleavage planes are smooth, they are usually quite easy to observe since they will reflect light like a smooth piece of glass or mirror. A test for cleavage is to turn the mineral in the light to see if there are any shiny surfaces.*

Suggest that the children discover cleavage for themselves by prying into a piece of mica with a knife. (Caution them on the proper method of using the knife.) Split the mica into thin sheets. These thin sheets can be split into thinner sheets. In what way have the sheets separated? *(Along parallel planes.)* Have the children feel the smoothness of each sheet. How many different examples of parallel planes can be seen? *(Only one.)* What is the nature of the cleavage surface? *(It is very shiny and smooth.)*

Have other children strike a sample of galena with a hammer. (Caution them about the use of the hammer. Put the galena in a paper bag or wrap it in cloth before breaking it.) What is the cleavage of galena? *(The cleavage faces make little cubes.)* How many directions of cleavage are there now? *(Three—the three dimensions of the solid cube.)* Next have the children strike a sample of calcite with a hammer. What is the cleavage here? *(The cleavage results in rhomb-shaped fragments, the sides of which are parallelograms.)* How many directions of cleavage are there in this case? *(Again there are three, one for each of the different sides.)*

Have the children observe the other minerals to see if they can detect any cleavage by looking for shiny surfaces. Remind them that cleavage is an inherent property of the mineral and the word refers to the way the mineral will break. The children may be able to discover cleavage in gypsum, feldspar, and fluorite.



Learnings: (x) Cleavage is the tendency of some minerals to break in smooth parallel planes. It is present in certain minerals and can aid in identification. (y) Cleavage varies in its completeness and perfection. Some minerals, such as mica, have a very discernible cleavage, also called perfect cleavage. Other minerals have a cleavage that is difficult to observe. (y) Cleavage may be in one, two, or three directions, depending upon the mineral. If the cleavage is in one direction only, parallel sheets will be observed. If the cleavage is in three directions, solid geometric figures, such as cubes or rhombi, will be observed.

ACTIVITY 9 (y,z)

IDENTIFYING MINERALS BY FRACTURE

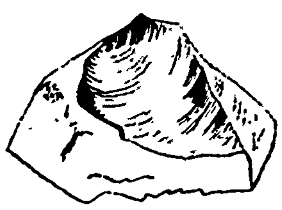
Purpose: To show that fracture may aid the process of mineral identification

Concept to be developed: Fracture is a description of the broken surface of a mineral that does not show cleavage.

Materials needed:

Hammer
Chipped glass
Indian arrowhead
Obsidian
Samples of different minerals

INTRODUCTION: Tell the children that although they learned about cleavage in the last Activity, they should realize that many minerals have no cleavage. The term used to describe how these minerals break is fracture. *Explain that the term fracture describes the surface of the mineral. For example, the surface may appear fibrous, earthy, even, or uneven. The most distinctive type of fracture is known as conchoidal fracture, which is shell-like in appearance. Mention the conch shell, from which this term is derived, and show the children a picture of one if it is available. Tell the children that fracture is another characteristic by which some minerals can be identified.*



Show the children a piece of obsidian. (Obsidian is not a mineral. It is a rock that has cooled very rapidly and thus has a glassy texture or appearance.) Let them handle different pieces. To be sure they understand the meaning of the term *fracture*, have one of them strike the piece of obsidian with a hammer. (Wrap the obsidian in cloth first.) What does the broken surface resemble? *(Concentric arcs or shells.)* (If you cannot obtain obsidian, try ordinary glass, which also has a conchoidal fracture. Be sure to wrap the glass in cloth before striking it with a hammer.) To further demonstrate fracture, note the fracture on an Indian arrowhead. (It is also conchoidal.)

Now have your children observe what happens to the various minerals upon breaking to determine which ones have distinctive fractures. What mineral has a fibrous fracture? *(Asbestos.)* What kind of fracture does clay have? *(Earthy.)* Quartz has a very characteristic fracture which is one of the main ways of distinguishing it from other similar-looking minerals. What is the fracture of quartz? *(Conchoidal.)* The Indian arrowhead has a conchoidal fracture because it is made of chert, or flint, a nontransparent quartz.

Learning: (y,z) Fracture is a description of the broken surface of a mineral that has no cleavage. Conchoidal fracture is one of the most distinctive types and in some cases may be an important clue to the identification of a mineral.

ACTIVITY 10 (x,y)

IDENTIFYING MINERALS BY HARDNESS

Purpose: To show that hardness may aid the process of mineral identification

Concept to be developed: The hardness of minerals is always constant for the same mineral and thus may be considered a characteristic property of minerals.

Materials needed:

Knife blade
Penny
Steel file
Window glass
Samples of different minerals

INTRODUCTION: Have children recall the different ways they have discovered of helping to identify a mineral. Now they will see another means of identification—hardness.

Tell the children that hardness is another very important characteristic used in the study and determination of minerals. The hardness of a mineral is its resistance to scratching. The hardness is usually determined by seeing what substance will scratch the mineral. For example, if quartz can scratch calcite, we would say that quartz is harder than calcite; if quartz cannot scratch calcite, we would say that calcite is harder than quartz.

Have a group of children experiment to determine the relative hardness of a fingernail, a steel file, a penny, and a knife blade. How are they listed in order of increasing hardness? (Fingernail is the softest, penny is next, then the knife blade, and the steel file is last.)

Have the children experiment with the hardness of minerals, determining what minerals the thumbnail will scratch, what minerals the penny will scratch, those that the knife will scratch, and those that the file will scratch. (After a mineral has once been scratched, there is no need to attempt to scratch it with the harder instrument, since it will obviously be scratched.) The children could make a chart of their findings something like the following:

Minerals scratched by the fingernail	Minerals scratched by the penny	Minerals scratched by the knife
gypsum talc	calcite halite	fluorite limonite

The relative hardness of the mineral is usually indicated by a number from 1 to 10. A hardness scale known as Mohs' scale, which lists common minerals in order of increasing hardness, is the one most frequently used. This scale lists the hardness of minerals as follows:

1.	talc	6.	feldspar
2.	gypsum	7.	quartz
3.	calcite	8.	topaz
4.	fluorite	9.	corundum
5.	apatite	10.	diamond

No. 10 (diamond) is the hardest mineral known, and it cannot be scratched by any other mineral. No. 1 (talc) is the softest and can be scratched by the fingernail.

Using the minerals of Mohs' scale as a reference, how can the children determine the hardness of their fingernails? *(The fingernail will scratch talc and gypsum but not calcite. Therefore, the fingernail is harder than 2 and softer than 3. It is considered to have a hardness of 2.5.)*

In the same way have the children determine the hardness of the penny, the knife blade, and the steel file. The results will be penny, 3; knife blade, 5.5; steel file, 6.5.

Using the fingernail, penny, knife, and file as guides, how can the children determine the hardness of the minerals in the collection or in unknown minerals they find? *(If they can scratch the mineral with a fingernail, they know its hardness must be less than 2.5; if they can scratch it with a knife but not a penny, its hardness must be between 3 and 5.5; if they cannot scratch it with the file, then it must be harder than 6.5.)*

The following list will be a helpful guide to the hardness of the most common minerals.

calcite	3	kaolinite	2.5
chalcopyrite	4	limonite	4–5.5
feldspar	6.5	magnetite	6
fluorite	4	malachite	4
galena	2.5	mica	2–2.5
graphite	1.5	pyrite	6.5
halite	2.5	quartz	7
hematite	5–6	sulfur	2
hornblende	5–6	zircon	7.5

Learnings: (x) The hardness of minerals is always constant for the same mineral, and thus it is a very good means of identifying minerals. (y) Hardness is usually indicated by a number from 1 to 10, with No. 1 representing the softest and No. 10 the hardest. Minerals that have the higher numbers will scratch those lower on the scale; for example, a mineral of hardness 8 will scratch a mineral of hardness 7. (x) By using common objects of known hardness, such as a knife, a penny, the fingernail, and a steel file, it is possible to estimate the hardness of unknown minerals.

ACTIVITY 11 (y,z)

IDENTIFYING MINERALS BY SPECIFIC GRAVITY

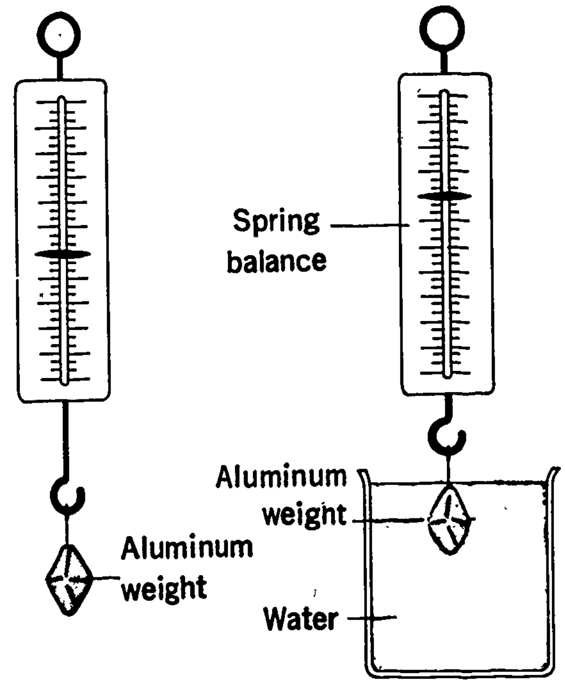
Purpose: To show that specific gravity is another characteristic that may aid in mineral identification

Concept to be developed: Specific gravity is a ratio of the weight of an object to the weight of an equal volume of water.

Materials needed:

Spring balance
Glass of water
Small piece of aluminum
Samples of different minerals

INTRODUCTION: Tell the children that you have a puzzle for them. How can a piece of aluminum weigh different amounts at different times if it is not changed in any way? Elicit their theories about this problem. Then have the children weigh a piece of aluminum on a spring balance and record the weight. Then have them immerse the aluminum (still suspended from the spring balance) in a beaker of water and record its weight again. Does the aluminum weigh more or less when it is immersed? (It weighs less.) *Why?* (The aluminum is buoyed up by a force equal to the water it displaced.) *Explain to the children that this loss of weight is the basis of another way to identify minerals—by their* specific gravity. *Specific gravity is the ratio of the weight of a substance to the weight of an equal volume of water. How is specific gravity determined? The specific gravity of a mineral equals the weight of the mineral in air divided by the loss of weight when it is weighed in water. (This loss of weight in water is equal to the weight of an equal volume of water—*



the weight of the water the object displaces. This is known as Archimedes' Principle.) Review the weights of the aluminum in and out of water. Then ask the children to subtract the weight of the aluminum in water from the weight of the aluminum in air. This will give the loss of weight in water. Then ask them to divide the weight in air by the loss of weight in water. This ratio is the specific gravity of aluminum. The following is an example of the method used.

Weight of aluminum in air = 50.0 grams
Weight of aluminum in water = 31.5 grams
Weight loss in water = 18.5 grams

$$\text{Specific gravity} = \frac{\text{Weight of aluminum in air}}{\text{Weight loss in water}} = \frac{50.0 \text{ grams}}{18.5 \text{ grams}} = 2.7$$

Note that specific gravity is a pure number, since it is a ratio and is not measured in grams, pounds, etc.

After the children understand how to find the specific gravity of aluminum, they might want to determine the specific gravity of other familiar objects. The following is a list of some familiar objects and their specific gravity:

cast iron	7.0–7.7
copper	8.9
glass	2.4–3.5
lead	11.3
zinc	7.1
water	1.0

Now have the children investigate the specific gravity of some of the minerals. They can suspend the minerals from the spring balance by a piece of thread and determine the specific gravity as they did for aluminum.

The following is a list of the specific gravities of some common minerals:

borax	1.7	fluorite	3.2
sulfur	2.0	topaz	3.5
halite	2.1	corundum	4.0
graphite	2.2	chalcopyrite	4.3
gypsum	2.3	zircon	4.7
feldspar	2.5	pyrite	4.9
quartz	2.7	magnetite	5.2
calcite	2.7	hematite	5.3
talc	2.8	galena	7.6
hornblende	3.1	gold	19.3

The specific gravities as listed are in some cases only an average. Certain minerals vary in specific gravity depending on the presence of certain impurities.

After the children have determined and recorded the specific gravity of a number of minerals, let them lift various minerals of known specific gravity (and similar volume) to compare the weights of the minerals. For example, let them see how galena feels when compared with quartz. *(It is much heavier than quartz.)* Which minerals are the heaviest? *(Metallic ones.)* Can the approximate specific gravity be estimated by lifting a mineral? *(Yes, if its volume is known.)*

Learnings: (x) The specific gravity of a mineral is a relatively constant characteristic and can be used as one means of identifying the mineral. (y,z) Specific gravity is equal to the weight of the substance divided by the loss of weight in water. (x) Specific gravity can be roughly estimated by lifting the minerals. Those of high specific gravity will be quite heavy.

ACTIVITY 12 (x)

IDENTIFYING MINERALS BY USING AN ACID

Purpose: To show that certain minerals react when treated with an acid and that this reaction can be considered a characteristic for the purposes of mineral identification

Concept to be developed: If a mineral effervesces when treated with hydrochloric acid, the mineral must be a carbonate.

Materials needed:

Weak solution of hydrochloric acid
Medicine dropper
Samples of different minerals

INTRODUCTION: Tell the children that some minerals react with acid, and this can be a useful aid in identification. Show the children a sample of the mineral calcite, and tell them that it is composed of calcium carbonate. Explain that acid reacts with calcium carbonate in a special way; the reaction results in the bubbling off of carbon dioxide, a gas.

Drop a small amount of dilute hydrochloric acid on a piece of calcite and have the children note what happens. *(A bubbly effervescence occurs.)* (*Caution:* The acid will not burn the skin at this dilution, but wash it off immediately if any touches the skin. Make certain it does not spill on clothes—it can burn holes in certain fabrics.)

What causes the bubbles? *(A chemical reaction occurs, resulting in the evolution of carbon dioxide.)*

Mineral	Hardness	Streak	Luster	Color	Cleavage	Fracture	Specific Gravity	Reacts with Hydrochloric Acid
talc	1.0	white	pearly	gray or green	one plane	——	2.8	No
graphite	1.5	black	metallic	lead gray	one plane	——	2.2	No
galena	2.5	lead gray	metallic	lead gray	cubic	——	7.6	No
halite	2.5	white	vitreous	colorless or white	cubic	——	2.1	No
calcite	3.0	white	vitreous	blue or white	rhombic	——	2.7	Yes
fluorite	4.0	white	vitreous	green, purple, or white	octohedral	——	3.2	No
pyrite	6.5	greenish black	metallic	pale brass yellow	——	uneven	4.9	No

You may want to use the chemical equation for this reaction:

$$\underset{\text{(calcite)}}{CaCO_3} + \underset{\text{(hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(calcium chloride)}}{CaCl_2} + \underset{\text{(carbon dioxide)}}{CO_2} + \underset{\text{(water)}}{H_2O}$$

This equation shows why the carbon dioxide is formed when calcite is treated with hydrochloric acid. The calcite is composed of calcium (Ca) and carbonate (CO_3), while the hydrochloric acid is composed of hydrogen (H) and chloride (Cl). When the calcite reacts with the acid, the calcium combines with the chloride to form calcium chloride ($CaCl_2$), and the hydrogen combines with the carbonate to form hydrogen carbonate (H_2CO_3), also called carbonic acid. The hydrogen carbonate, however, is unstable, and it immediately decomposes into water (H_2O) and carbon dioxide (CO_2).*

Put a small drop of dilute hydrochloric acid on some of the other minerals in the collections. What happens? *(If the mineral is a carbonate, it effervesces.)* What can be concluded about the use of dilute hydrochloric acid as a test in mineral identification? *(The test is helpful in determining whether a mineral is a carbonate compound, since minerals that do not contain carbonate will not effervesce.)*

It should be pointed out to the children that this test does *not* specifically identify calcite. Other minerals that are also carbonate compounds, such as magnesite (magnesium carbonate), dolomite (calcium magnesium carbonate), siderite (ferric carbonate), and strontianite (strontium carbonate), will also evolve carbon dioxide gas when treated with dilute hydrochloric acid. If one or more of these other minerals are available, the children should be allowed to test them.

* For a further discussion of chemical reactions, see *Atoms and Molecules*, by Seymour Trieger (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

Learnings: (y) When dilute hydrochloric acid reacts with a mineral that contains carbonate, the evolution of carbon dioxide gas results. (x) Calcite is composed of calcium carbonate and will effervesce when treated with dilute hydrochloric acid. However, since other mineral carbonates will also effervesce when treated this way, the test is not specific for calcite.

Extending Ideas: The children have now seen various techniques for identifying minerals. Have them make a chart with the characteristics of each mineral on it. This chart can be used as a reference key in determining the name of an unknown mineral. The children may wish to experiment with several types of charts to see which might be the most useful to them in identifying minerals. One such chart might be arranged in the order of hardness as shown in the accompanying illustration. How is such a completed chart used to determine minerals? *(First the children determine the hardness of the mineral. After this, they look at all the minerals that have this hardness to see which one fits the characteristics of the unknown mineral.)*

In the more advanced grades, to help the children learn how to do research, you might assign individual children or committees the job of making reports on various minerals; the topics for the reports might be the uses of the minerals or the geographic locations of their deposits.

Other students may wish to make their own mineral collections. They might keep the minerals in a shoe box or a cigar box. Duplicate specimens can be traded.

The children will have fun trying to identify "mystery" minerals you might exhibit every other day. The properties of the mineral could be listed as "clues" to its identity. The child who identifies it could be given the specimen for his collection.

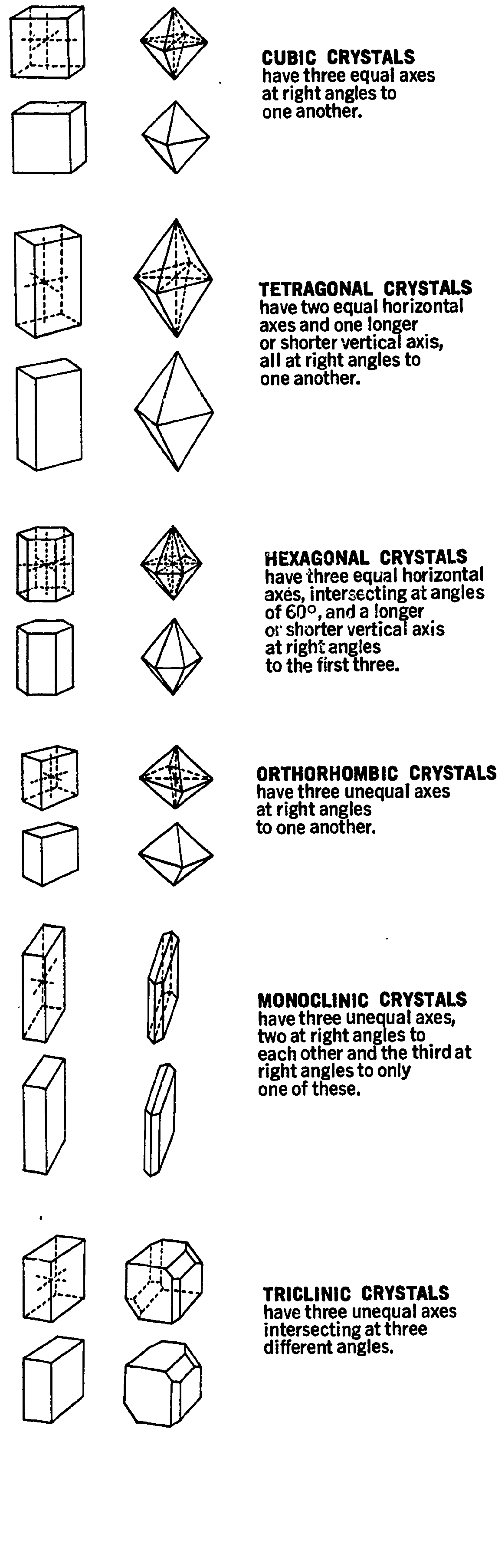
Summing Up Ideas: In this section the children have learned the characteristics of minerals and how these characteristics can be used in the process of identification. They have seen that the color of the streak left by a mineral is not necessarily the same as the mineral's external color. They have seen that a mineral may have either fracture or cleavage, which may be distinctive or characteristic. They have learned about the characteristic hardness of minerals and how Mohs' scale is used in mineral identification. The children have also seen that a mineral may be either transparent or opaque and that it may have a characteristic luster. They have learned that specific gravity is the ratio of the weight of an object to the weight of an equal volume of water and how to measure and calculate a body's specific gravity. In addition, they have seen that only certain minerals react with dilute hydrochloric acid to produce carbon dioxide gas and that this test can be used to identify those minerals that are carbonates.

HOW ARE CRYSTALS FORMED?

Crystals are solids with a natural geometric form. They may be cubes, rectangles, or complex geometric figures. A crystal reflects the internal structure of the mineral or substance, since the crystal form is the structural form of molecules that make up the mineral. Crystal shape can be an important means of identifying minerals.

Certain factors regulate the growth of crystals: the temperature of the liquid that contains the dissolved material; the rate of evaporation of the solution; the presence of foreign particles in the solution; the degree of solubility of the dissolved substance; the degree of supersaturation (an excess over what is normally dissolved) of the solution; and the tendency of the particular substance to crystallize or form crystals.

The study of crystals is a fascinating one and critical in mineral identification. The six basic



systems of crystals (and minerals showing each type) are cubic (galena and garnet), tetragonal (zircon), hexagonal (quartz and calcite), orthorhombic (sulfur), monoclinic (gypsum), triclinic (rhodonite).

As an introduction to the following Activities, the children can observe crystals of minerals with a magnifying glass. Calcite, quartz, and pyrite crystals are easily obtained. The children can also observe crystals of salt and sugar.

In the following Activities, the children will become more familiar with crystals as natural geometric formations in the crust of the Earth.

ACTIVITY 13 (x,y)

PRODUCING CRYSTALS THROUGH THE EVAPORATION OF A LIQUID

Purpose: To establish the basic ideas of crystals and crystal formation

Concept to be developed: As a salt solution evaporates, the particles of that salt form crystals of characteristic geometric shape.

Materials needed:

- Table salt (sodium chloride)
- Microscope or magnifying glasses
- Microscope slide
- Shallow dish
- Test tubes or small jars
- Medicine dropper

INTRODUCTION: One way to introduce a study of crystals is to point out to the children that each particle of the table salt they use daily has another special characteristic besides its taste. Let them speculate about what it might be. Give each child some salt crystals on a square of paper. Ask the children to look at them, feel them, and then describe their findings. Are the grains separate or all clumped together? (Some might be clumped together, but they can be separated into individual particles.) *What do they feel like? Can the children tell their shape? Explain to the children that they can learn more about the shape of the grains by looking at some particles under a microscope or magnifying glass. Have them put some of the salt on a glass slide and observe the crystals under a magnifying glass or a microscope. What is the shape of a salt grain?* (It looks like a perfect cube.) *Do all the cubes look alike?* (Almost all of them have the cube shape.)

Have the children place some grains of salt in a test tube half full of water. What happens to the grains? *(They sink to the bottom, get smaller, and then disappear.)* What happened to them? *(They dissolved in the water.)* Can the children see them when they are dissolved? *(No.)* Can the children tell that salt is in the water just by looking at the water? *(No.)* How can they tell that salt is in the water? *(The water will taste salty if it contains enough salt.)* Dissolve more salt in the water. What happens to the height of the liquid in the test tube? *(The liquid rises.)* Why did the liquid rise? *(The salt took up room.)* Add more salt until no more will dissolve, that is, until the water is saturated with salt. Why will no more salt dissolve in the water? *(The water can hold only a particular amount of salt.)*

Pour a little of the saturated salt solution on a microscope slide and project the image of the slide, using a film strip projector. Children can notice the formation and growth of the crystals as the image is projected on a screen. Where does the growth first appear? *(At the edge of the drop of water.)* Why does the growth first appear along the edge? *(This is the shallowest part and evaporates first.)* Why does the water evaporate so rapidly? *(The heat generated by the projector speeds up the evaporation of the water.)* What is formed on the slide? *(Crystals of salt.)* What shape do they have? *(The same as before—a cube shape.)* How do they differ from the salt crystals first observed? *(These are much smaller, and there are more of them.)* What happened to the water? *(It evaporated.)*

A few members of the class may want to dissolve two crystals of salt in a drop of water, evaporate the water, and count the number of crystals produced. Children might be encouraged to find out if the speed of evaporation determines the size of the salt crystals formed. *(It does. The faster the evaporation, the smaller the crystals.)* How might they do this? *(They should consider the amount of heat needed to achieve various rates of evaporation.)*

Other children may want to try other crystals, such as those of Epsom salts, to see their shape and the patterns formed in crystallization.

Some children may want to tell of their experiences in visiting caves and seeing crystal formations formed from the evaporation of a liquid. Beautiful formations of stalactites, stalagmites, and columns can be observed in caves like the Mammoth Cave in Kentucky, the Luray Caverns in Virginia, and Carlsbad Caverns in New Mexico.

Have any of the children ever seen or found geodes? These are rocks with a central cavity that is lined with crystals, usually quartz or calcite. The crystals formed from the evaporation of a liquid that was once enclosed in the rock.

Learnings: (x,y) As salt solutions evaporate, the particles of that salt form crystals with characteristic geometric shapes. (x,y) The rate of evaporation affects the size of the crystals. A slow rate of evaporation will result in larger crystals. (x,y) Crystals form in nature by slow evaporation of a liquid that contains dissolved salts. (x) A saturated solution is one that contains all the dissolved substance that it can hold.

ACTIVITY 14 (x,y)

PRODUCING CRYSTALS FROM A SUPERSATURATED SOLUTION

Purpose: To show that large crystals can be grown in supersaturated solutions

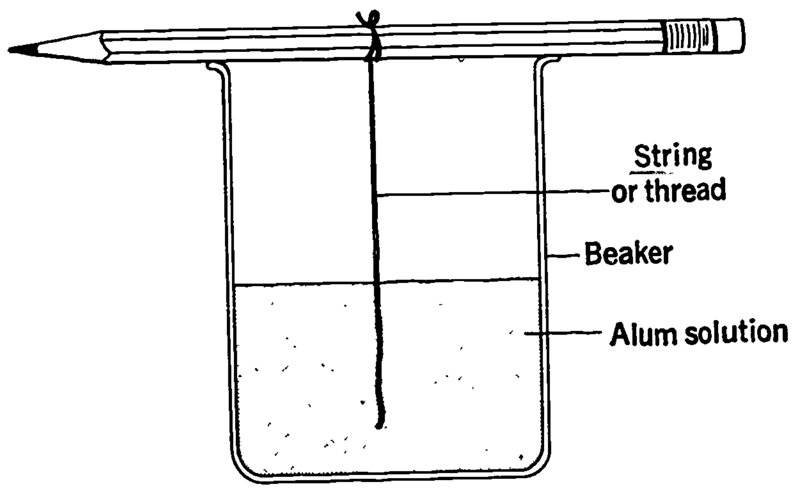
Concept to be developed: Large crystals can be grown by depositing particles of a salt upon crystals of that salt.

Materials needed:

Alum (available at drugstores)
Glass beaker
Water
Hot plate
String
Pencil
Cup
Stirring spoon

INTRODUCTION: Point out to the children that there is another way of producing crystals. Have them dissolve about one-quarter cup of alum in one cup of water. What happens to the alum? (It all dissolves.) *Can any more dissolve in the liquid?* (Yes.) *Have the children add more alum until no more can dissolve, even if the solution is stirred vigorously. Point out that the children have made a solution that is saturated. Ask them how they might determine this and test their ideas.*

Now have a child pour half of this saturated solution into a beaker, place the beaker on a hot plate and heat it. When the solution is boiling, a few more crystals of alum should be added. What happens to the crystals? *(They dissolve.)* Why do they dissolve now, although they did not before? *(The water is hot and can hold more alum in solution.)* Have another child stir the solution and dissolve more crystals until no more



can dissolve. Children will discover that they have made a solution that holds more alum than it normally would at room temperature. This is called a supersaturated solution.

Next, remove the beaker from the hot plate. Suspend a cotton thread from the center of a pencil and place the pencil over the beaker as shown in the illustration. Have the children observe the thread after several hours and then after several days. What is observed? *(Crystals form and grow on the string.)* What is the purpose of the string? *(It acts as a point for crystals to start forming.)*

Other children could try sugar instead of alum and make "rock candy" by crystallization. (Caution the children against eating any material made, however, because of contamination.)

Learnings: (x) Crystals can be grown from a supersaturated solution. (y) A supersaturated solution is one that holds more salt than the normal amount at room temperature. A supersaturated solution can be produced by heating the solution and then dissolving more salt.

ACTIVITY 15 (x)

PRODUCING CRYSTALS BY COOLING A LIQUID

Purpose: To show that crystals can be formed by the cooling of certain liquids

Concept to be developed: Molten sulfur forms characteristic crystals when it is cooled slowly.

Materials needed:

Propane torch, Bunsen burner, or hot plate
Sulfur
Test tube
Filter paper
Funnel
Beaker

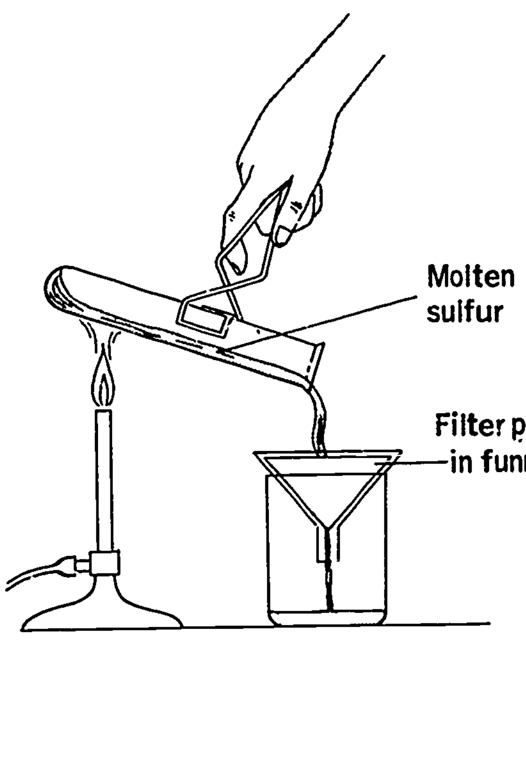
INTRODUCTION: Show the children a sample of sulfur and ask them where it comes from. Some children may know that it is mined. Explain that in some operations the sulfur is heated underground, forced up a tube, and cooled in large containers on the surface. It is then crushed and powdered.

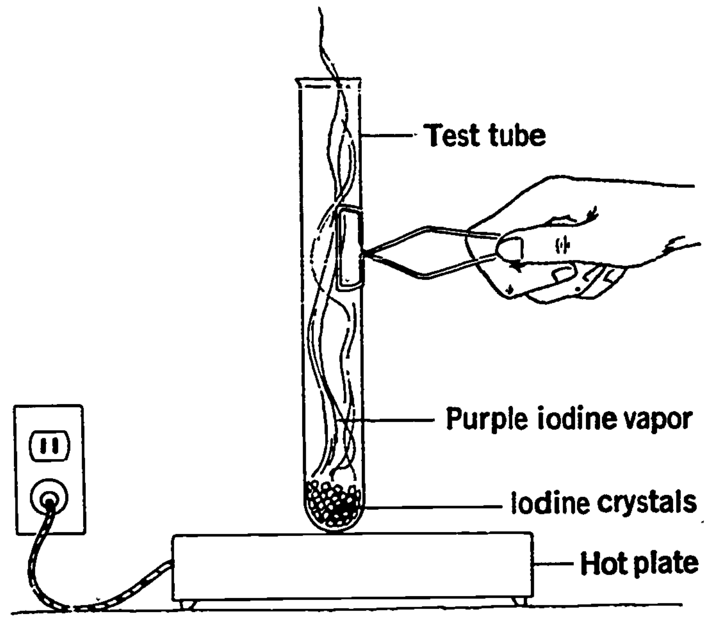
Remind the children that they have learned that some crystals are formed by heating and evaporating. Now they will discover another way in which some crystals are formed.

Have the children examine some powdered sulfur. What color is it? *(Yellow.)* Ask them to describe how it feels. *(It feels like dry talcum powder.)* Have them examine some sulfur powder with a magnifying glass. Are there any crystal shapes present? *(No.)*

Have the children fill a test tube half full of sulfur and heat it over a propane torch, Bunsen burner, or hot plate. (Be sure to open the windows because irritating fumes will be given off.) As the sulfur heats, have the children notice the various changes. What happens to the sulfur? *(It melts.)* Does the color change? *(Yes, it becomes dark yellow and then red.)* Next have the children pour the molten sulfur into the filter paper (as shown in the illustration) and allow it to cool slowly. What happens? *(Crystals form as the liquid cools.)*

To show what happens if the molten sulfur is cooled rapidly, have the children pour some into a glass of cold water. What happens? *(It rapidly solidifies.)* Are there any crystals? *(No.)* Why not? *(Rapidly cooled liquids solidify into amorphous, or noncrystalline, glasslike solids.)*





Learnings: (x) Sulfur can be melted by heating and will form its characteristic crystals if the molten sulfur is cooled slowly. (x,y) Rapid cooling results in an amorphous, or noncrystalline, solid.

ACTIVITY 16 (x,y)

PRODUCING CRYSTALS BY COOLING A VAPOR

Purpose: To show that crystals can also form by the cooling of a vapor

Concept to be developed: The vapors of certain substances produce crystals when they are cooled.

Materials needed:

Iodine crystals
Test tube
Hot plate
Glass plate
Magnifying glass

INTRODUCTION: Have the children recall their previous experiences with producing crystals. You may want to summarize their learnings in this way: They produced crystals by heating and evaporating (alum, salt, and sugar) and by cooling a liquid (sulfur). Next they will discover another way crystals are formed. They will be working with iodine crystals. Most children know about iodine and its use as an antiseptic, tincture of iodine. Mention that iodine is also found in sea water, in the salt water of gas wells, and in compounds of Chile saltpeter.

Have the children place a few iodine crystals in a test tube and heat it over a hot plate. What happens to the crystals? *(They turn into a gas.)* What is the color of the gas? *(Purple.)* Place the test tube on its side and continue to heat it.

Pour some of the purple vapor onto a cold glass plate. What happens to the vapor? *(Some of it is cooled and forms crystals of iodine on the plate.)* Examine the crystals. What can be seen? *(Blue-gray crystals of iodine.)* How do they differ from the original crystals? *(They are more regular in shape and smaller in size.)* After all the iodine in the test tube has been vaporized, allow the vapor inside to cool slowly to room temperature. How do the crystals look? *(Very similar to the original crystals.)*

Learning: (x) A vapor of an element or compound can change directly into crystals of that element or compound.

Extending Ideas: Some particularly interested students may want to investigate crystals a little further. You might suggest that they make crystal models using such materials as sponge, wood, or Styrofoam.

Some children might enjoy growing crystals of minerals other than the ones used in the preceding Activities. The children might try to grow crystals of each of the six types and display them when the crystals have grown.

Summing Up Ideas: In this section the children learned how the crystals of the various minerals are formed. They learned the six basic types of crystals—cubic, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic. They saw how crystals can be produced by the evaporation of a liquid, by growth from a supersaturated solution, by cooling a liquid, and by cooling a vapor.

WHAT ARE ROCKS?

A rock is any natural material that makes up part of the Earth's crust. Most rocks are made of many minerals, but some, such as pure marble, contain only one. Some rocks, such as coal, are made of materials that are not mineral.

Rocks have been named for localities (syenite after Syene, Egypt), for people (charnockite after Job Charnock, the founder of Calcutta), for their mineral composition (quartzite for quartz), for their grain size (sandstone for its sand-size particles), and for various physical features (soapstone for its smoothness).

The geologist studies the mineral composition of a rock as well as the texture and structure of its component parts. Rocks are classified on the basis of the way they were formed. Through observation and experimentation the geologist can determine if the rock was formed by the cooling and hardening of molten material to form *igneous rock,* by the deposition of material to form *sedimentary rock,* or by the alteration of previously formed rocks by heat, pressure, movement of the crust, and chemical action of liquids and gases to form *metamorphic rock.* These three rock types are the main divisions in the rock classification and will be treated separately in the following Activities.

Igneous Rock: Igneous rock originates as a hot molten liquid, or magma. Two important factors that affect the type of rock are the composition of the magma and the rate of cooling. These factors are the basis for the system of classification used. Grain size, structure, and mineral content are the main features of importance to be observed. The grain size, or texture, is associated with the rate of cooling—a coarse texture resulting from slow cooling and a fine texture from rapid cooling. The children will remember how sulfur behaved when cooled slowly and when cooled rapidly (see Activity 15). The mineral composition depends upon the chemical composition of the material from which the igneous rocks were formed. Although two rocks may have the same mineral composition, coming from the same "mother material," or magma, they may appear very different because of the texture.

Geologists no longer believe that the Earth is composed of molten materials beneath the thin surface layers. In addition, they no longer believe that there is a complete zone of molten rock anywhere. They believe that the interior rock is prevented from melting because of the great amount of pressure put upon it by the weight of the rock above it, and thus it is kept in a semiplastic condition.

When pressure is reduced, as by cracks in the solid rock above, the hot semiplastic material becomes molten. If the molten material hardens before it reaches the surface, rocks that have a coarse texture, such as granite, are formed. These are called *intrusive* igneous rocks. If the molten material reaches the surface and then hardens, such very fine-grained rocks as obsidian, basalt, and pumice are formed. These rocks are called *extrusive* igneous rocks.

Sedimentary Rock: Sedimentary rock is classed as a secondary rock, since it is formed from already existing rock particles or sediments pressed together and cemented by materials deposited from solution. Sedimentary rocks can also be formed by precipitation, that is, by the accumulation of material being carried as dissolved matter in water. Individual grains of sand, for example, may accumulate and be pressed together to form sandstone; finer particles of clay and mud may accumulate to form shale.

Metamorphic Rock: Metamorphic rock is also a secondary rock. Igneous and sedimentary rocks may alter their structure and conformation when subjected to drastic changes of heat and pressure. The product is a metamorphic rock.

ACTIVITY 17 (x,y)

CLASSIFYING IGNEOUS ROCKS

Purpose: To show on what basis igneous rocks are classified

Concept to be developed: Igneous rocks are formed by the cooling of molten material.

Materials needed:

Igneous rocks: basalt, obsidian, pumice, granite, and gabbro (Rocks can be purchased from scientific supply companies and from museum shops.)
Magnifying glasses

INTRODUCTION: Show the children specimens of the different igneous rocks—basalt, pumice, obsidian, granite, and gabbro. Emphasize that these are all igneous rocks and develop the meaning of that term, to be added to the children's vocabulary. Use as much information as you think appropriate from the introduction to this section.

The children should work in small groups to examine the rocks closely. Have them see what they can discover about each rock. You may want to have each rock labeled and have each group make a list of their findings for the various rock specimens. A magnifying glass for each group will be useful for examining the rocks. After the groups have completed their work, use such questions as the following to assist children in summarizing their findings: Which rocks have minerals large enough to be seen with the unaided eye? *(Granite and gabbro.)* Which ones have minerals so small that they cannot be seen even with a magnifying glass? *(Basalt, pumice, and obsidian.)* What do the children observe that is unusual about pumice? *(It is full of holes and is very light in weight.)* Remind the children of their experience with the cooling of sulfur to form large crystals and small grains. Then ask whether pumice cooled slowly or rapidly? *(Rapidly, since it is very fine-grained.)* What is the reason for all the holes? *(A comparison could be made between pumice and ordinary bread. Both are full of holes. The holes in the bread were caused by a leavening agent, which produced carbon dioxide gas. The holes in the pumice were also caused by gases, which were within the liquid magma as it solidified.)* Which of the rocks are dark in color? *(Obsidian, basalt, and gabbro.)* Which are light in color? *(Pumice and granite.)*

With this information, the children can make a key, such as the following, to identify the five igneous rocks.

A. Those that have visible minerals
   1. Dark in color—gabbro
   2. Light in color—granite
B. Those that have no visible minerals
   1. Full of holes and very light—pumice
   2. Not full of holes
      a. Glassy in appearance—obsidian
      b. Not glassy in appearance—basalt

Another key the children could devise for the same five rocks is the following:

A. Light in color
   1. Visible minerals—granite
   2. Minerals not visible—pumice
B. Dark in color
   1. Visible minerals—gabbro
   2. Minerals not visible
      a. Glassy—obsidian
      b. Not glassy—basalt

There are other keys the children could devise. For example, they might have keyed the rocks by hardness or by density, but this would be much more difficult.

Learnings: (y) Rocks can be grouped into a key, which can later be used to identify these rocks. (x) Very-fine-grained rocks cooled rapidly; coarse-grained rocks cooled slowly. (x) Pumice, an extremely light rock, cooled very rapidly. Gases contained within the molten rock as it hardened produced the holes.

ACTIVITY 18 (y)

CLASSIFYING DEPOSITED SEDIMENTARY ROCKS

Purpose: To show how sedimentary rocks are formed

Concept to be developed: Some sedimentary rocks are formed of deposited grains or particles that are later pressed close together by overlying layers, cementing the particles together.

Materials needed:

Clay
Sand
Fine gravel
Sandstone
Conglomerate
Shale
Water
1-quart jar

INTRODUCTION: Tell the children that this Activity will help them classify another kind of rock, sedimentary *rock. Develop the meaning of the term as you consider appropriate, using material from the introduction to this section. For this Activity, the children can work in small groups. Give each group a sample of sandstone, conglomerate, and shale. Let the children look at the samples, feel them, and give their ideas about how they might have been formed. They may recognize the sandstone just by the small grains of sand they can feel. Tell them the names of the other rocks. Then have them make some artificial rocks to compare with the natural ones they have examined.*

Let the children mix together one-half cup each of clay, sand, and fine gravel. Put the mixture in the quart jar and add two cups of water. Shake the contents and then allow the mixture to settle.

Have the children examine the mixture through the glass and compare this mass with the rocks (shale, sandstone, and conglomerate).

In which are the grains more compacted? *(The rocks.)* Why? *(There was more pressure upon them when they were formed.)*

How would the three rocks be classified according to size of grain particles? *(Shale has the finest particles, and conglomerate has the largest. Conglomerate is often called "puddingstone" because of the larger stones found within the rock.)*

Learnings: (x,y,z) Some sedimentary rocks are formed of deposited grains pressed close together by subsequent layers and then cemented together. (x,y,z) Shale resulted from very fine particles being pressed together; sandstone is the result of cemented sand grains; and conglomerate is formed from various sized particles, some of which may be quite large, that are cemented together.

ACTIVITY 19 (y)

CLASSIFYING PRECIPITATED SEDIMENTARY ROCKS

Purpose: To show another way sedimentary rocks are formed

Concept to be developed: Sedimentary rocks can be formed by the precipitation of rock particles from solutions.

Materials needed:

Pint jar
Water
Salt
Limestone, chert, or gypsum

INTRODUCTION: Show the limestone, chert, or gypsum to the children and explain that these were formed in a different manner from sandstone. Explain that rocks like limestone, chert, and gypsum were particles once dissolved in water. The minerals precipitated, *or came out of solution, and were deposited to form rocks.*

To show how this might happen, have a group of children make a saturated solution of salt by dissolving as much salt as possible in one-half cup of water. Allow the solution to evaporate for several days.

Examine the resulting salt formations. Where is the salt found? *(At the water's edge.)* What color is the salt? *(White.)* Why were the crystals not visible in the saturated solution? *(Because the salt was dissolved in the water.)* Precipitated sedimentary rocks are formed in much the same way.

Compare the salt with precipitated rocks like limestone, chert, and gypsum. Which is the harder, the salt or the precipitated rock? *(The rock.)* Why is it harder? *(There was more pressure placed above it.)*

Learnings: (y,z) Particles in precipitated sedimentary rocks were once dissolved in water and later precipitated out of solution.

ACTIVITY 20 (x,y)

COMPARING DIFFERENT KINDS OF SEDIMENTARY ROCKS

Purpose: To show the differences between different kinds of sedimentary rocks

Concept to be developed: Many types of sedimentary rocks are easily distinguished from one another.

Materials needed:

Shale
Sandstone
Conglomerate
Limestone
Fossiliferous limestone
Bituminous coal
Chalk
Coquina

INTRODUCTION: Have the children make collections of sedimentary rocks and use them in making a key. You may have to supplement their collections. Help them plan the key.

Grain differences can be compared as one means of separation. The children can also try the acid test (dilute hydrochloric acid) on all the rocks. Which ones show a reaction? *(Those rocks containing carbonate will effervesce. These include limestone, chalk, and coquina. Sandstone sometimes effervesces if the cementing substance around the sand grains is calcite.)* This reaction of the rocks to acid can be included in the key.

What differences do the children observe between chalk and coquina? *(Coquina is composed of visible animal shells cemented together. Chalk is very fine grained in comparison.)* If you have a microscope, you might want to have the children observe the chalk grains under magnification. The children may be able to observe that chalk also is composed of shells—very minute ones of tiny microscopic animals.

Point out how coal is different from the other rocks (besides being black and smudgy). Coal is formed by the compacting of plant remains under great pressure. Peat and lignite are earlier stages in the formation of coal. They are less compacted and more plantlike. The harder the coal, the more it has been compacted by heat and pressure. Hard coal burns with a hot, clean flame; peat and lignite are poor fuels that burn with a very smoky flame. The class can compare the various stages of coal if peat and lignite are obtainable.

Have the children observe the animal fossils in the limestone. How did the impressions get there? *(Animals were among the material deposited.)* What do fossils indicate about the rocks? *(They indicate the conditions that existed when the rocks were formed and what animals were present.)* No fossils are observed in igneous rocks because the rocks were formed under conditions too hot for any plant or animal remains to have been preserved.

Next have the children observe the sandstone, conglomerate, and shale. In what ways do they differ? *(Mainly in grain size.)* Which has the largest grains? *(Conglomerate.)* Ask the children to think of ways conglomerate could have formed. *(This rock results from the cementing together of pebbles and rock fragments.)* What does it remind them of? *(Some conglomerate resembles ordinary cement.)*

What can the children discover about the sandstone? What happens when it is rubbed? *(Sand particles fall off.)* What mineral is the sand? *(Quartz, usually.)* Will the sandstone normally react to acid? *(No.)*

Ask the children where sandstone might be formed. Where is sand particularly abundant? *(Sand is found on beaches near, and on the bottoms of, large bodies of water, such as lakes or oceans. Sand deposits in deserts indicate that at one time there was a lake that has since dried up.)* How is the sandstone formed? *(Sand grains become compacted together and cemented with some mineral substance.)*

How does shale differ from the other two rocks? *(It is very fine-grained.)* Of what is shale probably composed? *(The children may suggest such things as mud, clay, or fine dirt. Shale is generally considered a rock composed of clay particles cemented together.)*

Learnings: (y) Dilute hydrochloric acid may be used as a test to classify sedimentary rocks as carbonates or noncarbonates. Any rock with calcite or animal shell will effervesce. (x) Coal results from plant remains that have been compressed by overlying beds. (x) Chalk and coquina are composed of animal shells that have been cemented together. The shells in chalk are microscopic. (x) Fossils can be found only in sedimentary rocks. They indicate the conditions and the life present when the rock was formed. (x) Some of the rocks may be separated on the basis of grain size. Conglomerate is composed of pebble-size grains; sandstone is composed of smaller "sand" grains; while shale is very fine grained and probably a result of cemented clay.

ACTIVITY 21 (x,y)

COMPARING SEDIMENTARY ROCK WITH METAMORPHIC ROCK

Purpose: To illustrate the differences between sedimentary and metamorphic rock

Concept to be developed: Metamorphic rocks are harder than the sedimentary rocks from which they were derived.

Materials needed:

Shale and slate
Limestone and marble
Sandstone and quartzite
Water
Medicine dropper
Magnifying glass
Dilute hydrochloric acid

INTRODUCTION: Display the rocks and a magnifying glass on a table. Over a period of several days let the children go to the table to examine the rocks. Suggest that they use a hardness test on each rock. Have them list their findings. After all the children have had this opportunity, let them share what they have discovered about each rock. You might ask them to list the characteristics of each.

Now discuss the shale and slate. Explain that blackboards are often made of slate. Have them examine some pieces of blackboard (obtained from the custodian). What characteristics make slate a good blackboard material? *(It is hard, fine grained, can be smoothed to a flat surface, does not have a high glare, and takes chalk well.)* Compare slate with shale. Why would shale be an ineffective blackboard material? *(It is too soft.)*

Have the children examine a piece of limestone and a piece of marble. Have them guess which is harder. How could they find out? *(By trying to scratch one with the other; the harder rock will scratch the softer rock.)* Let the children examine both with a magnifying glass. Which one has particles closer together? *(Marble.)* Place a drop of dilute hydrochloric acid on each rock, using a medicine dropper. What is the result? *(Bubbles of a gas evolve from both.)* What does this indicate? *(They are both composed of carbonates; actually, both are made of calcium carbonate.)*

Next have the children compare the sandstone and the quartzite. Remind them that sandstone is a sedimentary rock composed of sand-size grains of quartz cemented together. Do they observe any differences? What happens when sandstone is rubbed? *(The grains separate and fall away.)* What happens when quartzite is rubbed? *(Nothing; the grains cannot be separated.)* Which rock is harder? *(Quartzite; the sandstone can be easily scratched.)* What is the difference between the two rocks? *(Quartzite is much harder than the sandstone. During the process of metamorphism, great heat and pressure caused the sand grains to melt and become welded together.)*

After examining the rocks, the children might make a chart similar to the one shown.

Rock	Soft	Hard	Sedimentary	Metamorphic
sandstone	x		x	
quartzite		x		x
shale	x		x	
slate		x		x
marble		x		x
limestone	x		x	

Learnings: (y,z) Metamorphism is a process by which rocks become changed by heat and pressure. This change alters their appearance and makes them harder and more compact. (x) Metamorphic rocks are harder than the sedimentary rocks from which they came.

Summing Up Ideas: The preceding group of Activities has given the children a chance to examine various kinds of rocks found in the Earth's crust. They have compared several different kinds and have seen how some have been formed. They have learned that igneous rocks are formed by solidification of molten rock; that sedimentary rocks are formed by precipitation from solutions; and that metamorphic rocks are formed by the action of increased heat and pressure on igneous and sedimentary rocks. They have been encouraged to make their own collections and to try to identify them by the use of keys.

HOW ARE SOILS MADE?

Soil is the loose surface material of the Earth's crust in which plants take root and grow. It is an important product of weathered rock. Weathering involves the breaking up of rocks into small pieces. Weathering is brought about through physical, chemical, and biological processes, some of which will be discussed in this section. These processes depend upon the moisture and temperature present in the geographic location.

Physical processes involve the fragmenting of the rock. The fragmentation is often due to ice forming in small rock fractures or cracks. Other fragmentation may be caused by sudden changes in temperature.

Chemical processes involve changes in the composition of the rock. These changes can be due to reactions with oxygen, water, or carbon dioxide.

Biological processes involve the splitting of rocks by plants and animals. This splitting can be caused by the pushing of plant roots or by the burrowing of animals.

Through these physical, chemical, and biological processes soil is made.

The following Activities illustrate how physical and chemical processes can be important factors in the weathering, or breaking up, of rocks to eventually form soil.

ACTIVITY 22 (x)

OBSERVING AN EFFECT OF FREEZING WATER

Purpose: To demonstrate that the formation of ice is one of the physical processes that weather rock

Concept to be developed: When water freezes, the ice occupies a greater volume than did the water.

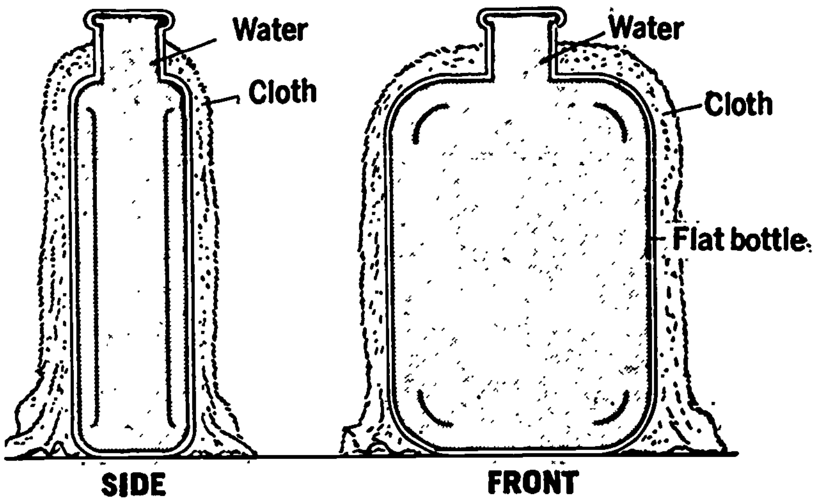
Materials needed:

Flat-sided glass bottle (syrup often comes in this type of bottle)
Cloth wrapping
Water
Refrigerator

INTRODUCTION: Ask the children if they have seen large cracks in rocks or in pavement and if they know what might have caused them. One child will probably mention the force exerted by freezing water. This Activity will demonstrate to your children the force water can exert when it freezes.

Have a child fill the bottle with water and put the top on securely. Wrap the bottle in a cloth (to prevent the shattered glass from dropping into the refrigerator). Put the bottle in the freezing compartment of a refrigerator. After 24 hours remove the bottle and examine it. What can be observed? *(The bottle will probably be cracked.)* Why is the bottle cracked? *(Pressure was exerted upon it.)* What caused the pressure? *(The force exerted by the ice as it expanded.)* Why did the ice exert a force? *(As water freezes, it expands and takes up more space.)*

Cutaway View of Bottle



Guide the children's thinking as they apply their findings to what might happen out-of-doors. As water in a crack of a rock freezes, the rock is split farther apart because the ice takes up more space than the liquid did.

Learnings: (x) Water expands with freezing and may enlarge the cracks in rocks, eventually breaking the rocks into smaller pieces. (x,y) The expansion of water as it becomes ice is strictly a physical process, since no chemical change takes place.

ACTIVITY 23 (x)

OBSERVING AN EFFECT OF CHANGES OF TEMPERATURE

Purpose: To demonstrate that variation in temperature is another of the physical processes that weather rock

Concept to be developed: Sudden changes of temperature may cause rocks to split into smaller pieces, forming soils.

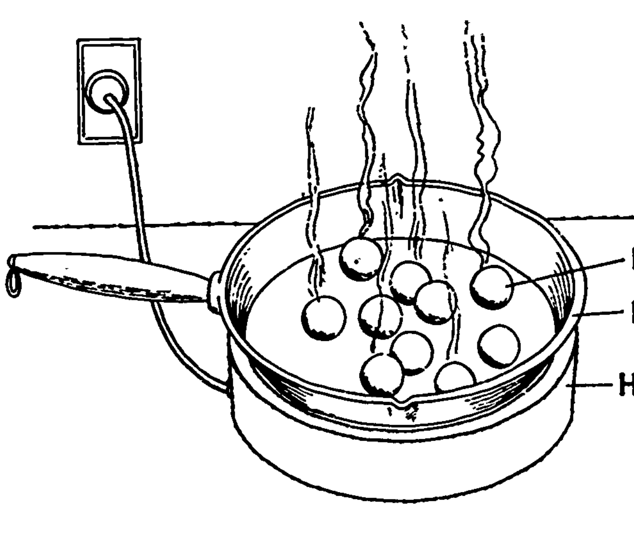
Materials needed:

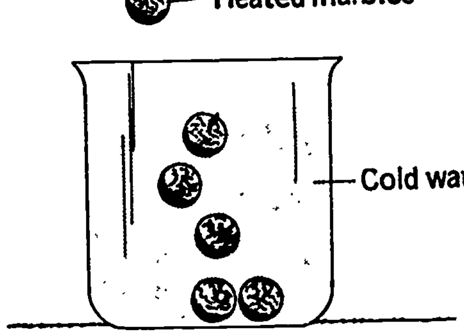
Frying pan
Clear glass marbles
Cold water
Hot plate

INTRODUCTION: Remind the children that they have seen how freezing water can break rocks. Ask them if they can think of other ways that rocks can break. One of the children may mention temperature changes. Some of the children may have gone on camping trips and used rocks to form a ring to contain their campfire. Ask them whether they have ever poured water on the fire and observed what *happened to some of the hot rocks. This Activity will help them to discover how changes in temperature can affect rocks.*

Ask some children to donate several clear glass marbles for this Activity. (Six marbles should be enough.) Have the children examine the marbles and observe how easily they can see through them. Have the children make certain there are no cracks in the marbles.

Have the children place five of the six marbles in a frying pan and heat the marbles over the hot plate for about five minutes. Allow the marbles to roll into a glass of cold water while they are still hot. After they have cooled, remove them and have the children examine them once more. How are they different? *(They now contain many cracks.)* Compare them with the unheated marble. *(The unheated marble is still clear.)* Why did the heated marbles crack? *(The sudden cooling cracked the marbles because of the sudden contraction of the glass. As glass gets hotter, it expands; as it cools, it contracts.)*





Relate this experiment to rocks that expand when heated by the sun and contract when the temperature drops at night. Describe how the sudden temperature change, especially noted in deserts, produces a cracking of the rocks. This is called weathering.

Learnings: (x). Marbles become cracked with sudden changes of temperature. (x,y) Rocks also become broken and fractured when exposed to sudden and extreme temperature changes. This type of physical weathering process occurs mainly in desert areas, which are known to have wide temperature variations.

ACTIVITY 24 (y)

MEASURING THE WATER CONTENT OF LOAMY SOIL

Purpose: To demonstrate one of the characteristics of loamy soils

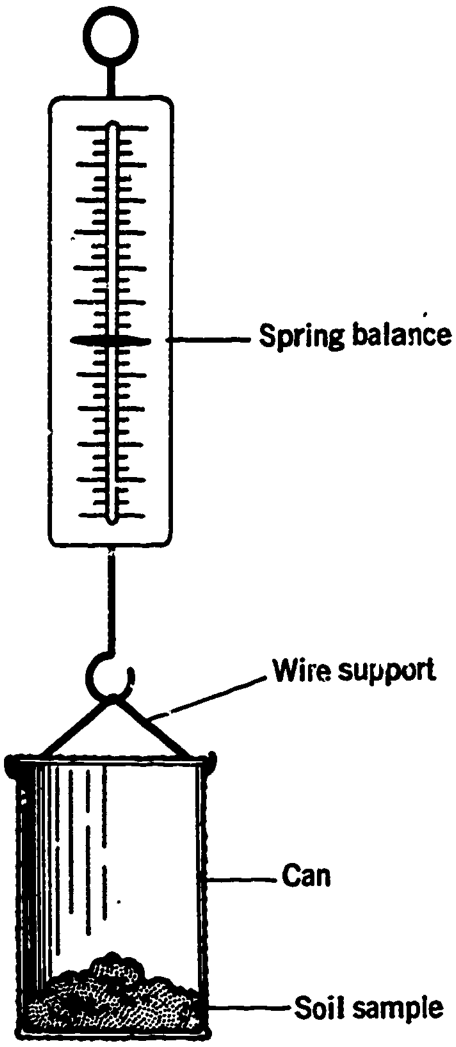
Concept to be developed: Loamy soils may contain large amounts of water.

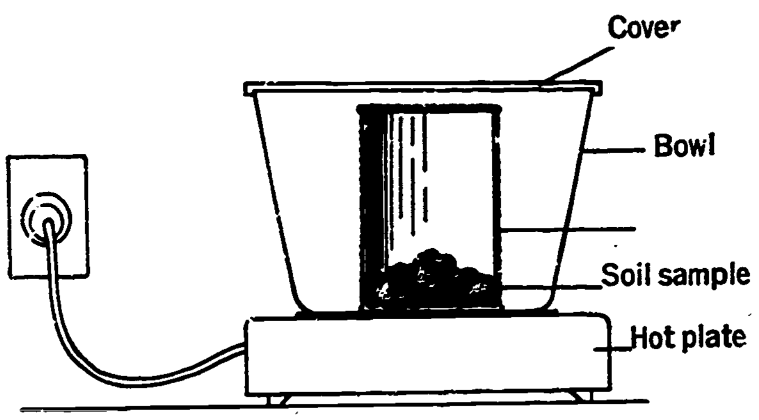
Materials needed:

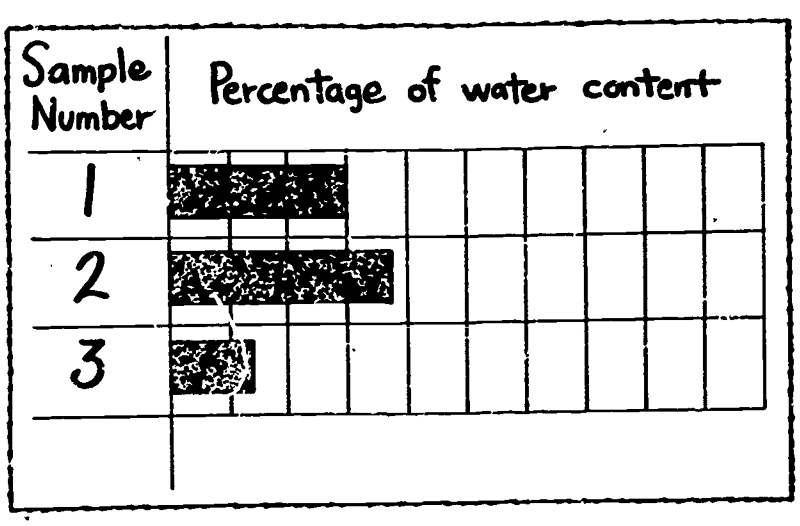
Spring balance
Tin can
Several 1-quart pans with covers
Oven or hot plate
Samples of different garden soils

INTRODUCTION: Discuss the kinds of soil children have observed in different places—color, size of particles, and other characteristics. Have several children bring to class a sample of black garden soil, about one cup of each sample. Have the class number the samples and examine each sample carefully. You may want to write the following questions on the blackboard to direct the children's examinations. Do the samples show differences in color? (One may be darker than the others.) *Do they feel the same?* (One may be heavier than the others.) *How else do the samples differ?* (They may vary in looseness of particles or in moisture content.)

After the children have made their observations, have them weigh and record the weights of each sample. They can punch two holes in a tin can and use the can as a soil holder. The can should be suspended from a spring balance by a wire bale. The children must be cautioned to be accurate in their weighing measurements. To obtain the weight of the soil, the weight of the empty container must be subtracted from the weight of the soil and container. After each sample has been weighed, have the children place each soil sample in a pan and keep it in an oven







at 350°F. for an hour. If no oven is available, they can improvise by placing a large loosely covered ceramic bowl on a hot plate. Place the soil sample in a pan. Cover the pan and put it in the bowl, cover the bowl, and allow the soil to heat for several hours.

How do you know that water escapes from the soil during this heating? *(The soil looks and feels dry after heating. Since water boils at 212°F. and the oven was set at 350°F., the water in the soil must have boiled away.)*

Have the children remove the dried soil sample, weigh the sample as before, and record the weight. Was there a loss in the amount of moisture in the sample? *(Yes.)* How much of a loss? *(It will vary for each sample.)* Perhaps your children might record their findings by making a graph, such as the one shown in the illustration, showing the percentage of moisture in the various samples. The percentage of moisture is equal to the weight loss divided by the weight before drying. What might make the differences in the water content in the various samples? *(Soil found near a surface or underground supply of water, soil that has been recently irrigated, and soil taken from a protected, shaded area that allows minimum evaporation will all have large water contents.)*

A more accurate measurement will be observed if the class has access to a balance scale. You probably can borrow one from the high school.

The children may want to heat the soil for a longer period to see if there is still further water loss.

Learning: (x) Loamy garden soil can hold considerable water.

ACTIVITY 25 (y)

MEASURING THE HUMUS CONTENT OF LOAMY SOIL

Purpose: To show that loamy soil contains a detectable amount of humus

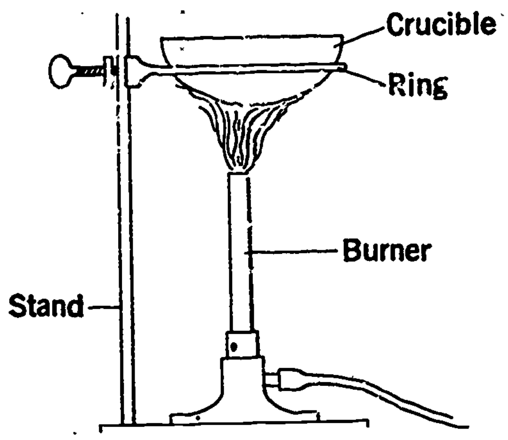
Concept to be developed: Humus is composed of decayed organic matter that burns when strongly heated.

Materials needed:

Bunsen burner or propane burner
Porcelain container or crucible
Garden soil
Spring balance or tray balance scale

INTRODUCTION: In the previous Activity, the children observed and measured the amount of *moisture in loamy soils. This Activity will give them an opportunity to observe and measure the amount of humus in loamy soils. It may be interesting for the children to collect samples of black garden soil from around the school. Number and dry the samples, as in Activity 24, or use the same dry samples that were prepared in Activity 24. Quarter-cup samples should be adequate.*

Have the children weigh the empty crucible or porcelain container. The children can weigh the crucible on a tray balance or a spring balance. Then have them place a dry sample in the container. These containers will not crack when placed over direct flame. Weigh the dry soil in the container on a tray or a spring balance. Subtract the weight of the empty container from the weight of the container and the soil. This gives the weight of the dry soil alone. It is important to get accurate readings and keep accurate records in all Activities involving measurements.



Apply heat to the samples, using a Bunsen burner or propane burner. (Most hardware stores sell propane burners.) The container may become red-hot as the organic material is burned up. Caution the children to be careful of the flame and the hot container.

Apply heat to the samples for at least fifteen minutes. Is there any change in the soil? *(Some particles may flame, some may smolder and give off smoke, and there may be a change to a gray coloration.)* Allow the container to cool. Have the children weigh and record the weight of each soil sample. Was there a loss of weight for each soil sample? *(Yes.)* How much? *(It varied for each sample.)* Why was there a weight loss? *(Humus is made up of decomposed organic matter. Organic matter contains carbon, which will burn if strongly heated and give off a gas as an end product. As the humus burned, the weight of the soil decreased.)* Why are there differences in the humus content in the various samples? *(Humus content varies, depending on closeness to trees, shrubs, and other plants, on the application of fertilizers, and on the amount of animal life near the location.)*

The children might like to make a graph, similar to the one made in the last Activity for percentage of water content, to show the percentage of humus in each soil sample.

Learnings: (x) Loamy garden soil contains a measurable amount of humus. (x,y,z) Humus is composed of decayed organic matter from living things. (x,y) Organic matter burns when strongly heated.

ACTIVITY 26 (y)

OBSERVING THE SAND IN LOAMY SOIL

Purpose: To show that loamy soil contains particles of sand

Concept to be developed: The sand particles in loamy soil may exhibit various physical properties.

Materials needed:

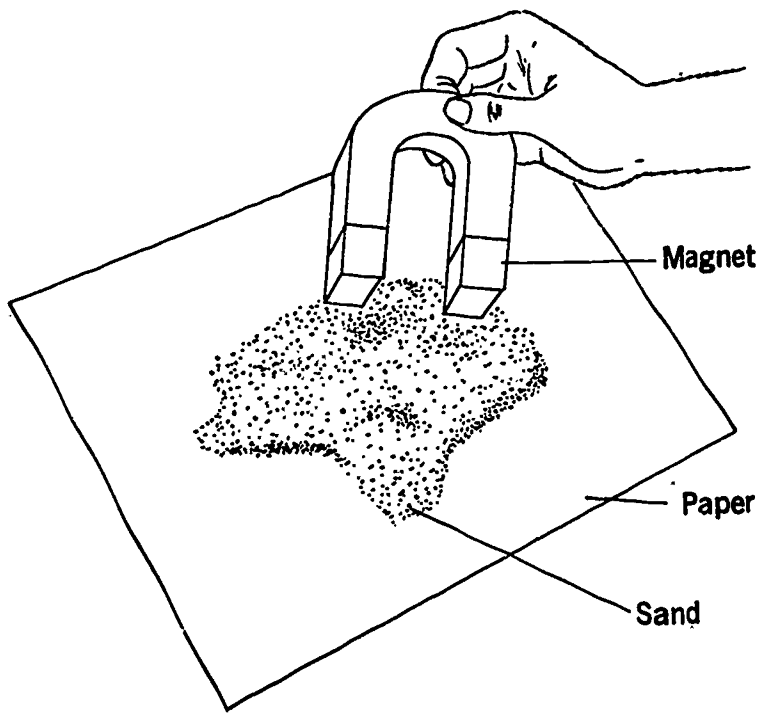
- Heated soil from Activity 25
- Sand
- Sandpaper
- Magnifying glass
- Microscope
- Samples of loamy soil
- Wire screen

INTRODUCTION: The children have already discovered the presence of moisture and humus in loamy soil. What else is to be found in it? The children may have observed that some of their samples of garden soil contained sand.

Have the children examine samples of sand. (Some of the best sand for this Activity is washed aquarium sand. It is made of larger particles and is easily procured in pet shops.) Point out that sand is made of small rock particles varying in size from 1/12 inch to 1/400 inch and that sand may be made of different minerals. (Remind the children that a mineral is a natural earth substance with a definite chemical composition.) Mention that the most common mineral making up sand is quartz. The children will remember observing quartz and noting some of its characteristics. Quartz is a compound of the elements silica and oxygen. Questions such as the following may be helpful to children as they examine their samples: Are sand grains the same shape? *(No, they have many shapes.)* Are the grains the same size? *(No, they vary in size.)* Have the children sift the sand grains through a fine wire screen. What does this tell about the size of the grains? *(Those that pass through are smaller than the size of the openings.)* What colors are observed among the sand grains? *(White, black, and red, among others.)* Why are there sand grains of different colors? *(Because of the different minerals found in sand.)*

Have a child pour about one tablespoonful of sand into a glass of water. What happens to the grains? *(They sink to the bottom.)* Is sand more dense or less dense than water? *(More dense.)*

Next tell the children that sand may have some properties related to the way light passes through it. These are called optical properties. Matter is said to be *transparent, translucent,* or *opaque.* These are terms the children should note and remember when making exact observations in this and other Activities. Point out that a transparent object is one through which light passes easily and which one can see through. (Window glass is an example.) A translucent object is one through which light passes, but which one cannot see through. (Frosted glass is an example.) An opaque object is one through which light does not pass and which one cannot see through. (Iron is an example.) Have a child place some sand grains on a printed page and examine the grains with a magnifying glass. What optical properties do they show? *(Many are translucent, most are opaque, some may be transparent.)*



Introduce the idea that some minerals have magnetic properties, or characteristics. For instance, some iron ores are attracted to a magnet, just as an iron nail is attracted. Have the children place a strong magnet on some sand particles and determine the number of particles out of a given sample of particles that are magnetic.

Some children may want to examine with a magnifying glass some of the particles found on sandpaper. How do these grains differ from the grains of sand from another source? *(The grains on sandpaper are probably much more uniform in size and color.)* How is this explained? *(Sandpaper is prepared by gluing only a certain size and kind of sand particles to a paper backing.)*

Have the children collect samples of loamy soil and some samples of heated soil from Activity 25 (in which they measured the humus content of loamy soil). They should examine these samples with a magnifying glass or microscope. What size, shape, and color do they have? Do they have any magnetic properties? Ask the children what they think made the differences in sand particles. How might they verify their assumptions or ideas?

Learning: (x,y,z) Loamy garden soil has sand particles in it that may exhibit various physical properties, such as optical and magnetic properties.

ACTIVITY 27 (x,y)

MEASURING THE DEPTH OF LOAMY SOIL

Purpose: To show that the depth of loamy soil varies from area to area

Concept to be developed: The amount of organic material (material that can decay into humus) supplied to an area will determine the depth of the loamy soil.

Materials needed:

Yardstick
Shovel or post-hole digger

INTRODUCTION: Take the children to an area near the school where they can examine the soil. Carefully dig up some of the soil. Lay it on a sheet of newspaper spread on the ground. You may want the children to work in small groups, each group examining a shovelful of soil. Ask the children what they think contributes to the humus of the soil in the location. Is there any evidence to support their hypothesis? (They should look for evidence of leaves, roots from grass plants, or perhaps insect bodies.)

Let the children find the depth of the surface soil by digging to the point where the dark humus soil ends and another soil type begins. The underlying soil type can be identified by color and texture (size, compactness, and composition of particles).

Why would the soil have a greater depth of loam in a forest than in the region of a sand dune? *(The forest area accumulates the leaves and other organic matter at a faster rate than the area near a sand dune.)*

Perhaps the class has other areas available for examination. If possible have them examine the soil in a prairie area. What does the prairie contribute to the richness of the soil? *(Decayed grass and roots.)* How deep is the prairie soil? Perhaps they might also examine the soil of a marshland. The class may want to prepare a chart showing the various depths of loamy soil found in various areas, such as garden soil, prairie soil, forest soil, and marshland.

Learnings: (x) Loamy soil varies in depth in different areas. (x,y) The amount of organic material supplied to the area will influence the depth of loam.

ACTIVITY 28 (y,z)

MAKING A SOIL PROFILE

Purpose: To introduce the idea of soil horizons

Concept to be developed: Soil horizons are layers of soil, each layer having a distinctly different compositon.

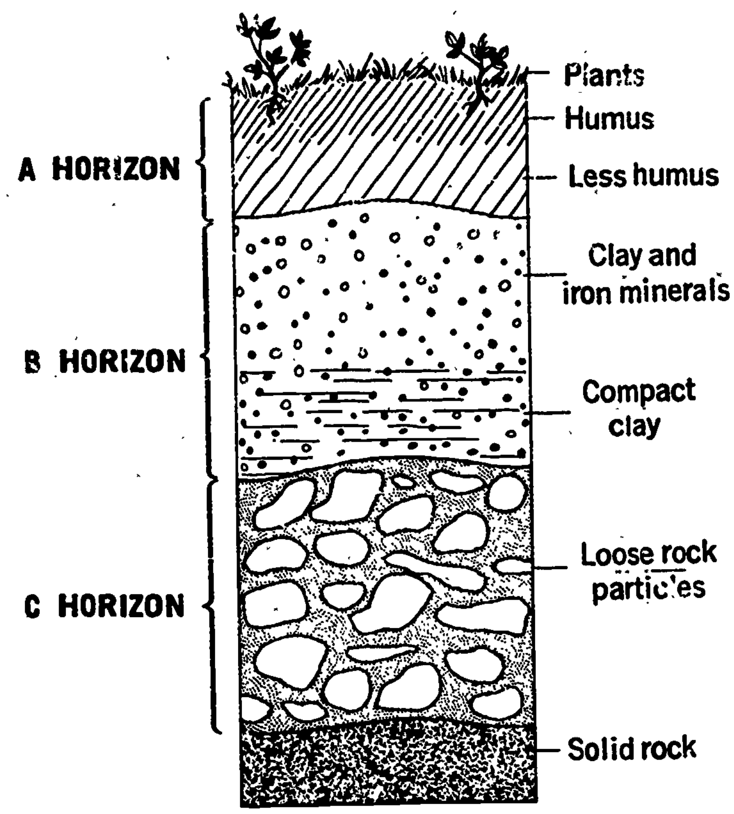
Materials needed:

Tall cylindrical jar
Shovel

INTRODUCTION: In measuring the depth of a loamy soil, the children have observed that a different type of soil was beneath the loamy soil. Point out that all soils are composed of different layers. The children can visit another area to see these layers of soil.

Have them dig a hole into some garden soil. As they dig downward, do they notice a change in the soil? *(They should.)* In what ways does the soil change? *(There is less humus. There is also more clay in most cases.)*

Introduce the idea that mature or well-developed soils have typical "profiles" or sequences of layers. Children may know that all soils have the same type of layering, but there is considerable variation within the layers. Explain that each layer, or "horizon" as it is called, is designated by a letter—*A*, *B*, or *C*. The *A* horizon is the topsoil and is usually rich in humus and organic material. The *B* horizon, or subsoil, is beneath the *A* horizon and frequently contains clay and iron minerals. It is less rich in organic material and humus. The bottom part of the *B* horizon may be quite hard and compact because of an accumulation of clay. The *C* horizon lies just above the hard rock and just below the *B* horizon. It consists of weathered rock particles. Have one of the children write these definitions on the chalkboard for the class to remember.



If there are any suitable road cuts or streams near your school, the children can observe an entire soil profile. Have some of the members of the class take samples from each portion of the profile that has a different type of soil. Place the samples in small labeled containers that indicate the location of the specimen, that is, which was the topmost specimen, which was the next beneath it, etc. To get a better understanding of the soil profile, the children can determine which is the *A* horizon, which is the *B* horizon, and which is the *C* horizon. Have them measure the depth of the horizons. Which is the largest? *(Usually the B horizon.)*

With the samples that the children have collected, they can make their own miniature soil profile. Have them place the different soils into the tall cylindrical jar with the *C* horizon on the bottom and ending with the upper part of the *A* horizon on the top. Adhesive tape or small gu.nmed labels can be used to identify the horizons in the jar.

Have the children observe the profile for any differences in the soil. Are there any color changes? Does texture change?

To illustrate that soils differ in different localities, have the children observe soil profiles in different areas. Have them compare colors. *(Some soils may be quite red and others black or gray.)* Is the depth of each horizon the same? *(No, some soils may have almost no* A *horizon and a very long* B *horizon. Others may have a greater* A *horizon.)*

Learnings: (y,z) Soils are described as having profiles, or typical layers designated as *A, B,* and *C* horizons. The *A* horizon is the topsoil, the *B* horizon the subsoil, and the *C* horizon the weathered rock material. (y,z) The horizons differ in size, color, and texture. (y,z) Soils in different localities have different profiles. Those in forests have a larger *A* horizon with more humus. The size and appearance of *B* horizons vary considerably. Some may be very red, others gray or ashy or blackish. The amount of clay in the *B* horizon is also variable. Some profiles may have a very compact layer of clay at the bottom of the *B* horizon.

ACTIVITY 29 (y,z)

COMPARING THE RATE OF PERMEABILITY OF SAND, LOAM, AND CLAY

Purpose: To compare the rates of permeability of sandy, loamy, and clay soils

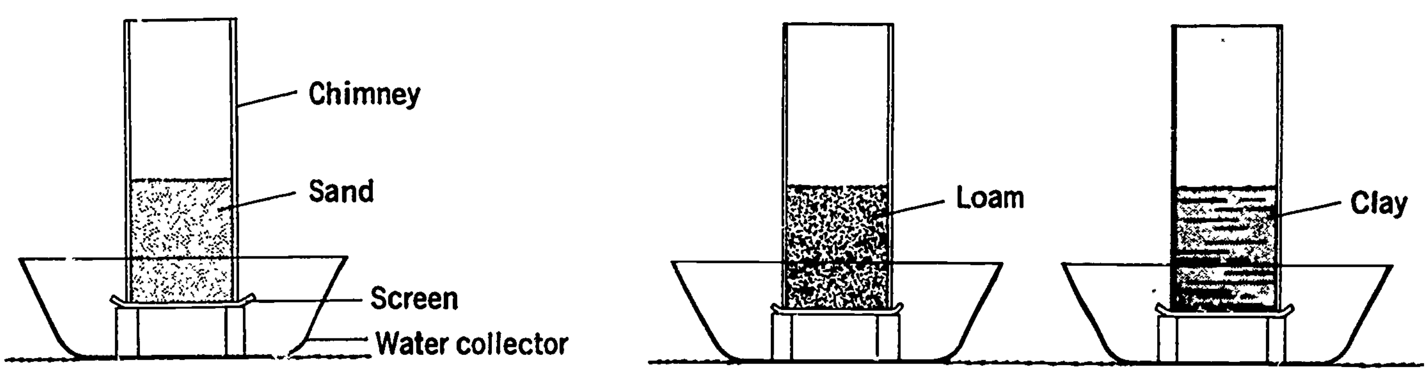
Concept to be developed: The rate of permeability of a soil is the rate at which a liquid will pass through it.

Materials needed:

- Samples of sandy, loamy, and clay soils
- 3 glass chimneys
- Fine mesh wire
- Measuring cup
- String
- Water

INTRODUCTION: The children have observed some of the characteristics of loamy soils, that is, soils containing considerable quantities of humus. Next they should discover that not all soils contain a large amount of humus. Some soils are largely sand, while others are largely clay. Pose the question: Will these soils behave differently and appear different? The following Activity will introduce the children to some of the characteristics of sandy and clay soils.

Tell the class that soils differ in the degree to which they will allow water to move through them. Mention that this characteristic of allowing water to pass through is called *permeability*. Have the children check the meaning of the verb *permeate* in the dictionary before they proceed. Then make the point that in this case permeability refers to the rate at which a liquid will pass through a substance. Have the children set up the Activity as follows: Attach a fine wire-mesh screen to the bottom of each glass chimney.



A string can be used to attach the bent screen to the chimney. Fill one chimney half full with sand, another half full with loam, and the third half full with clay. Pour one-half cup of water into each. Have the children observe what happens, using a stopwatch to determine the time it takes for the water to permeate the samples. They should keep a record for each sample. Which sample did the water pass through first? *(Probably the sand, then the loam, and last, the clay.)* Why did the sand have the greatest permeability? *(The grains did not hold back or absorb the water particles.)*

Which type of soil will have the least "holding effect" on rain water—sandy, loamy, or clay soil? *(Sandy soil, for water permeates the sand faster than the loam or clay.)* Why is forest soil generally moist? *(It has a greater amount of humus, which tends to hold the moisture.)*

Learning: (y,z) In comparing rates of permeability, sand is first in permeability, followed by loam, and then by clay.

ACTIVITY 30 (x,y,z)

COMPARING THE SIZE AND SHAPE OF CLAY PARTICLES AND SAND PARTICLES

Purpose: To show that clay particles are much smaller than sand particles

Concept to be developed: The primary difference between sandy and clay soils is the size of the soil particles.

Materials needed:

- Microscope or magnifying glass
- Fine wire-mesh strainer or hobby-shop ceramic strainer
- Clay samples
- Sand grains

INTRODUCTION: Give each child some sand and a sample of dry clay. (You can use dry clay powder, dry water-base clay, or clay from a road cutting.) Have each child rub some particles from the dry clay and compare the size of clay particles with the size of sand particles. Which are smaller? (Clay particles are much smaller.) *Have the children compare the ease with which clay particles and sand particles pass through a fine wire-mesh strainer.*

Have children examine the particles of clay and sand under a microscope of magnifying glass to compare their relative size and shape. Do the clay particles vary? *(Yes, both vary in shape and size.)*

Now have some members of the class slowly add water to the clay sample and observe the results. *(The clay takes up the water and becomes very gummy and compact.)* What happens when the children add water to a sample of sand? Is there a difference in behavior between the two samples? *(Yes, the water passes right through the sand, and the grains still remain separated.)* Which would be better for growing plants, sand or clay? *(Sand, because clay would form a hard compact mass through which the roots could not penetrate.)*

Learnings: (x) Clay particles are much smaller than sand particles. (x,y,z) Clay particles adsorb water and become compacted together. Some clays can be molded and are said to be plastic. (x,y) Sand would be better than clay for growing plants, since water passes through sand more easily, and the texture is loose enough to allow root growth.

ACTIVITY 31 (x)

TESTING SOILS FOR pH

Purpose: To show that soils vary in their degree of acidity or alkalinity

Concept to be developed: The pH of a soil indicates its degree of acidity or alkalinity: the lower the pH, the greater the acidity; the higher the pH, the greater the alkalinity.

Materials needed:

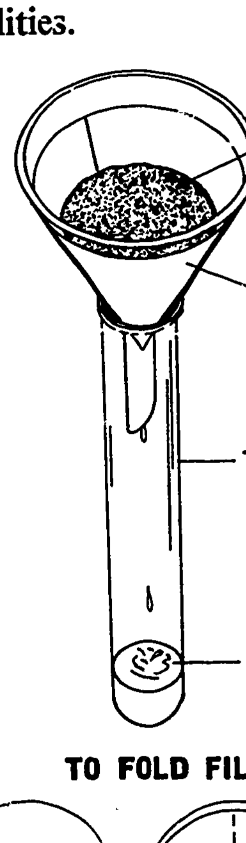
- Red and blue litmus paper or hydrion paper
- Water
- 6 different soil samples
- 7 test tubes
- Medicine dropper
- Filter paper
- Funnel

INTRODUCTION: Review with the children what they have learned: that besides differing in the sizes of their particles, soils differ in many other respects, including color, composition, and texture. An additional way in which soils differ is called pH, a term indicating the amount of acidity or alkalinity of a liquid. Acid substances, such as vinegar and lemon juice, have a low pH. Alkaline, or basic, substances, such as ammonia or baking soda, have a high pH. Explain to the children that pH can be determined by using an indicator such as litmus paper. Blue litmus paper, for example, turns red in the presence of an acid; red litmus paper turns blue in the presence of a base. Another pH indicator is hydrion paper, which has an indicating range of 1 to 11. A pH value of 7 indicates that the sample is neutral, that is, neither acidic nor alkaline. A value lower than 7 indicates an acid condition. A value higher *than 7 indicates an alkaline or basic condition. A color chart accompanying the paper indicates the pH through color comparisons. Hydrion paper is readily available through most chemical supply companies.*

Have the children select soil samples from various locations and place the samples in labeled test tubes—one level teaspoonful of soil in each test tube. Then have them add three medicine droppers of water to each test tube. Shake and allow each mixture to settle. (You may want the class to filter the mixture instead of allowing it to settle. If a filter paper is used, the test is made on the liquid that filters through the paper and not on the material remaining on the filter paper.)

Now have the children test the clear water with blue and red litmus paper or hydrion paper. Several children may want to prepare a chart to show the condition of the soil samples as acid, basic, or neutral. Some children may ask why some soils differ in the characteristic of acidity. *(Underlying rocks may make a difference. Fertilizers and decompositions of organic matter may also alter the pH condition.)*

Learnings: (x) The acidity or alkalinity of the soil can be determined by the use of certain indicators. (x) Soils will differ in acidity in different localities.



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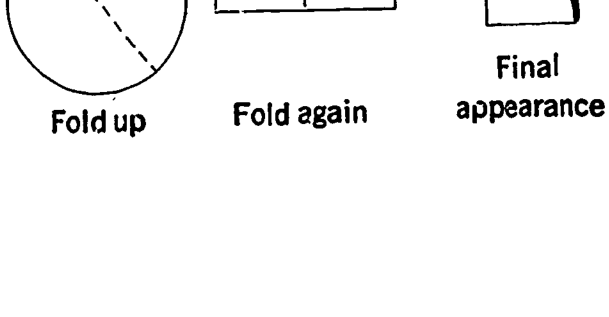


ACTIVITY 32 (x,y)

CHANGING THE pH OF A SOIL

Purpose: To show that the acidity of a soil can be artificially controlled

Concept to be developed: Acidic soils can be made alkaline by adding crushed limestone.

Materials needed:

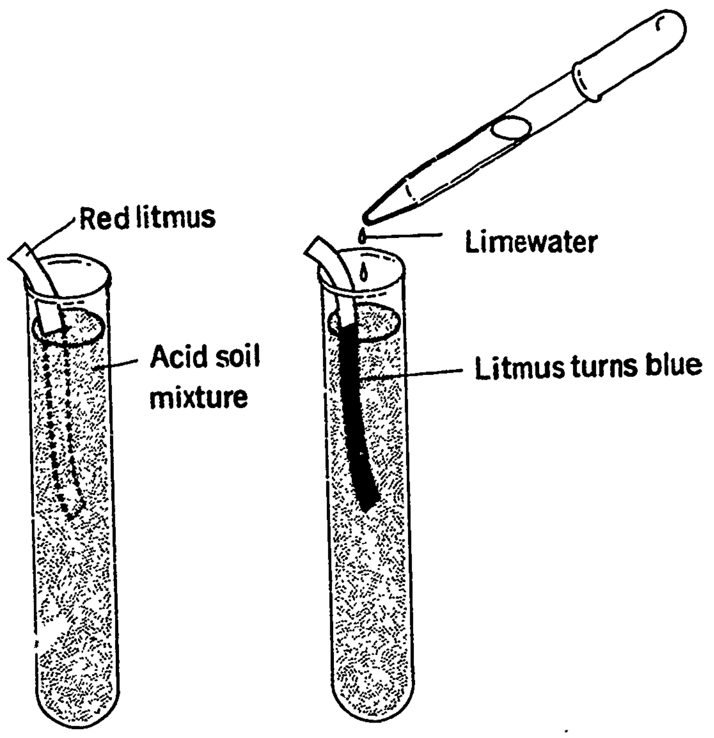
Acid soil sample
Test tubes
Water
Powdered limestone
Litmus or hydrion paper

INTRODUCTION: Discuss with the children the importance of changing the acidity of some soils. Some plants will grow better in a more basic soil. For this reason it may be desirable to change the pH of the soil. Suggest that it is possible to bring about such a change.

Have each of several groups of children select a sample of an acid soil. (One teaspoonful of soil is sufficient.) Have them place this sample in a test tube, add several medicine droppers of water, and shake. (Water must be added, for indicators do not react in a dry state.) Allow the soil to settle or filter the mixture through a filter paper. Then test the liquid with blue litmus or hydrion paper.

If blue litmus paper turns red, the soil is an acid soil. If the color of hydrion paper is of the range lower than pH 7, the soil is an acid soil.

Have the children secure some powdered limestone or crush some limestone rock with a hammer, being careful of flying chips. Have them place one teaspoonful of powdered limestone in a test tube, add two medicine droppers of water, and shake. Let the mixture settle and test the liquid with red litmus or hydrion paper. What does the test indicate? *(A basic, or alkaline, condition.)* Have the children collect about one teaspoonful of water from the acid soil mixture. Add to it some limestone water, one drop at a time, testing the solution with blue litmus or hydrion paper after each drop is added, until the acid condition changes. Record the number of drops it takes to produce a change for each of the soil samples. Why does it take more drops to produce a change in certain soil samples? *(The soil is more acid.)* How do you know when the acid condition changes? *(The color of the indicator—the litmus or hydrion paper— changes.)* Why do farmers add powdered limestone to their



soils? *(To change the soils from an acid to a basic condition.)* Why do they want the soils to change from an acid condition? *(Certain plants grow better in a nonacid soil. Clover may double its yield if it is grown in a soil that has been treated with limestone.)*

Learnings: (x) Acid soil can be made basic by adding crushed limestone. (x,y) Farmers frequently add lime to soil, since many plants grow better in a basic soil.

ACTIVITY 33 (y,z)

EXAMINING ANIMAL LIFE IN SOIL

Purpose: To show that many kinds of animal life exist in the soil

Concept to be developed: The activities of animals in the soil change the texture and the composition of the soil.

Materials needed:

Soil sample
Magnifying glass
Alcohol or Formalin solution
Preserving bottles

INTRODUCTION: Tell the children that besides being acidic or alkaline, the soil may have animal life of various kinds in it. Explain that the kind and amount of plant and animal life in soils varies in different soils. The important thing is that this life is often a factor that can change the makeup of the soil. In the following Activity the class will examine the kinds of life found in samples of soil.

Have the class examine the surface of a square yard of soil. Note any earthworm mounds, anthills, or other signs of animal activities. Carefully remove the surface plant life and examine the soil for further signs of animal life. You may want to preserve in an alcohol solution the forms of animal life found at different depths (on and beneath the surface). Snails, slugs, and earthworms can be preserved in a 6%–8% Formalin solution (obtainable from the high school or from a chemical supply house). Insects, spiders, and other jointed-leg animals can be preserved in an 85% alcohol solution (obtainable from a drugstore).

Present these questions to the children: How do earthworms enable more air to enter the soil? How do they turn over the soil? Does their eating soil particles change the composition of the soil? Do their droppings and dead bodies change the composition of the soil?

To get an idea of the great amount of soil earthworms bring up to the surface, the class can weigh the amount of soil found in an earthworm mound or the mound of a raised anthill. They should count the number of such mounds in a square yard and then try to estimate the weight of soil turned over in an acre.

Learning: (x) Many kinds of animals live in the soil. Their activities change the texture and composition of the soil. Earthworms, for example, are important in keeping the soil texture loose and in adding a certain amount of organic material to the soil.

ACTIVITY 34 (x)

EXAMINING PLANT LIFE IN SOILS

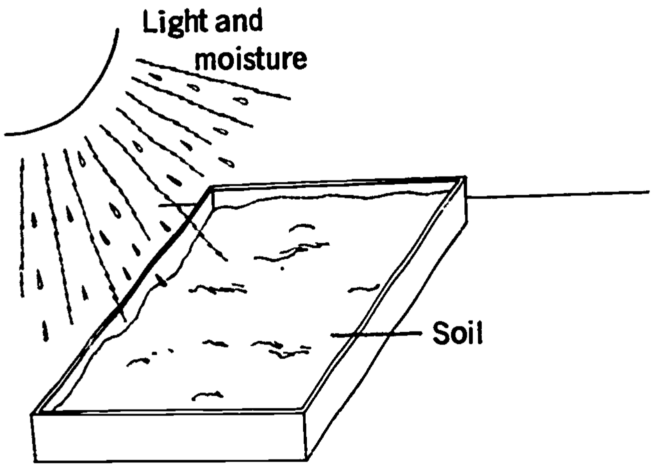
Purpose: To demonstrate that soils contain large amounts of dormant plant life

Concept to be developed: The dormant plant life in soils can be activated under the proper conditions.

Materials needed:

Topsoil
Bean seeds
Water
Water glass

INTRODUCTION: Tell the children that animal life is not the only type of life that can be found in soils. Suggest that they investigate the soil for the presence of any plant life. Have members of the class take samples of topsoil during the dormant winter period. They should provide the samples with moisture, warmth (room temperature), and sunlight and observe the kind and amount of plant growth that appears.



Have a group of children collect soil samples from dry areas in vacant lots or along roadsides. Give these samples warmth, moisture, and light and note any germination. Why did this growth not take place before? *(Favorable conditions for growth were not present.)* Which factors were probably the most important? *(Moisture and temperature.)*

Have the children soak bean seeds in water for 24 hours and then place the bean seeds in a glass filled with soil, so that the seeds are visible. What is the growth that often forms around the seeds? *(It is a fungus, which is a mold.)* What is the source of the fungus? *(Spores dormant in the soil.)*

Learning: (x,y) Soils contain much plant life that does not appear until the conditions are favorable for its growth.

Summing Up Ideas: The Activities in this section were designed to extend the children's experiences with soils. The children should have learned that there are three types of soils: loamy soils, sandy soils, and clay soils. Loamy soils have a high humus content and retain a great deal of moisture. The primary difference between sandy soils and clay soils is the size of their particles; the particles that make up sandy soils are much larger than those that make up clay soils. The children should also have learned that the acidity and alkalinity of soils may vary, and that pH is a measure of the acidity and alkalinity. In addition, the children should have become aware of the large amount of animal and plant life present in soils.

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary, and intermediate grade children, the ideas with the most meaning and application are these:

- Minerals can be identified by certain characteristics.
- The external color and the color of the streak left by a mineral may not be the same.
- The luster of a mineral is the way it reflects light.
- Cleavage is the tendency for some minerals to break in smooth, parallel planes.
- Minerals that do not exhibit cleavage exhibit fracture.
- The hardness of a mineral is always constant for the same mineral and thus is a good means of identification.
- The specific gravity of a mineral is a relatively constant characteristic.
- Minerals that contain carbonates will effervesce when treated with dilute hydrochloric acid.
- Crystals form in nature by the slow evaporation of liquids that contain dissolved salts.
- A rock is any natural material that makes up part of the Earth's crust.
- Very-fined-grained rocks cool rapidly; coarse-grained rocks cool slowly.
- Soils are produced by the weathering of rocks.
- Loamy garden soil is a soil type that can hold a large amount of water.
- Loamy garden soil contains a measurable amount of humus.
- Sandy soils are better for root growth than are clay soils.
- The acidity or alkalinity of the soil can be determined by certain indicators.

In addition to these ideas, in the intermediate and upper grades the children should be led to develop concepts that are more complex and more quantitative:

- Cleavage can be in one, two, or three directions, depending on the mineral.
- Fracture is the description of the broken surface of a mineral that has no cleavage.
- The hardness of minerals is usually indicated by a number from 1 to 10, with No. 1 the softest and No. 10 the hardest.
- Specific gravity is the weight of a substance divided by its loss of weight in water.
- Sedimentary rocks are rocks having grains pressed together by overlying beds and then cemented together.
- Metamorphism is a process in which rocks become changed by heat and pressure; this change alters their appearance and makes them harder and more compact.
- Humus is composed of decayed organic matter from living things.
- Sandy soil is more permeable than loamy soil, which is more permeable than clay soil.
- pH is a measurement of acidity; the lower the pH, the greater the acidity.

3

INVESTIGATING THE HYDROSPHERE

The second sphere or layer of the Earth is the hydrosphere, or water layer. Water is vital in man's life. It is almost everywhere. It is in the food he eats and the air he breathes. In addition, it is a major part of him as well as of other living things. It is used to carry waste materials from homes and factories, to water lawns, to wash cars, and to aid the growth of the plants and animals that people use for food. It produces power to turn generators, which make electricity. Water is necessary for all living things.

Children have many experiences with water, one of the most abundant substances on the Earth. They know something about its nature when they drink it, bathe in it, play in it, and swim in it. They may ask such questions as these: "Is there really water in all our foods?" "Where does the water in rivers and lakes come from?" "How does water get into wells?" "Why does it take longer to boil potatoes if you are on a mountain than if you are at sea level?" "What is 'hard' water?" "Why does water soak into some materials and not into others?"

The following Activities suggest methods of investigation. It is hoped that the children will have a chance to try ideas of their own.

WHERE IS WATER FOUND?

Water is found in rivers, lakes, ponds, and oceans. It is also present in soils, rocks, and living things. Water is present in air and can form clouds, from which it can return to the Earth as rain and snow. The Activities in this section might best be introduced by a discussion of the topic: How much of our Earth really is water?

ACTIVITY 35 (x)

COMPARING THE AMOUNT OF THE EARTH'S WATER AND LAND SURFACE

Purpose: To show that the largest part of the Earth's surface is covered by water

Concept to be developed: Water covers about 71% of the Earth's surface.

Materials needed:

Globe of the Earth

INTRODUCTION: How much water is there on the Earth's surface? Which covers a greater area, land or sea? These are two questions you might write on the blackboard and ask children to answer. Then place the globe on a table in front of the children and have them observe the different colors on the globe.

What color represents the water? *(Usually the color is blue.)* What color represents land? *(Usually colors other than blue or white.)* If there is an area shown in white, what does it represent? *(Snow and ice.)* Where do you find the ice covering? *(At the North and South poles.)* Which color covers a greater area of the globe? *(The blue.)* Is there more water, land, or ice covering our Earth? *(Water.)* Ask the children to estimate what percentage of the Earth's surface is covered by water. *(About 71%.)* Let them suggest ways to measure the area covered by the water.

Learning: (x) Water covers the greatest part of the Earth's surface. About 71% is water.

ACTIVITY 36 (x,y)

DETERMINING IF WATER IS IN THE FOOD WE EAT

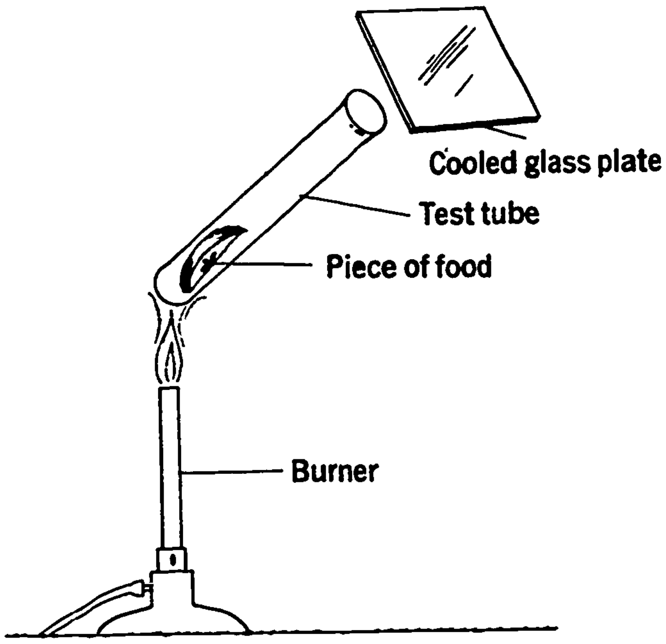
Purpose: To show that water is found in most of the foods we eat

Concept to be developed: The drying of foods is accompanied by shrinkage and by loss of weight.

Materials needed:

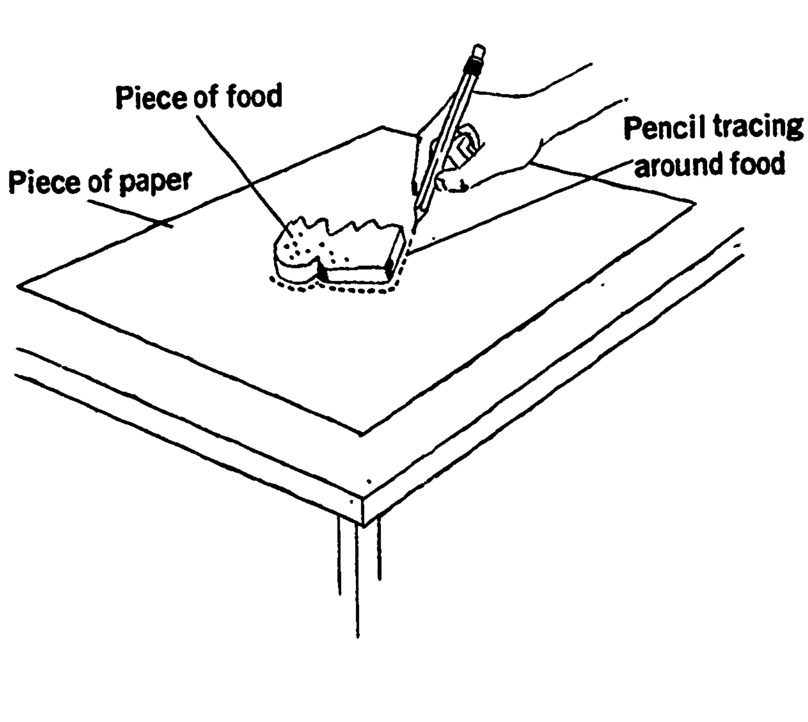
Apples
Potatoes
Lettuce
Bread
Crackers
Hot plate
Test tube
Glass plate

INTRODUCTION: Have the children talk about where they think water may be found. You might make a list of their ideas and chart them. From time to time, the children may want to add to the chart as they get other ideas. Some children may suggest that the food we eat contains water. Encourage them to give the reasons for their thinking. Then suggest that there is a way to test their ideas. Ask them to bring small quantities of various kinds of foods to school for testing.



Along with the foods they bring you might want to have samples of the foods listed above. The names of the foods might be listed on the blackboard. Let children give their ideas about how to detect the presence of water in different foods. It may be suggested that a piece of the food be placed in a test tube and heated slowly. When a cool, square piece of glass is placed over the mouth of the test tube, the children will see droplets of water forming on its under surface. The amount of water present on the glass depends upon the amount of water present in the food. It may be necessary to use a cool glass for each trial, so that the water vapor will condense into water droplets.

Some foods have very little moisture in them (dried beans and rice, for example) and will show little, if any, moisture on the glass surface. How does the food differ in appearance after being heated? *(It feels harder, or it may become dry and powdery.)* Why? *(The moisture has been driven out by the heat.)* Were there any other changes? *(Yes, a change in weight and possible shrinkage from water loss.)*



For another test the children can place pieces of food on a piece of paper, trace around the food, and place the paper and food in a warm place. After a day or so, they will observe that the food is shrinking from loss of moisture. Have them weigh the food before and after beginning this part of the Activity to see if there is a difference in weight.

The children can also make a display of dehydrated foods. They may want to add water to some of these foods to see what happens.

Learnings: (x) Water is found in most of the food we eat. Foods such as raisins, dried apricots, beans, and dried milk have had most of the water removed. (x,y) The drying of foods is accompanied by shrinkage and a loss of weight.

ACTIVITY 37 (x)

SHOWING THAT THERE IS MOISTURE IN A PERSON'S BREATH

Purpose: To show that water vapor is present in the air that people exhale

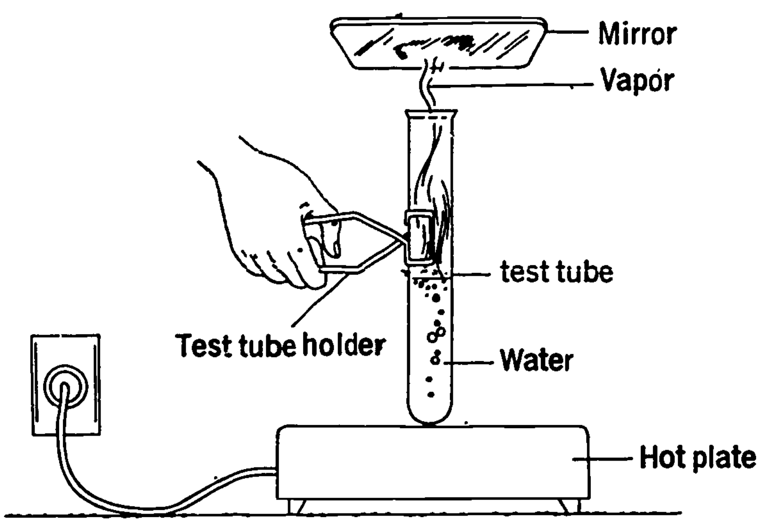
Concept to be developed: In cold weather the water vapor in the air can be detected when it condenses to form droplets of water.

Materials needed:

Mirror
Test tube and test-tube holder
Water
Hot plate
2-hole cork
2 glass tubes
Calcium chloride
Glass tubing

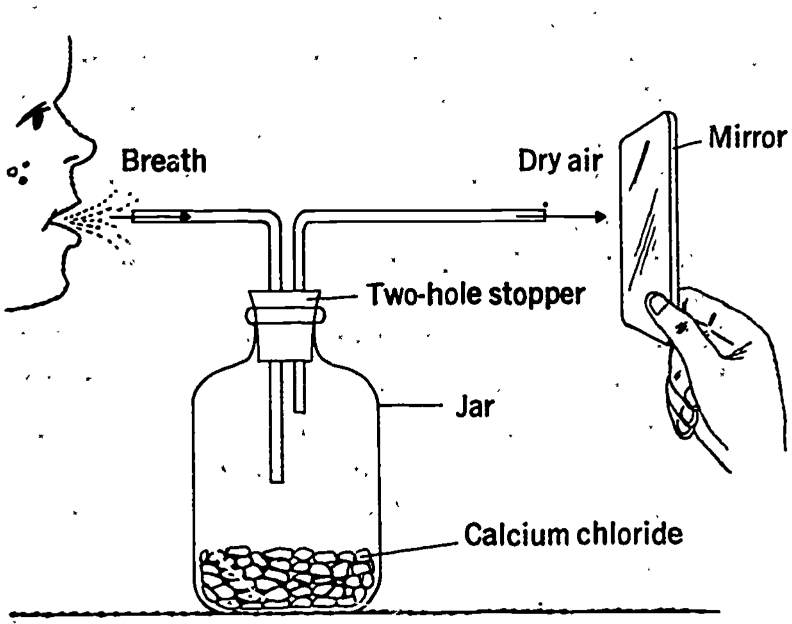
INTRODUCTION: Most children have "seen their breath" on a cold day. Encourage them to describe this and similar experiences. Perhaps some will relate how sometimes their breath changes to frost that they can see on their coat collars or scarves. This Activity will help the children to find out if, besides being present in foods, water exists in a person's breath.

Have one of the children fill a test tube half full of water. Using a test-tube holder, heat the tube over a hot plate. Point the open end of the tube toward a mirror about an inch away. What happens? *(The mirror becomes clouded.)* What causes this change? *(Moisture adheres to the surface of the mirror.)*



Dry the mirror and have a child hold it close to his mouth and blow on it. What effect is observed? *(The mirror again becomes clouded.)* What causes this change? *(Moisture from the child's breath adheres to the mirror.)* Suggest that there is a way to remove the moisture from the breath before breathing against the mirror. Encourage theories about this and then point out that it can be done by blowing through a right-angle tube into a jar of a chemical called calcium chloride. Set up the jar as illustrated, with another right-angle glass tube through which the dried air can be forced. Ask the children why the air coming from this jar does not cloud the mirror. What has the chemical done? *(The calcium chloride acted as a drying agent and removed the water vapor.)*

The children may comment further on the "appearance" of breath. What happens in very cold weather? *(A "cloudiness" can be seen when a person exhales, or breathes out.)* Why? *(The water vapor in his breath condenses to form tiny droplets of water and forms a small cloud.)*



Learnings: (x) Water vapor is present in the air that people exhale. It is this moisture that clouds glass. (x,y) In cold weather this water vapor in the breath can be seen as it condenses to form droplets of water.

Summing Up Ideas: In this section the children were introduced to the idea that water can be found in many places and in many things. They learned that water covered about 71% of the Earth's surface. They also learned that many foods contain water. In addition, they learned that there is water in people's breath and that this can be seen under certain conditions.

WHAT ARE SOME OF THE CHARACTERISTICS OF WATER?

Water is a chemical compound composed of the elements hydrogen and oxygen. All compounds have definite physical properties that can be examined, such as boiling point, freezing point, and color. The following Activities will introduce the children to some of the important characteristics of water.

ACTIVITY 38 (x)

COMPARING THE FLOW OF WATER WITH THE FLOW OF OTHER LIQUIDS

Purpose: To show that water flows quite easily

Concept to be developed: All fluids have a property called viscosity, a resistance to flow. The viscosity of water is very low, so water flows quite easily.

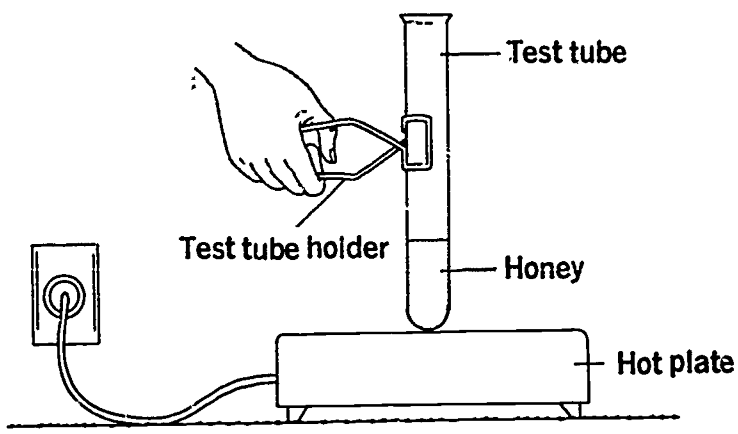
Materials needed:

Water
Cane or maple syrup
Honey
4 test tubes with corks
Test-tube holder
Hot plate

INTRODUCTION: The children have learned that water is present in many unexpected places, such as in foods and in people. Now they should be ready to discover some of the characteristics of water, in order to understand its importance to the Earth.

Have some of the children fill one test tube half full of water, another half full of cane or maple syrup, and the third test tube half full of honey. Place a tight-fitting cork in each tube.

Ask the children to turn each test tube upside down and to observe what happens to each



liquid. *(Each liquid moves to the other half of the test tube.)* How did the liquids get to the other end? *(They flowed to the other end of the tube.)* Did each liquid flow at the same speed? *(No.)* Which liquid flowed to the other half of the tube most rapidly? *(The water.)* Which liquid flowed to the other half of the tube least rapidly? *(The honey.)* After the children have made their observations, develop the meaning of the word *viscosity*.

Have a child place more honey in another test tube, filling it about half full. Have the child use a test-tube holder and heat the honey over a hot plate. *Caution:* Be sure the test tube does not touch the hot plate. After the honey has been warmed, have the child place a cork in the test tube and turn the test tube upside down. Ask the children to compare the rate of flow of this honey with that of the honey that was not warmed. What does heating do to the honey? *(Heating makes it less viscous.)* Ask the children if they have ever heard the expression "as slow as molasses in January." Is it appropriate?

Let the children speculate whether heating water will make it less viscous. How could they test this?

Point out that the ability of water to flow is very important, as this accounts for the formation of streams and rivers and enables man to direct the passage of water to places of better use. Have the children guess what the world might be like if water were as "thick" as honey.

Learnings: (x) Water has the ability to flow. (y,z) Some liquids flow with difficulty and are called viscous. Molasses and honey are examples of these. (y,z) Heat can cause honey to lose some of its viscosity.

ACTIVITY 39 (x,y)

WEIGHING WATER

Purpose: To determine the density of water

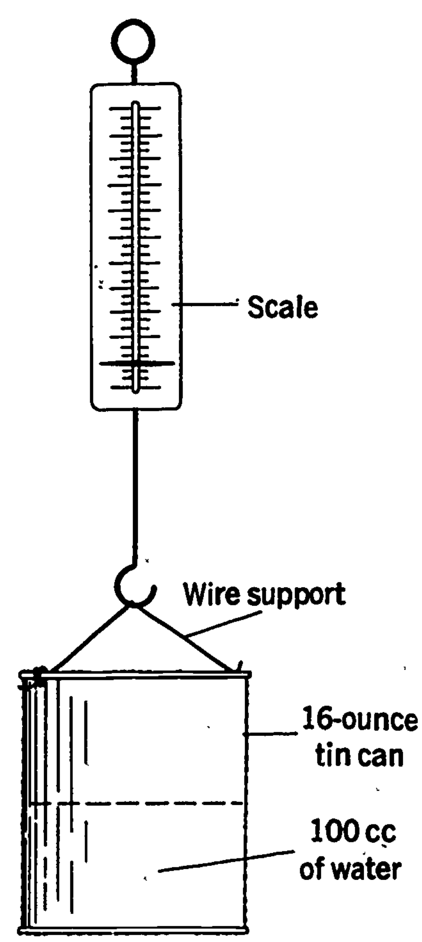
Concept to be developed: The density of water can be expressed as 1 gram per cubic centimeter, or 62.4 pounds per cubic foot.

Materials needed:

- Spring balance, calibrated in grams
- Tin can, 16-ounce capacity
- Water
- Wire
- Graduated cylinder, calibrated in cubic centimeters (cc)

INTRODUCTION: The children have observed one of the characteristics of water—its ability to flow. They can now investigate another of its characteristics—its density. This Activity will show them how they can determine the density of water.

Have one of the children punch two holes in the tin can and suspend it by a wire from the spring scale. Weigh the can and the wire and record the weight. Have another child accurately measure out 100 cc of water in the graduated cylinder and pour the water into the can. Have a child weigh the can of water and record the weight. The children will observe that the weight of the water is equal to the difference between



the second weight recorded (water + can + wire) and the first weight recorded (can + wire). For example,

Weight of can, wire, and water	=	150 grams
Weight of can and wire	=	50 grams
Weight of 100 cc of water	=	100 grams

Have the class estimate the weight of 200 cc of water. *(200 grams.)* What is the weight of 1 cc? Have the children measure out 1 cc of water and determine the weight. *(Each cubic centimeter weighs 1 gram.)*

Remind the children that density is weight per unit volume. Then ask them, What is the density of water? *(One gram per cubic centimeter.)*

Some of the children may wish to work out mathematically the density of water in pounds per cubic foot. To do this, they will have to know the following relationships:

1 cubic foot = 28,322 cubic centimeters

1 pound = 453. 59 grams

Knowing these two relationships, the children should proceed in the following manner. If 1 cubic foot of water is equal to 28,322 cubic centimeters of water, and 1 cubic centimeter weighs 1 gram, then 1 cubic foot of water will weigh 28,322 grams. Since 1 pound is equal to 453.59 grams, then the weight of 1 cubic foot of water (in pounds) will be equal to 28,322 divided by 453.59, or 62.4 pounds. Therefore, the density of water can also be expressed as 62.4 pounds per cubic foot.

Learning: (y,z) The density of water can be expressed as either 1 gram per cubic centimeter or 62.4 pounds per cubic foot.

ACTIVITY 40 (y,z)

COMPARING THE DENSITY OF WATER WITH THAT OF OTHER LIQUIDS

Purpose: To show that the density of different liquids varies

Concept to be developed: The ratio of the density of a substance to the density of water is called its specific gravity.

Materials needed:

Graduated cylinder, calibrated in cubic centimeters
Tin cans, 16-ounce capacity
Spring balance, calibrated in grams
Glycerine
Wire
Alcohol
Other liquids
Olive jar

INTRODUCTION: Now that the children have determined the density of water, they can determine the density of the other liquids and compare these with water. In preparation for this Activity help the children make a string or wire support to hold an olive jar. Weigh the jar and support. Fill the olive jar about three-quarters full of water. Stick a paper pointer on the jar to indicate the exact water height. Weigh the jar and water in grams. Empty the water into a graduated cylinder and measure the amount of water. Subtract the weight of the jar and support from its weight with the water. The weight in grams should equal the number of cubic centimeters.

Have the children measure 100 cc of glycerine into a tin can in the same manner as they did the water in the preceding Activity. Then let them determine the weight of the glycerine as they did that of water. What is the weight of 100 cc of glycerine? *(126 grams.)* What is the density of glycerine? *(1.26 grams per cubic centimeter.)* Have the children repeat the Activity, using alcohol in place of the glycerine. What is the weight of 100 cc of alcohol? *(80 grams.)* What is the density of alcohol? *(0.8 grams per cubic centimeter.)* Which is more dense, glycerine or water? *(Glycerine.)* Which is more dense, alcohol or water? *(Water.)*

The children may wish to find the density of some other liqiuds. The following list gives the density, in grams per cubic centimeter, of some common liquids.

Liquid	Density (in grams per cc)
benzene	0.90
gasoline	0.67
kerosene	0.82
milk	1.03
castor oil	0.97
linseed oil	0.94
olive oil	0.92
vinegar	1.05

Once the children have seen how the densities of some other liquids compare with the density of water, they may be interested in learning the relationship between density and specific gravity.

Next have the children dry the glass ar fill it to the mark with glycerine. How mu .. glycerine is this? *(The same as the measured volume of water.)* Weigh the glycerine and the jar. What is the weight of the glycerine? *(Subtract the weight of jar from weight of glycerine and jar.)* Divide the weight of the glycerine by the weight of an equal amount of water. This gives the comparative weight of glycerine to water, or the *specific gravity* of glycerine. (The children should note that the specific gravity is equal to the density if the density is measured in grams per cubic centimeter.) Have the children repeat the procedure to find the specific gravity of other liquids, such as alcohol.

Learnings: (y) The density of liquids varies. (y) Water is used as a standard to compare the densities of other substances. This comparison is the specific gravity of a substance. Specific gravity is equal to the weight of a substance divided by the weight of an equal volume of water. (y,z) A substance with a specific gravity greater than 1 is more dense than water. The greater the specific gravity, the denser the substance.

ACTIVITY 41 (y,z)

DETERMINING THE BOILING POINT OF WATER

Purpose: To show that the boiling point of water is 100° Centigrade (212° Fahrenheit) at sea level

Concept to be developed: The boiling point of a substance is the temperature at which it changes from the liquid state to the gaseous state.

Materials needed:

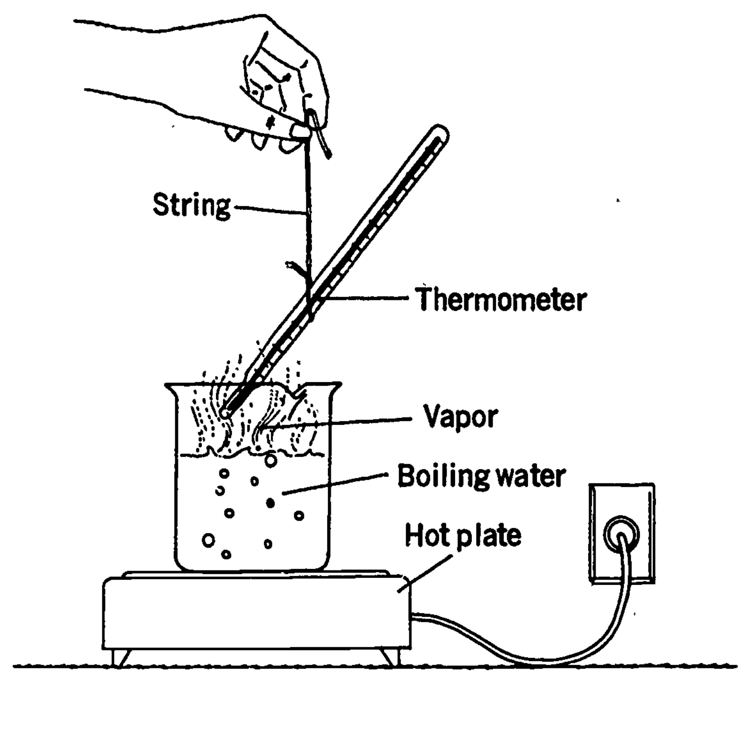
Thermometer registering over 100° Centigrade or 212° Fahrenheit
Beaker of water
Hot plate

INTRODUCTION: Discuss with the children that most substances exist in three states—solid, liquid, and gaseous. Ask them whether they know how substances might be changed from one state to another. Some may know that it is possible to change a substance from one state to another by changing the temperature. For example, water, a liquid, can be changed to a solid (ice) by freezing; or water can be changed to the gaseous state by heating. The point at which a liquid changes to a gas is called the boiling point. The children will discover what the boiling point of water is in the following Activity.*

* For a further discussion of the three states of matter, see *Atoms and Molecules,* by Seymour Trieger (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

Water boils at 212°F. or 100°C. when the air pressure is 14.7 pounds per square inch. This is the average pressure at sea level: a column of air above a square inch of surface at sea level weighs 14.7 pounds. As the air pressure is reduced, water boils at a lower temperature. Water boils at 90°C. when the pressure is 10.16 pounds per square inch and at 115°C. when the pressure is 24.55 pounds per square inch. In a pressure cooker the increased pressure raises the boiling point of the water.

In this Activity, the children can determine the boiling point of water for their location. Have the children place some water in a beaker and boil it on a hot plate. Suspend a laboratory thermometer in the vapor, just above the boiling water. (A laboratory thermometer has the scale etched on the glass and has a range of over 100°C.) Have the children read and record the temperature. Why is the figure probably slightly under 100°C.? *(Because the air pressure is probably less than that at sea level—14.7 pounds per square inch.)* Would the temperature of boiling water be higher or lower than 100°C. on a mountain? *(Lower than 100°C.)* Would it take a longer or shorter time to cook potatoes on a mountain? *(Longer.)* Why? *(The water would not become as hot before it boiled at the higher altitude.)* What is the principle of a pressure cooker? *(It allows the water to become hotter before it begins to boil and thus cooks things more rapidly.)*



Learnings: (y) The boiling point of a substance is the temperature at which the liquid state changes to the gaseous state. (y,z) The boiling point of water at sea level is 100°C. This boiling point will vary depending upon the pressure exerted above the water's surface. At high altitudes the air pressure is lower and the boiling point is correspondingly lower.

ACTIVITY 42 (x,y)

RAISING THE BOILING POINT OF WATER

Purpose: To show how the boiling point of water can be raised

Concept to be developed: When table salt is dissolved in water, the boiling point of the water is raised.

Materials needed:

Table salt
Beaker of water
Hot plate
Graduated cylinder
Laboratory thermometer registering over 100°C.

INTRODUCTION: In the preceding Activity, the class determined that the boiling point of water was about 100°C. but varied with the pressure exerted upon it. Mention to them now that another factor affecting the boiling point is the material dissolved in the water. Tell the children that in this Activity they will determine the boiling point of water that has table salt dissolved in it. Ask them whether they think the addition of salt will make a difference and have them give their reasons.

Have a child pour 100 cc of water in a beaker. Then have him put the beaker over a hot plate and boil the water. Have the child read and record the temperature of the vapor just above the boiling water.

Next have one of the children add enough table salt to the hot water to make a supersaturated salt solution (a solution in which no more salt will dissolve.) Then have him boil the solution. Have the child read and record the temperature at which the water now boils. Compare the two temperature readings. Why does the water now boil at a higher temperature? *(Table salt is dissolved in the water.)* Explain that chemists use this principle of determining the raised boiling point of water to determine how much salt is dissolved in a given quantity of water.

Learnings: (x) When table salt is dissolved in water, the boiling point is raised.

ACTIVITY 43 (y,z)

LOWERING THE BOILING POINT OF WATER

Purpose: To show that the temperature at which water will boil can be lowered

Concept to be developed: Reducing the air pressure above the surface of the water will cause it to boil at a lower temperature.

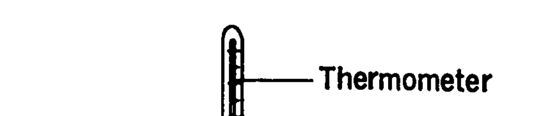
Materials needed:

Pyrex flask with a 1-hole rubber stopper
Water
Towel
Hot plate
Laboratory thermometer

INTRODUCTION: Discuss with the class that they have determined the boiling point of water to be 100°C. at normal atmospheric pressure of 14.7 pounds per square inch. Point out that there are several ways used to reduce this weight of air, thereby enabling water to boil or to turn to a gas at a lower temperature. Encourage them to give their ideas. Suggest that one way is to go to a higher elevation. Another way is to withdraw some of the air from above the water.

The children can reduce the pressure of 14.7 pounds per square inch above the water in the following way. Have some children pour water into the flask, about one-quarter full. Then have them boil the water on a hot plate. Place a thermometer in the vapor just above the boiling water. Have the children read and record the boiling point of water.

Next have them carefully push a moistened thermometer through the one-hole stopper. (Moistened glassware can be pushed through rubber more easily.) The thermometer should be pushed far enough through to reach the point just above the surface of the boiling water. Carefully remove the flask from the hot plate. What



happens? *(The water stops boiling.)* Why? *(There is no longer enough heat at that pressure to cause it to boil.)* Have the children place the cork and thermometer into the mouth of the flask. Then have them place a towel that has been soaked in cold water around the sides of the flask. What happens? *(The water begins to boil.)* Why? *(The water vapor inside the flask condensed to water again, creating a lower pressure above the water. With the lessened pressure the water will boil at the lower temperature.)*

You may be able to borrow a vacuum pump from the high school. By pumping air out of a flask containing hot water, the children may be able to reduce the air pressure enough to cause the water to boil.

Learning: (y) Reduced air pressure over the surface of water will lower the boiling point.

ACTIVITY 44 (y,z)

DETERMINING THE FREEZING POINT OF WATER

Purpose: To show that the freezing point of water is 0° Centigrade (32° Fahrenheit) at sea level

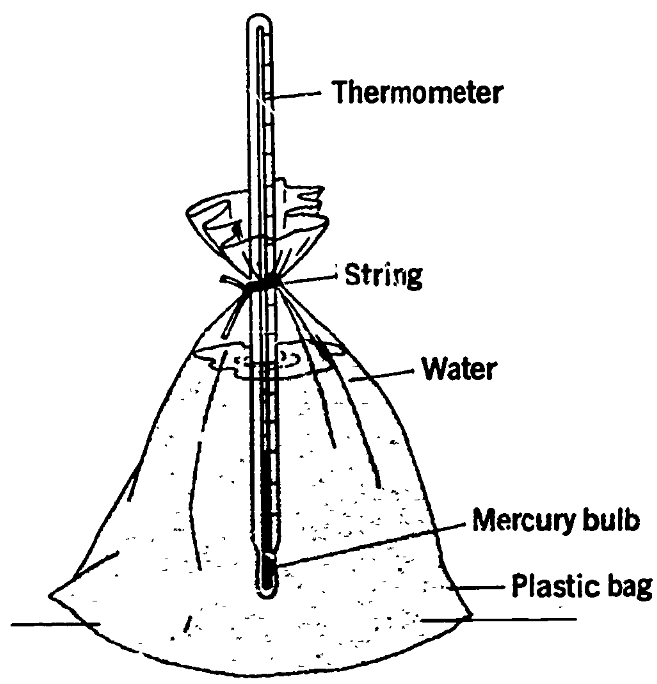
Concept to be developed: The freezing point of a substance is the temperature at which it changes from the liquid state to the solid state.

Materials needed:

Plastic bag
Refrigerator
Shallow pan
Water
Laboratory thermometer
String
Paraffin
Glycerine
Dry ice
Olive oil
Alchohol
Mercury

INTRODUCTION: Tell the children that it is possible to change the liquid state of water into the solid state by lowering the temperature, and that the point at which the change occurs is called the freezing point. *Ask the children if they think that all substances freeze at the same temperature. Point out that the next Activity will give them an opportunity to compare the freezing points of water and other common substances. Have the children collect different kinds of liquids, such as those mentioned above.*

Have the children place some water in a plastic bag, inserting a laboratory thermometer so that the bulb end is suspended in the water, and tie



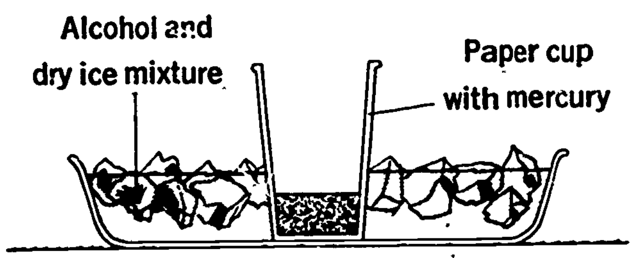
a string around the top of the bag (the top end of the thermometer should be sticking out). Place this setup in a freezing compartment for several hours. When the water has frozen, remove the bag from the freezing compartment. Read and record the thermometer reading. How would your class account for the fact that the reading might be below 0°C. or 32°F.? *(Once all the water has frozen, the ice can become cooler if the freezer unit is set at a temperature below 0°C.)* Remove the plastic bag from around the ice block and allow the block to stand in a shallow pan until it begins to melt. Read the temperature of the thermometer after the ice block has been raised just to its melting point. What is the temperature reading now? *(32°F. or 0°C.)*

Some of the children might like to compare the freezing point of water with that of other liquids. If so, they should obtain and try some of the other liquids listed above. The following table gives the freezing points of these liquids.

Liquid	Freezing point °Centigrade	Freezing point °Fahrenheit
alcohol	–117	–179
glycerine	17	63
olive oil	2–6	35–43
paraffin	55	131
mercury	–39	–38

With some children you might want to compare the freezing point of water with the freezing point of paraffin. To do this, have them melt some paraffin in a beaker over a hot plate, then remove the paraffin from the hot plate and stir it with a glass rod until cooled but not hardened. When the paraffin is just forming a hardened surface, they should stir with the laboratory thermometer and record the temperature when the paraffin hardens. This is its freezing point. What is the reading? *(About 131°F. or 55°C.)* How does frozen paraffin differ from liquid paraffin? *(It does not flow.)*

Some of the children might like to freeze some mercury. Have them place a small quantity of mercury in a paper cup and place the cup in a mixture of alcohol and dry ice (at −80°C.). (Use extreme caution in handling dry ice. Gloves or tongs should always be used, for if dry ice comes in contact with the skin, it may cause serious skin injury.) Next, the children should break



the chunks of ice with a hammer and place the chunks in a beaker half full of alcohol. The alcohol is reduced to a temperature of −80°C. When the mercury reaches a temperature of −39°C., the mercury freezes. How does frozen mercury differ from liquid mercury? *(It is a solid and does not flow.)*

Learnings: (y,z) Water freezes at 0° Centigrade or 32° Fahrenheit. Some liquids freeze above that temperature, and some other liquids freeze below that temperature. Mercury freezes at a temperature of −39° C. Paraffin freezes at a temperature of 55°C.

ACTIVITY 45 (x,y)

LOWERING THE FREEZING POINT OF WATER

Purpose: To show that the freezing temperature of water can be lowered

Concept to be developed: The freezing point of water can be lowered by dissolving certain substances in it.

Materials needed:

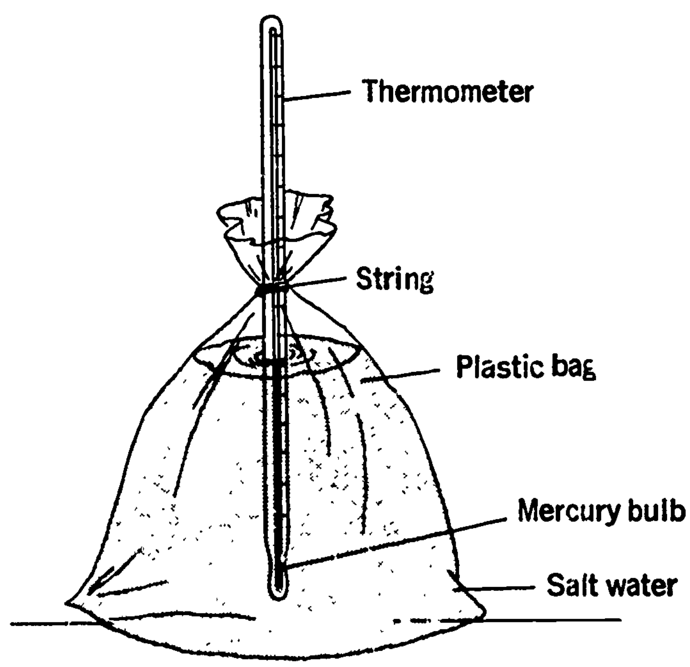
- Salt
- Laboratory thermometer
- Water
- Plastic bag
- String
- Refrigerator
- Alcohol
- Shallow pan

INTRODUCTION: The children now know that water normally freezes at a temperature of 0°C. or 32°F., as they saw this happen in the preceding Activity. This Activity will show the children that dissolving certain substances in water changes the freezing point of the water.

The children should put enough salt into a plastic bag full of water to make a saturated solution. Have them place enough salt in the bag so that some crystals will not dissolve, but instead will remain on the bottom of the plastic bag. Then have them place a thermometer in the bag and tie the neck of the bag with a string so that the thermometer is sticking out. They should then place this setup in the freezing compartment of a refrigerator. (The freezing unit may have to be turned to its coldest position.) When the solution has frozen, remove the plastic bag from the refrigerator. Let the block of ice stand in a shallow pan until it begins to melt. The children should read and record the temperature of the mixture when it just reaches the melting point. Is there any difference between this temperature and that of the frozen water without salt? *(Yes, the salt-water block of ice is at a lower temperature.)* Why? *(Adding salt to water lowers the freezing point.)*

The children might like to discuss this concept and its effect upon the oceans. The oceans contain considerable salt and will thus have a freezing temperature lower than that of fresh water. Is this advantageous? Why?

Some children may want to mix certain amounts of alcohol and water together to see if



they can freeze the mixture using the $-80°C$. temperature of a mixture of dry ice and alcohol. (See Activity 44.)

To help children apply their learnings, you might ask, Why does your father put alcohol or antifreeze in his car radiator during the wintertime? *(The alcohol or antifreeze lowers the freezing point of the water. Therefore, the water will not freeze and damage the radiator.)*

Encourage children to dissolve other substances in water to see how the freezing point is affected.

Learnings: (x) When salt is dissolved in water, the freezing point of the water is lowered. (y) A mixture of alcohol and water also has a lower freezing point than that of pure water.

ACTIVITY 46 (y,z)

DEMONSTRATING THE COHESIVENESS OF WATER

Purpose: To show why water takes the shape of drops

Concept to be developed: Cohesion is the tendency of substances to stick together.

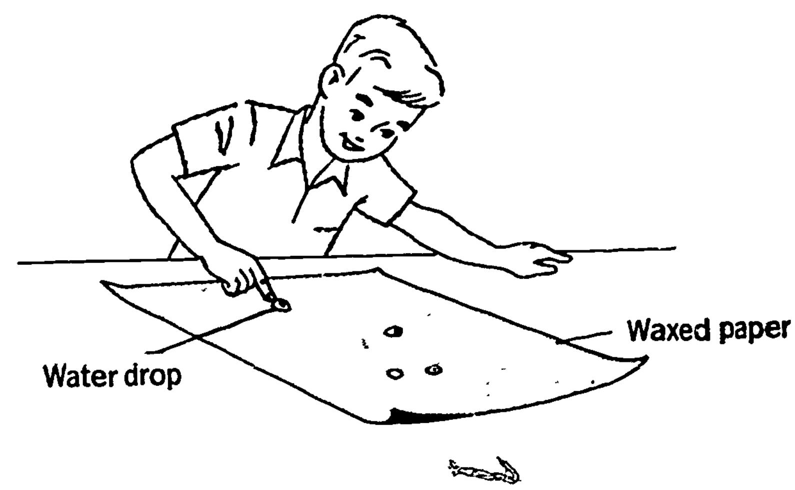
Materials needed:

- Water
- Mercury
- Wax paper
- Medicine dropper
- Magnifying glass

INTRODUCTION: Tell children that they are going to discover another characteristic of liqiuds. First, discuss the word cohesion *with them. Cohesion is the force of attraction of like substances.*

Give each child a small square of wax paper. Fill a medicine dropper with water and place a few small drops on each piece of wax paper. Do the drops make the paper wet? *(No.)* Have children push some of the drops together. What happens? *(The water sticks together as larger drops.)* What shape do the drops take? *(They are ball-shaped.)* Do they all have the same shape? *(No, the smaller ones are more spherical, the larger ones are flatter.)* What happens when two small spherical drops are brought together? *(They form a larger and flatter drop.)* Let the children speculate about what would happen if a larger, flatter drop were separated into two smaller droplets. Have them try it.

The children might like to see if other liquids exhibit cohesion, too. Have them repeat the procedures, using some small drops of mercury



(or mineral oil) in place of the water. *Caution:* Do not let the children touch the mercury with their bare fingers; it is poisonous if taken internally. The children should use the tip of a pencil or small stick to move the drops of mercury across the wax paper. Which is the more cohesive, mercury or water? *(Mercury.)* How can you tell? *(The mercury forms larger, rounder drops.)* Perhaps some children might like to compare the cohesive force of water with that of other liquids, such as alcohol and glycerine.

Learning: (y,z) Cohesion is the tendency of substances to stick together. Water shows a cohesive force, but [illegible] is not as great as the force exerted by many [illegible] liquids.

ACTIVITY 47 (y)

STUDYING THE SURFACE TENSION OF WATER

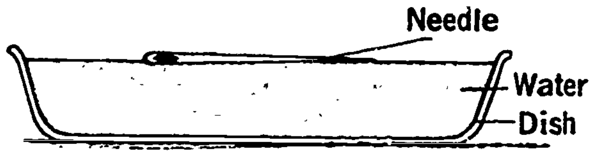
Purpose: To demonstrate the phenomenon of surface tension

Concept to be developed: The surface of water acts like an elastic membrane; this elasticity of the surface is called surface tension.

Materials needed:

- Razor
- Dish of water
- Needle
- Petroleum jelly

INTRODUCTION: Water has another interesting characteristic that the children may enjoy investigating. Perhaps they have observed water insects skimming over the surface of the water. The insects' feet depress the surface, yet they do not break through the surface of the water. There seems to be an elastic membrane covering the top of the water. Explain that this characteristic is surface tension. *It is caused by like particles (molecules) at the surface being pulled down more by water particles beneath than by like particles above. The result is a compacting of particles at the surface to behave like a tough membrane.*



The children can observe this by gently placing a thin, double-edged razor blade on the surface of a dish of water. The same thing can be done with a sewing needle. Lay the objects flat upon the surface. (Smearing a little petroleum jelly on the metal will make it easier to perform the Activity.) What do the children observe? *(The metal makes a little depression in the water but does not break the surface.)* Press on the blade and needle. What happens now? *(The water surface is broken, and the metals sink.)* What does this show about the water surface? *(The forces acting on the surface particles must be different from those acting on the particles in the interior.)*

Learning: (y) The surface of water acts like an elastic membrane. This elasticity of the surface is called surface tension.

ACTIVITY 48 (z)

MAKING WATER RISE IN CAPILLARY TUBES

Purpose: To show why water rises in capillary tubes

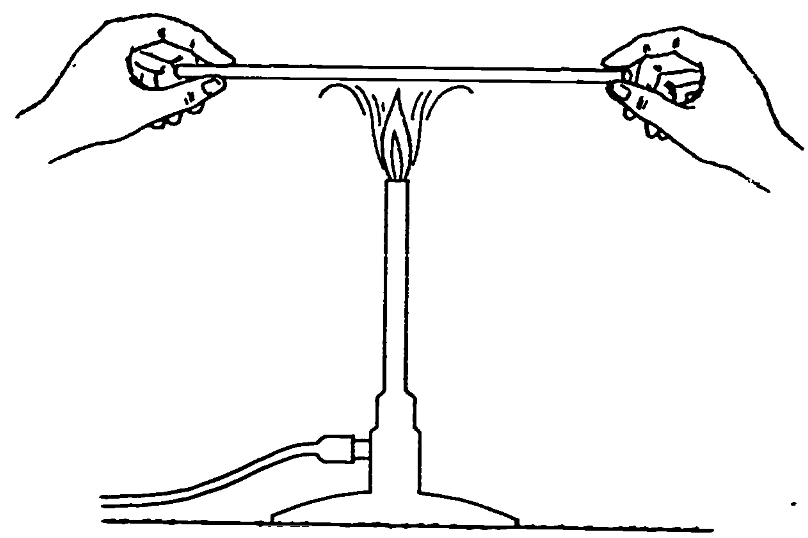
Concept to be developed: Water rises in capillary tubes because of adhesion, the attraction between unlike particles.

Materials needed:

- Water
- Capillary tubes or glass tubing
- Bunsen burner
- 2 pieces of glass about 2 x 2 inches

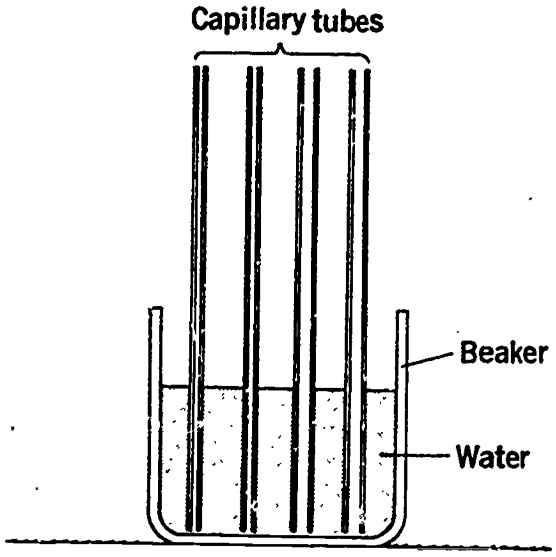
INTRODUCTION: Point out to the children that they have discovered that cohesion is the attraction that like particles have for each other. Now they can discover adhesion, *which is the attraction unlike particles have for each other. Hold up a piece of adhesive tape and discuss with the children that it is a kind of tape that sticks well to other objects, such as the skin or gauze. Water and other liquids show certain adhesive qualities. Explain that whenever unlike particles stick together, the force is called adhesion. It is this adhesive characteristic of water that keeps soils moist. Explain to the children that they can discover the adhesive quality of water by performing the following Activity.*

Fill a beaker about half full of water. Place some capillary tubes in the beaker. (Capillary tubes are glass tubes having inner diameters of



very small size. If you cannot get any, draw your own glass tubing into thinner tubes. This is accomplished by slowly rotating a glass tube in a propane or Bunsen flame while the tube is pulled at each end. The tube will stretch slowly to form a narrower tube. Remove it from the flame and break the tubing at convenient lengths with a file. The tubing can be broken easily after scratching a deep line on the glass with a file. The tube breaks when pressure is applied at the scratch mark.) What happens to the water in the tubes? *(It rises.)* Why? *(Water adheres—is attracted—to the sides of the tube.)* In which tubes does the water rise the highest? *(In the thinner tubes.)* Why? *(The amount of adhesion does not change with smaller diameters, but the amount of water it must act on is less. Therefore, the smaller amount of water can be pulled up higher.)*

Bring out during the discussion that this adhesive quality of water is very important in plant life, since it partially explains how water gets to the tops of tall trees. Plants such as trees and shrubs have tiny capillary tubes within the roots and stems that carry the water up the plant.



Learnings: (z) Adhesion is the attraction that unlike particles have for each other. (z) The rise of water in capillary tubes illustrates this adhesion.

ACTIVITY 49 (z)

COMPARING THE ADHESIVE PROPERTIES OF WATER AND OTHER LIQUIDS

Purpose: To show that the adhesive properties of different liquids are different

Concept to be developed: Water does not adhere to all substances equally.

Materials needed:

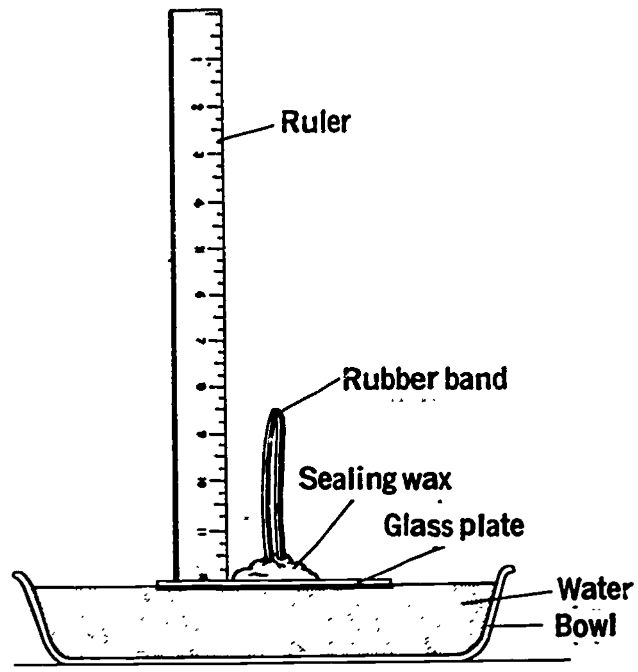
Mercury
2 glass plates
Rubber band
Syrup
Honey
Sealing wax
Ruler
Bowl
Alcohol

INTRODUCTION: Some children may want to investigate the adhesive properties of other liquids and compare them with those of water. By carrying out the following Activity, they will make some very interesting discoveries. They will find that not all liquids adhere to the same substance to the same degree. In this Activity, the children can measure the adhesion of water to glass and compare this to their findings on the adhesion of other liquids to glass; they can also compare the adhesion of water to substances other than glass.

Have a child fasten a rubber band to the center of a 2 by 2-inch piece of glass with sealing wax and then place the glass on the surface of a bowl of water. He should stretch the rubber band, pulling the glass from the water. Measure the distance the rubber band stretches before the adhesive force is disrupted. Record the distance in inches from the top of the rubber band to the surface of the water when the glass is finally lifted from the water.

Try this same experimental setup using syrup, honey, and alcohol in place of the water. Observe and record the findings for each. How do the results compare? Which shows the greatest amount of adhesion to the glass? Which shows the least?

Some members of the class may want to compare the adhesion of water to materials other than glass—they can try a piece of copper, wax paper, or plastic.



Children can apply their findings as you ask such questions as: Why are tentmakers concerned with the adhesive qualities of their fabrics with water? *(They want a minimum of adhesion, so that the water will roll off the fabric.)*

Learnings: (z) Water does not adhere equally to all substances. (z) Different liquids show a variation in their adhesion to different materials.

ACTIVITY 50 (x,y)

COMPARING THE TRANSMISSION OF LIGHT THROUGH WATER AND THROUGH OTHER LIQUIDS

Purpose: To show that water is transparent to light

Concept to be developed: A substance that transmits light is transparent; a substance that does not transmit light is opaque.

Materials needed:

Water
Vinegar
Mercury
4 test tubes
Newspaper

INTRODUCTION: Review with the children that water, vinegar, mercury, and air are fluids. If not held within definite boundaries, such as in a test tube, they flow. Tell the children that they can discover a characteristic of fluids in the following way.

Have children fill one test tube with water, another with vinegar, a third with mercury, and leave the fourth containing only air. Place a newspaper in back of each test tube and have children read through the test tubes. Can they read through each? *(They can read through the water, vinegar, and air.)* Why can they not read through the mercury? *(Light is not transmitted through this fluid.)*

From their observations, develop the meaning of the words *transparent* and *opaque*. *(A substance is transparent if light is transmitted readily through it, and opaque, if light cannot be transmitted through it.)* Explain that it is this ability of water to transmit light that enables plants to live under the surface of the water. Light is able to penetrate the water and give energy to the growing plants.

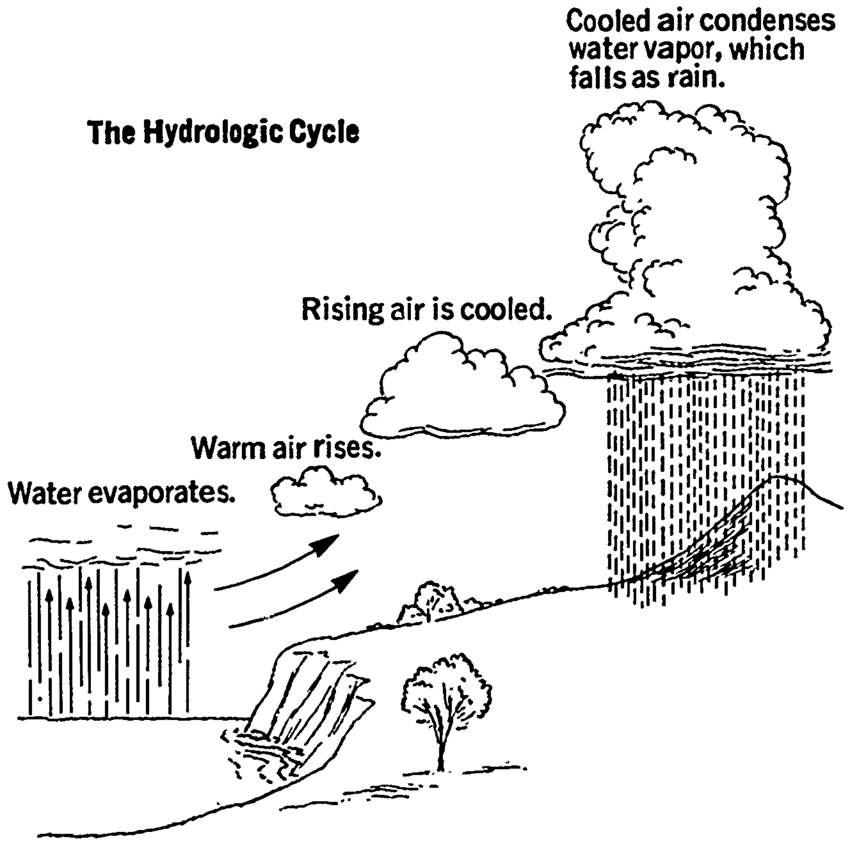
Learnings: (x) Transparency is the ability to transmit light readily. A substance is opaque if it does not transmit light. (y) Water and air are transparent fluids, but not all fluids are transparent.

Summing Up Ideas: In this section, children have discovered some of the characteristics of water. They found the density of water and found out how this density was used in comparison with the density of other substances to determine specific gravity. They performed Activities with the boiling point and the freezing point of water, and they found out how to lower and raise the boiling point and how to lower the freezing point. They compared the boiling point and freezing point of water to these points of other liquids. They studied the cohesion and adhesion of water to other materials and compared these properties with those of other liquids. Finally, the transparency of water was examined.

HOW DOES THE WATER CYCLE TAKE PLACE?

The water cycle starts in lakes, oceans, or other bodies of surface water, and is one of the important cycles in nature. Water is heated by the sun, causing the water to evaporate. When water evaporates, it changes from a liquid to a gas, or vapor. The water vapor passes into the atmosphere and becomes cooled. The cooled vapor *condenses*, or comes together, forming drops of water. The drops fall on the land as *precipitation*. Precipitation is the falling of water in the form of rain, hail, sleet, or snow. This cycle of

The Hydrologic Cycle



evaporation (the changing of a liquid into a gas), condensation (the cooling of the gas forming collected particles of matter), and precipitation (the falling of water particles as rain, hail, sleet, or snow) is called the *hydrologic cycle*, or water cycle.

ACTIVITY 51 (x)

EVAPORATING WATER

Purpose: To investigate the meaning of the word evaporation

Concept to be developed: Evaporation is the process of a liquid turning into a vapor.

Materials needed:

Water
Chalkboard
Sponge

INTRODUCTION: This Activity will help the children to investigate the meaning of the word evaporate. *Wet a sponge with water and have one of the children use it to wet the chalkboard in a large circle. (The exact size of the circle is not important.)*

Where is the water that was on the sponge? *(Some of the water is on the chalkboard.)* How can you tell that water is on the chalkboard? *(The chalkboard looks wet.)* Is the chalkboard wet? Have a child feel it.

Have the children observe what happens to the water on the chalkboard. *(The water disappears.)* Does all of the water disappear at the same time? *(No, some particles go before the other particles.)* Where do the particles go? *(Most of them go into the air—although some probably go into the chalkboard.)* Can you see the particles in the air? *(No.)* Then how do you know that they are in the air? *(See Chapter 4, which shows how to tell the relative humidity in the air.)* The water particles are called *water vapor*.

Learning (x) Evaporation is the process by which a liquid changes into a vapor.

ACTIVITY 52 (x,y)

COMPARING THE EVAPORATION OF WATER AND OTHER LIQUIDS

Purpose: To see if all liquids evaporate at the same rate

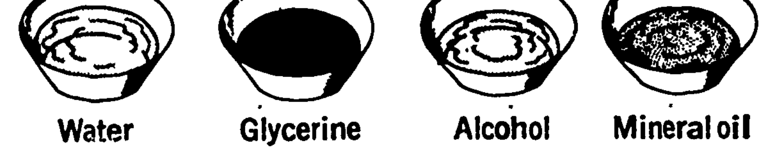
Concept to be developed: Some liquids evaporate more rapidly than others.

Materials needed:

Alcohol (from a drugstore)
Glycerine
Tablespoon
Crayons and paper
4 saucers
Water
Mineral oil

INTRODUCTION: Write the names of the liquids—alcohol, glycerine, and mineral oil—on the chalkboard and ask children whether they think these liquids will evaporate just as water does. Suggest that they try them and see.

Have a child measure one tablespoon of water and place it in a saucer. Point out the importance of having the same kind and size of saucers and the same amount of each liquid in the saucers. Have a child use a crayon and a piece of paper to make the label "water" and place it in front of the saucer containing water. Repeat the same procedure for each of the other liquids and make appropriate labels. Let the saucers sit for 24 hours at room temperature. At the end of this period have the children observe the results.



Water Glycerine Alcohol Mineral oil

(Only the alcohol and water have disappeared completely.) What has happened to these liquids? *(They have evaporated into the air.)* Are they liquid when they are in the air—that is, can the particles be seen and do they roll around, as water rolls in a glass? *(No, they are not liquids.)* What are they in the air? *(They have taken the form of an invisible vapor.)*

What happened to the other two liquids? *(A large portion of the glycerine and the mineral oil remained in the saucers.)* Why did they not disappear? *(These liquids do not evaporate or turn into a gas as rapidly as alcohol and water.)* Suggest to the children that they watch these two liquids to discover how long it takes them to evaporate.

Some children may want to spread alcohol and water onto the chalkboard (as in Activity 51) to see which evaporates more rapidly. *(The alcohol evaporates more rapidly.)*

Learning (x,y) Some liquids turn into a gas, or evaporate, very rapidly; others evaporate slowly.

ACTIVITY 53 (x,y)

SEEING HOW AIR MOTION AFFECTS EVAPORATION

Purpose: To investigate the effect of air motion upon the rate of evaporation of water

Concept to be developed: When air moves over water, it increases the water's rate of evaporation.

Materials needed:

Paper hand fan
Chalkboard
Water
Sponge
Watch with a second hand

INTRODUCTION: Now that the children have observed evaporation taking place, they may be interested in investigating some factors that might change the rate of evaporation. Some children will probably mention that things dry faster in the wind. Tell them that they can test this in the following way.

Ask four children to go to the chalkboard and have each child make two chalk circles on the board, each about as large as a dinner plate. Give each child a folded piece of construction paper—about 8 by 8 inches. Have each child wet the inside of both of his circles with a wet sponge. Then instruct the group to fan only one of the circles with the paper fan to see which circle loses its water first. When the water disappears it is said to evaporate. Which circle of water evaporates first? *(The circle that is fanned.)* Why? *(Because fanning removes the moist air above the circle, replacing it with dry air into which the water particles can "escape" more easily.)* One child might act as a timer to record the time it takes for evaporation to take place. He would begin timing with the first fanning and end when the circle is dry. Why do some circles take longer to evaporate? *(More water was present, or less fanning was done.)* Where did the water go? *(It went into the air as an invisible vapor.)*

You may want to have another group of children go to the chalkboard, draw circles, and see whether they can hasten evaporation by blowing on one of the circles.

Learnings: (x,y) Moving air over water increases the rate of evaporation. (x,y) Air over water becomes moistened, making it more difficult for evaporation to occur. Wind removes this moist air and replaces it with drier air.

ACTIVITY 54 (x)

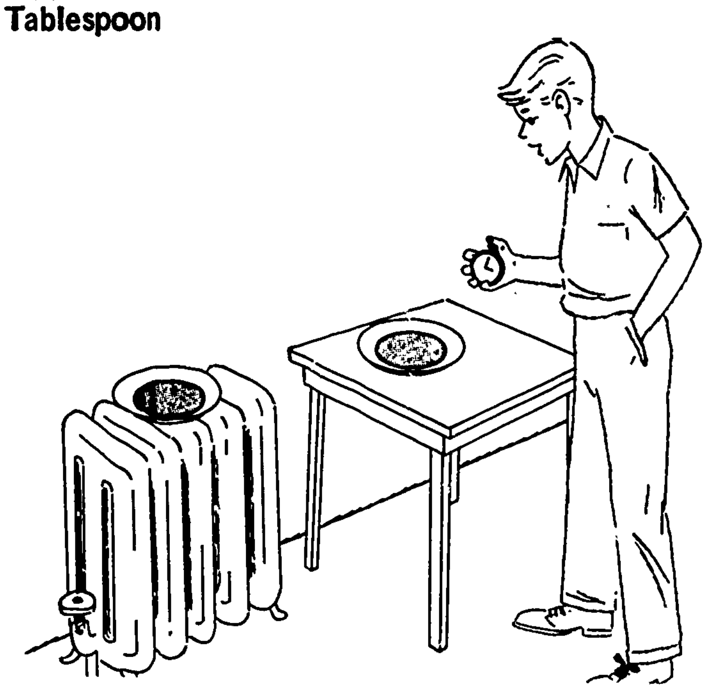
SEEING HOW HEAT AFFECTS EVAPORATION

Purpose: To show that heat affects the rate of evaporation of water

Concept to be developed: Water evaporates more quickly when its temperature is raised.

Materials needed:

Hot plate or radiator
2 beakers or Pyrex dishes
Stopwatch
Water
Tablespoon



Suggest to the children that there is another way to speed up the rate of evaporation of water. Have one of the children place a tablespoonful of water in a beaker or Pyrex dish and place it on a hot plate or radiator. Have another child place another dish containing the same amount of water on a table away from any source of heat. Have one child use a stopwatch and act as a timekeeper, recording the time the experiment began and the time that the water evaporated from each of the dishes. From which dish did the water evaporate first? *(The dish that was heated.)* Why? *(Increasing the temperature of the water particles helps them to "escape.")* Where did the water go? *(It went into the air as an invisible vapor.)*

Learning: (x) Heating water increases the rate of evaporation.

ACTIVITY 55 (y,z)

DISTILLING WATER

Purpose: To demonstrate the process of distillation

Concept to be developed: Distillation is the process of boiling a liquid, collecting its vapor, and then changing the vapor back into a liquid by the process of condensation.

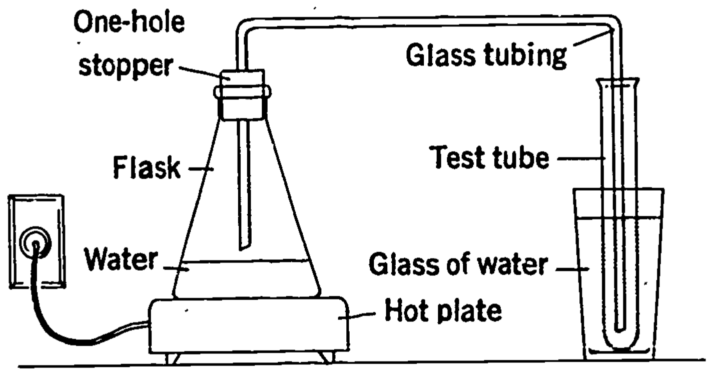
Materials needed:

250 milliliter (ml) flask
1-hole stopper
Glass tubing
Hot plate
Test tube
Glass
Water
Clamp

INTRODUCTION: Review with the children that they have had a variety of experiences in which they have seen liquids evaporate, that is, change into an invisible gas or vapor. This next Activity will help them discover how this vapor may, under certain conditions, change back into a liquid.

Show the children a carton or bottle labeled "distilled water," and tell them that perhaps they have seen such a container before, since some of their mothers may use distilled water in steam irons. Ask them if they know what distilled water is. Suggest that they can make some in the following way.

Pour some water into the 250-milliliter flask. Place a one-hole stopper, in which a glass tube with two bends (as shown in the illustration) has been inserted, into the flask. Have the chil-



dren observe what happens when heat is applied to the water in the flask. *(The water boils, and the liquid water turns into water vapor.)* Can you see this vapor? *(No, not in the tube.)* Can you see anything in the glass tube? *(Sometimes the vapor will be cooled enough in the tube to turn back into droplets of water.)*

What do the children observe coming out of the end of the tube? *(A white "cloud"—some of the children may call this cloud "steam." Steam, however, is invisible and cannot be seen.)* Why can you see the white cloud outside the tube but not inside it? *(The vapor is cooled upon leaving the tube, and the little particles come together to form a "cloud," which is made up of groups of water particles.)*

Direct the vapor into a test tube that is resting in a glass of cold water. Have the children observe what collects on the bottom of the test tube. Ask them what they think is forming in the bottom of the tube. *(Water.)* Why is more water forming now than before the vapor was directed into the test tube? *(The vapor is cooled faster by the cold water.)* The water formed is distilled water, which is pure water.

Learning: (y,z) Distillation is the process of boiling a liquid, cooling the vapor, and then changing the vapor back into a liquid by the process of condensation.

ACTIVITY 56 (x,y)

MAKING WATER VAPOR PRECIPITATE

Purpose: To show why water vapor precipitates as rain

Concept to be developed: When water droplets accumulate enough mass through the condensation of water vapor, they fall as raindrops.

Materials needed:

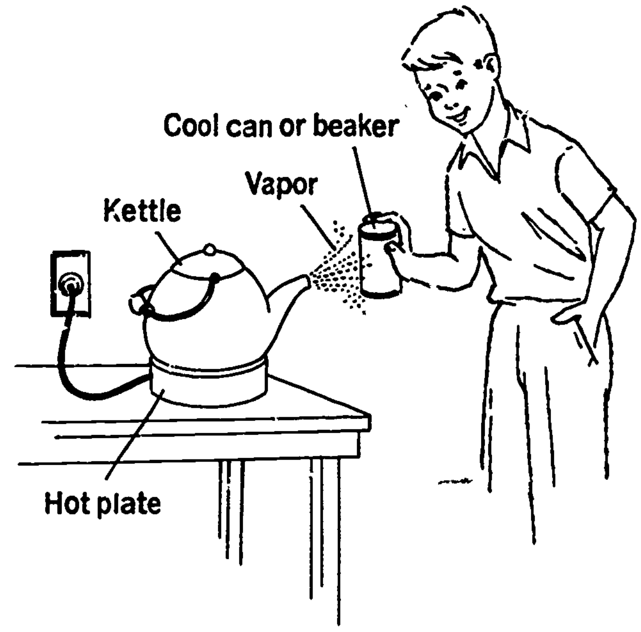
Glass or can of ice water
Teakettle
Hot plate
Water

INTRODUCTION: Discuss with the children what they think makes rain. Elicit from them the fact that water falls as rain when moisture condenses into particles that are denser than the air around them. Explain that the falling of these denser particles of water is called precipitation. *Suggest that it is possible for them to make rain (precipitation).*

Have them experiment with precipitation by boiling water in a teakettle over a hot plate. What do they see happening? *(A cloudlike formation occurs as the water vapor coming out of the spout of the teakettle is cooled.)* How is it cooled? *(By coming in contact with the cooler air around it.)* What happens to this cooler vapor? *(It turns into a cloudlike formation.)* What happens to the cloud? *(It disappears, and others form from more cooled vapors.)* What makes the cloud disappear? *(The particles separate and dissipate into the air.)*

Have the children place a glass or can full of ice water in front of the spout of the kettle. What happens now? *(Water droplets form on the glass or can.)* What happens to the droplets? *(They get bigger until they are so large that they fall as precipitation.)*

Learning: (x,y) When water droplets accumulate enough mass through the condensation of water vapor, they fall as raindrops.



ACTIVITY 57 (x,y)

MAKING A SEALED TERRARIUM TO SHOW THE WATER CYCLE

Purpose: To illustrate the mechanism of the water cycle

Concept to be developed: The water cycle functions through the evaporation, condensation, and precipitation of water.

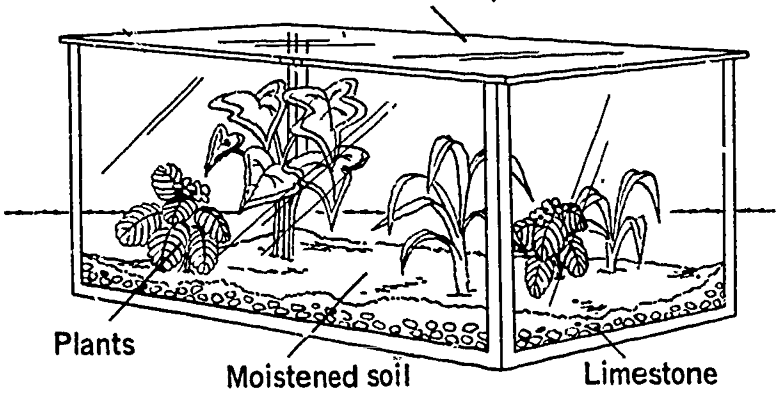
Materials needed:

Gallon jars (paste, mustard, or milk) or aquariums
Garden soil
Small plants
Crushed limestone
Living moss
Glass covering

INTRODUCTION: Discuss the water cycle with the children. During the discussion, bring out the children's concepts of evaporation and condensation. Suggest that they can discover the importance of these two processes in the water cycle and to plant life.

Ask several children to bring to school a gallon jar with a large opening. (If gallon jars are unobtainable, aquariums can be substituted.) Then place some crushed limestone rocks on the bottom of the jars. (Limestone helps keep the soil from becoming too acid.) Have the children place 3 inches of soil above the limestone and add some living moss or small fern or other plants they may find in a wooded area or ferns obtained from a florist. They should add enough water so that the soil is moist, but not so much that there are puddles of water showing. Finally, they should place a piece of glass over the top of each terrarium.

After several days, the children may observe some droplets of water clinging to the sides of the glass or hanging from the top glass. Where did the water come from? *(From the moistened soil and plants.)* How did the water get up there? *(It evaporated, and the vapor was cooled by the glass to form water droplets.)* Must water be added to the terrariums? *(Not much, if any at all, as the moisture stays within the container.)*



How does this experiment show the water cycle in nature? *(It shows how water evaporates from the ground and plants. The vapor cools and turns to rain.)*

Learning: (x,y) A sealed terrarium can represent the water cycle in nature. Water evaporates and turns to vapor. When it is cooled, it condenses, forming particles of water.

Summing Up Ideas: In this section on the water cycle in nature the children had a variety of experiences which would help them gain an understanding of three basic concepts—evaporation, condensation, and precipitation. To show the interrelationship of these three ideas, children made a terrarium and observed what the water cycle might be like in nature.

HOW IS WATER USED?

Water, in ponds and lakes, in rivers and streams, and in underground reservoirs, is vital to man's existence. Water is necessary to man for drinking. Water is important as a source of power and is useful as a cleansing agent. Water is also essential for all plant and animal life. Many plants and animals cannot exist out of the water. In the following Activities children can investigate some of the uses of water and see how water is necessary to plant and animal life.

ACTIVITY 58 (x)

FINDING PLANT LIFE IN SURFACE WATER

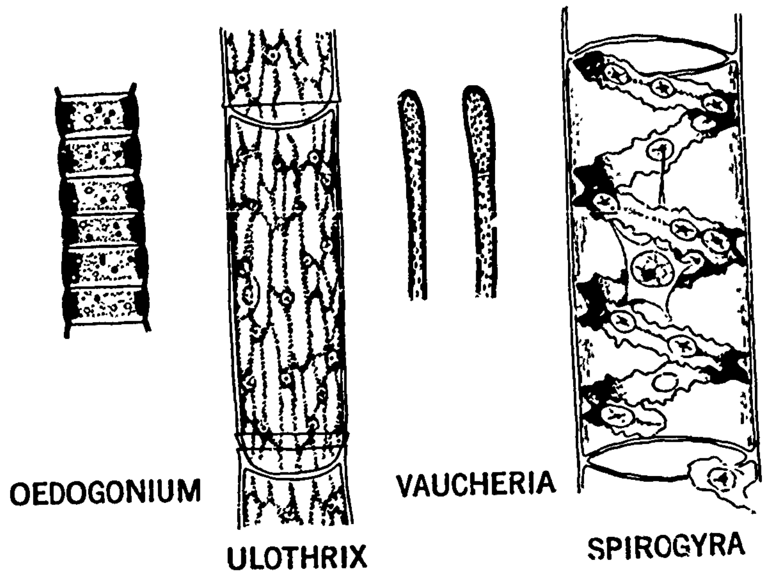
Purpose: To show that many forms of plant life can be found on the surface of bodies of water

Concept to be developed: Some plant life depends upon large quantities of water to survive and cannot live upon dry land.

Materials needed:

Pond water
Magnifying glass
Microscope
Microscope slides
Medicine dropper

INTRODUCTION: The children might enjoy searching for some of the small forms of plant life found in ponds and lakes. This miniature plant world can be observed under the microscope.



Have a few children in the class collect some water containing green scum from a pond, lake, or stream. If there is no scum available, you will probably find some on the sides of a fish aquarium that has been standing in the sunlight for several months.

First have the children use a magnifying glass to examine the green plant life. Then have them use a microscope to examine the green scum more closely. What is the composition of the scum? *(It is probably composed of tiny strands or filaments of algae.)* What color do they see in the algae? *(Green.)* This green color is due to the pigment *chlorophyll*. Chlorophyll is necessary in the manufacture of food and the giving off of oxygen into the water and air during the process of photosynthesis.* How is the chlorophyll distributed in the filaments? *(In some it is in spiraling bands. In others it may be dotted.)*

Children may discover other forms of plant life, such as duckweed or Valisneria, in a pond or lake. Some children may want to examine the structure of these water plants. How are they adapted to live in water?

Learnings: (x) Many forms of plant life are found in water. (x) Some plant life is dependent upon water and is not found on dry land. (x) Much of the plant life in lakes and ponds can be seen only with the aid of a microscope.

*For a further discussion of photosynthesis, see *Living Things*, by James Wailes (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

ACTIVITY 59 (x,y)

FINDING ANIMAL LIFE IN WATER

Purpose: To show that some forms of microscopic animal life live in water

Concept to be developed: Many of the microscopic animals that live in water serve as food for other living things.

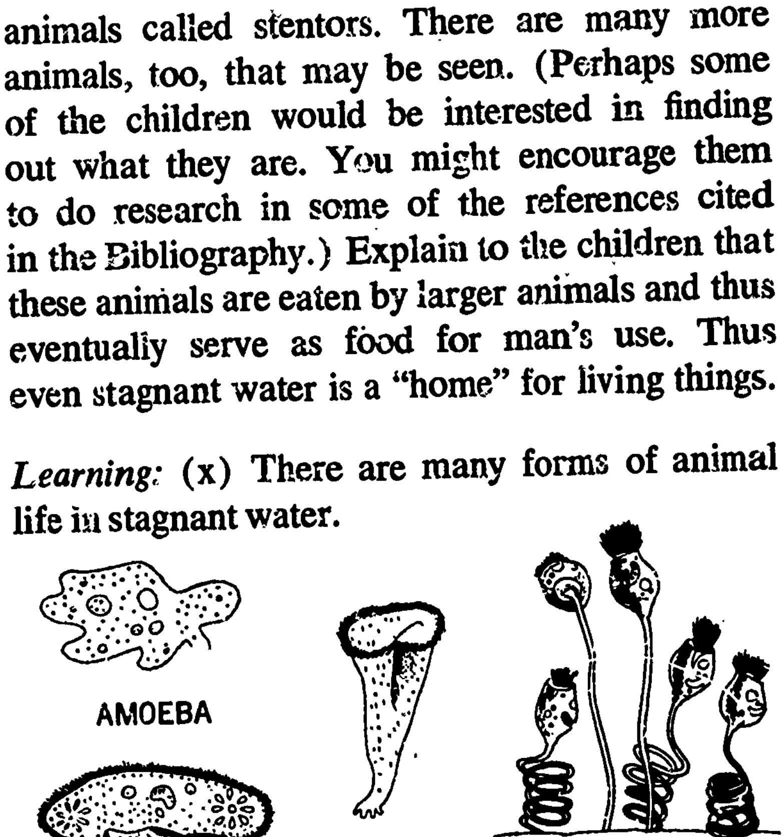
Materials needed:

Pond water
Microscope slide
Medicine dropper
Microscope

INTRODUCTION: Discuss with the children that they have seen a variety of plants that live in the water. However, point out that there are also animals found in water, but that they are so small that they can be seen only with a microscope. The children can discover what these animals look like if they get some stagnant pond water in a jar. (If no stagnant pond water is available, the children can create some if they place a handful of dried grass, leaves, or straw in a bowl of rain water that has been scooped from a puddle in dirt and allow the water to stand in a warm, light room for about two weeks.)

Have a child use a medicine dropper to remove a few drops of the water. Place the drops on a microscope slide and have the children observe the water through a microscope. The children may see some slipper-shaped, one-celled animals called paramecia, some bell-shaped animals called vorticellae, or some funnel-shaped animals called stentors. There are many more animals, too, that may be seen. (Perhaps some of the children would be interested in finding out what they are. You might encourage them to do research in some of the references cited in the Bibliography.) Explain to the children that these animals are eaten by larger animals and thus eventually serve as food for man's use. Thus even stagnant water is a "home" for living things.

Learning: (x) There are many forms of animal life in stagnant water.



ACTIVITY 60 (x)

PURIFYING WATER FOR DRINKING

Purpose: To show how water can be purified to make it fit for drinking

Concept to be developed: Filtering the water will remove many of the small plants and animals that may be living in it.

Materials needed:

Pond water
Filter paper
Funnel
Test tube
Microscope
Microscope slide
Medicine dropper

INTRODUCTION: Children are familiar with the fact that water is essential to man for drinking. Point out to them that man must first, however, make it safe by removing organisms in it. Ask the children how they think the water they drink is made safe. Where does their drinking water come from? Suggest that they can discover one way that water is made safe for drinking.

Have the children bring some pond water to the classroom or make some as was done in the preceding Activity. Use the medicine dropper and place a few drops of pond water on a slide. Then have the children examine the drops of water under the microscope. Do they see any plant or animal life in the drop? *(Your children may see some protozoans or algae—see Activities 58 and 59.)*

Now have a child take a piece of filter paper, fold it in half, then in half again, open it up to form a cone, and then place the cone in a moist funnel. The end of the funnel should fit into a test tube. Pour some pond water into the filter paper. What happens to the water? *(It passes through the filter paper.)* The filtered water comes out and passes into the test tube. What is the appearance of the water? *(It looks clear.)*

Have the children examine several drops of this water under the microscope. Do they see any sign of life or any particles? *(No.)* Why not? Point out that water still might have some living things in it that are not visible through the ordinary microscope, so water should be boiled or have chemicals added to it (iodine or chlorine) before it is used for drinking.

During the discussion mention that instead of using filter paper, cities like Chicago use large beds of sand through which the water is strained or filtered. Chicago uses filtered water from Lake Michigan and then adds chemicals to the water to make it fit to drink. Encourage interested children to find out other methods of purifying water, as used by other large cities. Have them report their findings to the class.

Learnings: (x) Filtering water helps to purify it by removing dirt particles and tiny organisms. (x,y) Chemicals are usually added to water to make it completely safe for drinking by killing any harmful things in it.

ACTIVITY 61 (x,y)

MAKING A MODEL WELL

Purpose: To illustrate how a well works

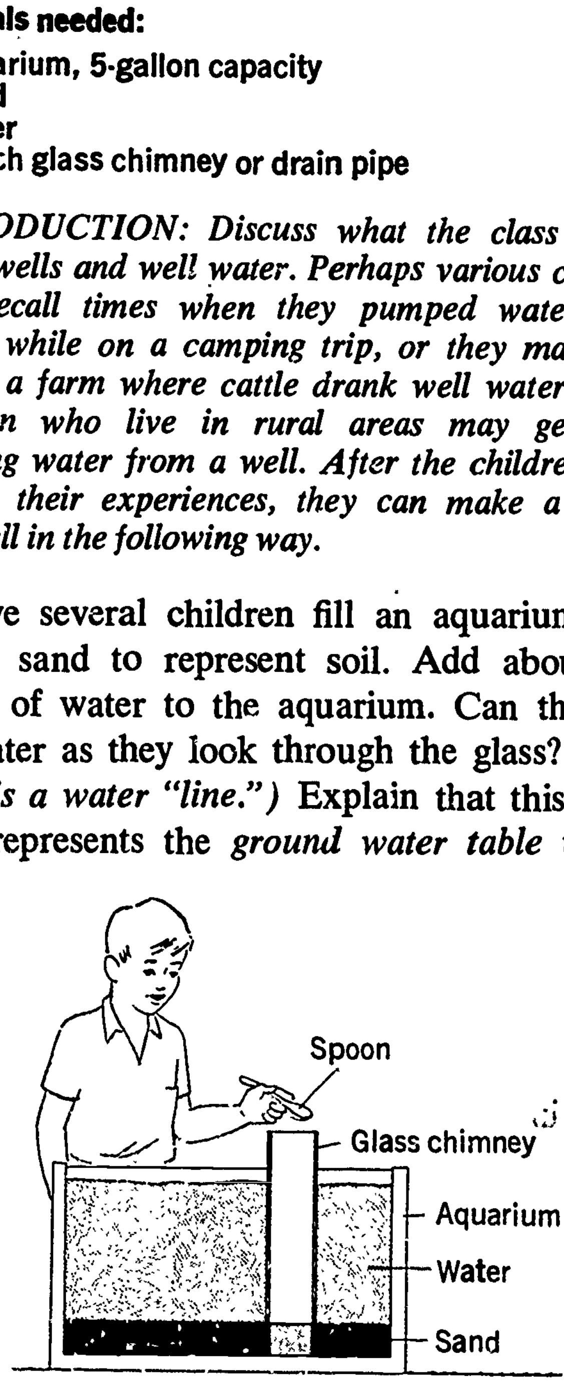
Concept to be developed: A well is a hole sunk in the soil to reach water. It must be deeper than the water-table level at that location.

Materials needed:

Aquarium, 5-gallon capacity
Sand
Water
8-inch glass chimney or drain pipe

INTRODUCTION: Discuss what the class knows about wells and well water. Perhaps various children may recall times when they pumped water from a well while on a camping trip, or they may have visited a farm where cattle drank well water. Some children who live in rural areas may get their drinking water from a well. After the children have related their experiences, they can make a model of a well in the following way.

Have several children fill an aquarium with coarse sand to represent soil. Add about one gallon of water to the aquarium. Can they see the water as they look through the glass? *(Yes, there is a water "line.")* Explain that this water level represents the *ground water table* that is



present under moist soil. The ground water table is the level of the hydrosphere at a particular location on the Earth.

Push the glass chimney or pipe into the soil, all the way to the bottom. Have one of the children remove the sand in the pipe with a long-handled spoon. How can he tell when he comes to the water table? *(The sand becomes quite wet and runny.)* He should keep removing sand until there is a well of water. Where does the water rise to in the well? *(To about the same level as the water table in the aquarium.)* How would the water be lifted up farther for man's use if this were an actual well? *(By buckets or a pump.)* Of what materials might the walls of the well be made? *(Concrete, cement, stones, or metal.)*

Have the children add more water to the aquarium. What happens? *(The level of the water table rises. The water in the well also rises.)* Discuss with the children the effect of weather on the water table under the ground and water in the well. What happens when there is a long period of dry weather?

Learnings: (y) A well is a hole sunk in the soil to reach water. It must be deeper than the water-table level at its location. (x,y) The level of the water table will fluctuate in response to weather conditions. A lot of rain will cause the water table to rise. (x,y) A lowered water table might cause wells to run dry.

ACTIVITY 62 (y,z)

MAKING A MODEL OF AN ARTESIAN WELL

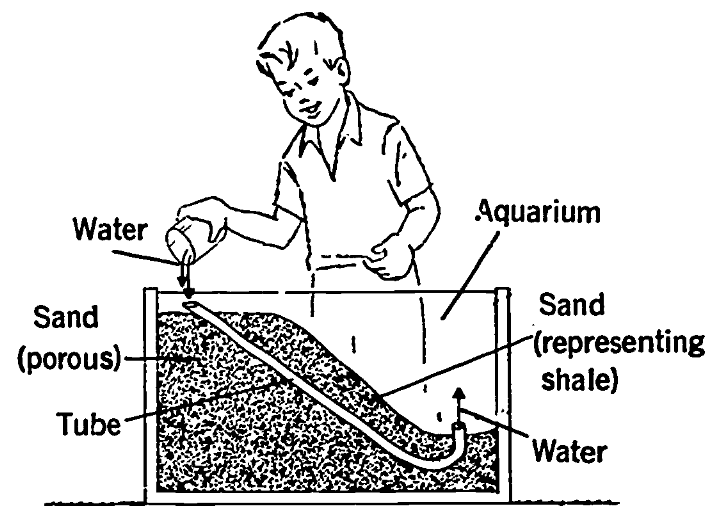
Purpose: To illustrate how an artesian well works

Concept to be developed: Water flows from artesian wells because of the pressure of the water above the surface of the well.

Materials needed:

Aquarium, 10-gallon capacity
Sand
18-inch rubber tube with a ½-inch diameter

INTRODUCTION: The children may live in areas where water for drinking and irrigation comes from artesian wells. They may be encouraged to discuss their ideas about the differences between an artesian well and the kind of well they made in the previous Activity. Suggest that they can make a model of an artesian well and compare the two types.



Have the children fill an aquarium with sand; have the sand slope from one end of the aquarium down to the other. This sand represents sandstone, a rock through which water passes readily. A child should next place the rubber tube on the sand with the lower end coming straight up, being careful that the bend in the tube will not prevent water from flowing through it. Then he should cover the tube with a different texture of sand to represent a layer of rock that will not allow water to flow through it as easily (usually shale).

Pour a quart of water on the exposed sand area and into the tube. What happens to the water at the other end of the tube? *(The water is forced out in a little stream.)* Why is the water forced out? *(Because of the pressure exerted by the water in back of it.)*

Point out to the children that in nature the sand represents a porous rock like sandstone, which will allow water to pass through it. The upright tube represents a pipe that might be drilled through the shale into the water-carrying sandstone.

What happens if the well end of the tube is raised to a height that is higher than the water source? *(The water will not come out of the well.)*

Learnings: (y,z) Water flows along beds of rock, such as sandstone, that are very permeable to water. (y,z) Water flows from artesian wells because of the pressure of water above the surface of the well.

ACTIVITY 63 (y,z)

SEEING HOW DEPTH AFFECTS WATER PRESSURE

Purpose: To demonstrate the effect of depth on water pressure

Concept to be developed: The pressure of water is partially determined by the height of the water above it.

Materials needed:

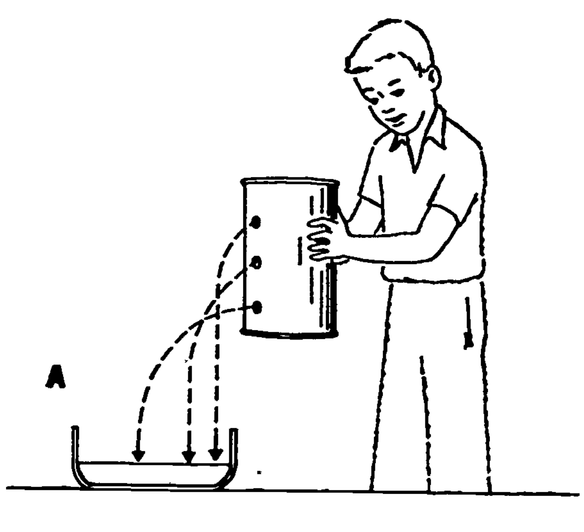
No. 10 tin can or tall fruit juice can
Water
Nail
Hammer
Ruler
Small corks

INTRODUCTION: Have children describe some of their experiences when they felt or saw the force of water: for example, the force of water coming from a garden hose directed toward the earth; the force (pressure) of waves as they break on a beach; the force of water coming from a faucet. Explain that in most people's homes the pressure of water can be controlled. This Activity can help the children discover what factors affect water pressure and how it can be controlled.

Explain to the children that one of the factors involving pressure on liquids is depth. The effect of depth on the pressure of a liquid can be studied as follows.

Have a child use a nail and hammer to make one hole near the top of the can, one in the middle, and one near the bottom. Plug each hole with a piece of cork. Fill the can with water and have one of the children pull out the bottom plug. What happens? *(The water comes out.)*

A



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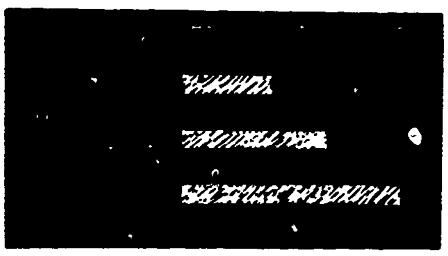


Why? *(Water is heavier than air and is pulled down by gravity.)* Measure with a ruler and record the horizontal distance from the can to the point to which the water is forced. Replace the plug. Have a child fill the can with water to the same level as before and remove the middle cork. Children should then measure the horizontal distance this stream of water is forced from the can and record the measurement. Repeat with the top cork and stream. What is observed? *(The lower the outlet, the greater the pressure and the greater the distance the water is pushed.)* Why is there greater pressure on the bottom? *(The height of the water is greater above the bottom hole than it is above the top hole.)* You may want the children to make a graph showing the results based on their measurements. How is such information meaningful in building a dam? *(The dam must be thicker at the bottom to withstand the greater pressure of water.)*

Learning: (y,z) Pressure of water is partially controlled by the height of the water above it.

ACTIVITY 64 (y,z)

MAKING A SIPHON

Purpose: To show how a siphon can be used to move water from place to place

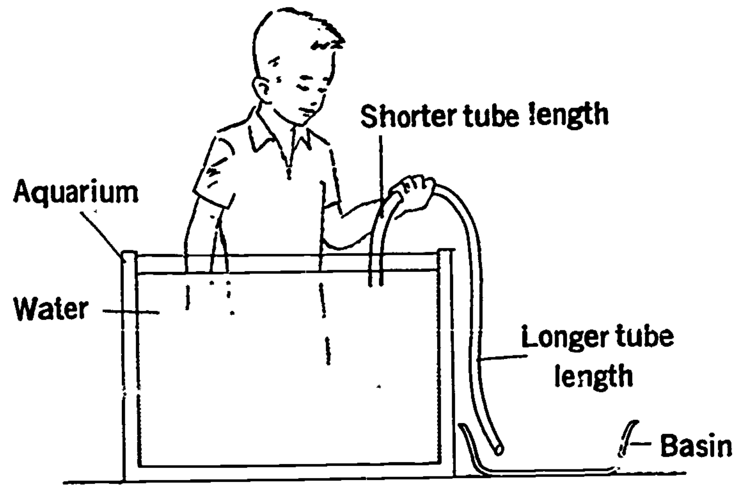
Concept to be developed: In order for a siphon to be used, the source of the supply of water must be at a higher level, or altitude, than the outlet of the siphon.

Materials needed:

Aquarium or battery jar
Plastic or rubber tubing
Basin

INTRODUCTION: Perhaps in the classroom or at home the children may have an aquarium filled with plant and animal life and wish to empty its contents to replace it with clean water. Ask the children how they might do this. Let them give their ideas and try them. Suggest that one way of doing this is by using a piece of rubber tubing and making a siphon. In using rubber tubing to make a siphon, certain conditions are necessary to make it work. The children might speculate about what these conditions are. Let them test their ideas.

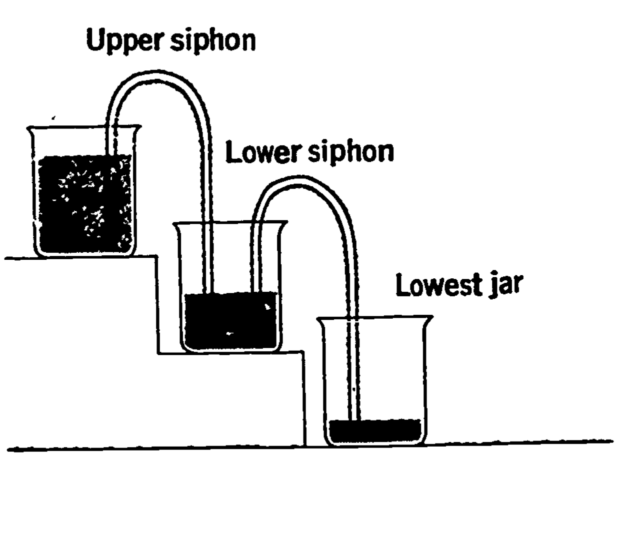
Have one of the children place a 4-foot length of tubing completely into the aquarium full of water. What happens to the air in the tubing? *(Air is forced out as the water fills the tubing.)* Completely fill the tube with water. How do you know when it is filled? *(No more air will*



come out as the tube is moved in various positions in the water.) Have a child press both ends of the tube closed so that no water can escape, and then lift one end over the side of the aquarium into the basin, while the other end is held in the bottom of the tank. Have him release both ends, but hold the higher end in the aquarium. What happens? *(Water from the aquarium pours into the basin.)* Which column of the tube has the greater depth of water in it? *(The column outside the aquarium.)* Which column would therefore have the greater pressure on it? *(The longer column of water.)* Why does the water go up the shorter column? *(As the water goes down the longer column, a lifting effect is produced on the shorter column.)* What causes this lifting effect? *(A partial vacuum resulting from the movement of water in the longer column.)*

Have one of the children lift the longer column and have the class notice the effect on the pressure. What is this effect? *(Water does not come out with as great a force.)* Why? *(The depth of water in the column is not as great.)*

Perhaps some of the children may want to make a series of jars in a siphon arrangement, as shown in the illustration.



Learning: (x,y,z) In a siphon the supply of water must be higher than the outlet as the water is directed through a tube from the supply to the outlet. As the water leaves the longer column, it produces a lifting effect by creating a partial vacuum. This lifting effect brings the water up the shorter column.

ACTIVITY 65 (x)

COMPARING THE ACTION OF SOAP IN HARD AND SOFT WATER

Purpose: To introduce the term **hard water**

Concept to be developed: Hard water is the result of certain materials being dissolved in water.

Materials needed:

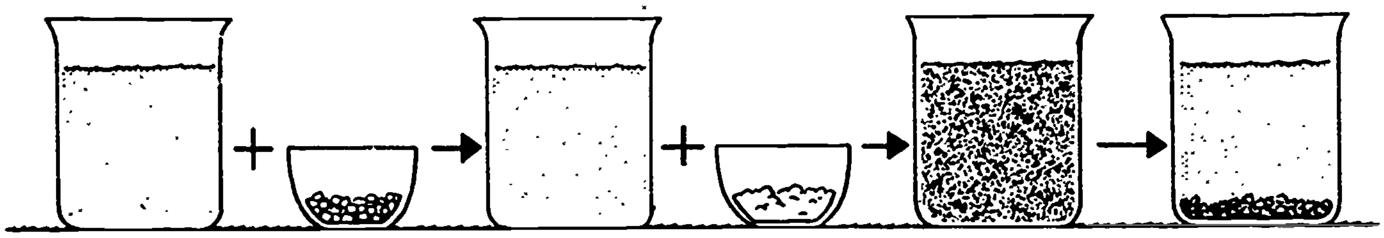
Epsom salts
Water
Table salt
Soap solution
2 test tubes or olive bottles

INTRODUCTION: Perhaps some of the children have heard of "hard" water. Discuss the term with them and ask if they know what it means. Explain that hard water is the name given to water that has a large concentration of calcium and magnesium salts. These salts react with the soap and prevent it from doing its job. How do the children know if water is hard or soft?

Bring out in discussion that some communities have water that has large amounts of mineral matter dissolved in it. When this is the case, it is quite difficult to make suds in this water even though a large quantity of soap is used. Such water is called "hard" water. Other communities have "soft" water. A small quantity of soap in this water will make a large amount of suds.

The children may be interested in comparing the effects of hard and soft water. Have some members of the class dissolve a teaspoonful of Epsom salts in a quart of warm water. Can the Epsom salts be seen? *(No, the salts are dissolved.)* How can it be proved that the salts are still there? *(Evaporate a tablespoonful of the solution in a Pyrex test tube by placing the tube over a hot plate. Note the white powder that remains.)*

Have children fill half of one test tube with the solution and half of the other test tube with rain water. *(Rain water is soft water, because it is free of dissolved minerals.)* Both liquids should be at the same temperature. Into each test tube a child should empty one-half a medicine



dropper of soap solution. The soap solution from a soap dispenser can be used, or a solution can be made by chipping a cracker-size piece of soap into a pint jar of rain water.

Have a child shake each test tube twenty times, while holding his thumb over the opening. What happens in each tube? *(There are a few suds in the test tube with the water containing Epsom salts—the hard water. There are many suds in the test tube containing rain water—soft water.)*

Learnings: (x,y) Hard water contains much dissolved mineral matter. (x) Soap suds form with difficulty in hard water.

ACTIVITY 66 (y,z)

MAKING HARD WATER SOFT

Purpose: To demonstrate how hard water can be softened

Concept to be developed: Washing soda softens hard water by reacting with the dissolved salts to precipitate them.

Materials needed:

- Borax
- Epsom salts
- Water
- Soap solution
- Beakers
- Washing soda
- Cotton cloth
- Petroleum jelly

INTRODUCTION: Discuss with the children the advantage of having soft water. Children should be able to state that suds are formed in much greater quantity in soft water than they are in hard water. Explain to them that suds act as emulsifying agents, which help to remove grease from objects by breaking up the grease particles and coating them with a film of soap. Ask the children if they think it is possible to change hard water into soft water. List the ideas the children have and test them. The following Activity will show how hard water becomes soft.

To a quart of rain water have the children add a teaspoonful of Epsom salts to make the water hard. Have them pour some of this hard water into a beaker until it is half full and then add three medicine droppers of soap solution to it. Next have them cut a 6-inch square of cotton cloth. Let them rub petroleum jelly on the cloth and get the cloth dirty by rubbing it on the floor. See that the dirt is equally distributed and then cut the cloth in half. Have them try to wash one piece of the cloth in the beaker of hard water that contains the soap.

Then have the children pour some hard water into a beaker so that it is about half full. Have them make a softening agent by mixing five teaspoonfuls of washing soda in a glass of warm water. After allowing the mixture to settle, let them add the soda mixture to the hard water. What happens? *(The mixture turns cloudy.)* Allow it to settle overnight. What happens to the cloudy mixture? *(It turns clear, and the precipitate settles. The minerals have precipitated out of the solution.)* Next have the children add three medicine droppers of soap solution. Let them attempt to wash the other half of the dirty cloth in this solution. Does the cloth get clean? *(Much cleaner than when the hard water was used.)* Your class might want to try just rain water and the soap solution to see how well this cleans dirty cloths.

Learning: (y,z) Washing soda will soften hard water by precipitating the minerals out of the solution.

Summing Up Ideas: In this section the children were introduced to some of the many uses of water. They learned of the plant and animal life that can be found in the lakes and ponds of the hydrosphere. They learned how the water table, which is the portion of the hydrosphere that is found beneath the surface of the Earth, can be tapped by wells to provide water for man's use. The children were also introduced to the idea of hard and soft water and how hard water can be made soft to make it easier to use for washing.

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary, and intermediate grade children, the kinds of ideas with the most meaning and application are these:

- Water covers the greatest part of the Earth's surface; about 71% of the surface is covered by water.
- The drying of foods is accompanied by shrinkage and loss of weight.
- Water vapor is present in the air that people exhale; it is this moisture that produces the clouding of glass.
- The density of liquids varies.
- The boiling point of a substance is the temperature at which the liquid state changes to the gaseous state.
- When table salt is dissolved in water, the boiling point is raised.
- When table salt is dissolved in water, the freezing point is lowered.
- Water and air are transparent fluids, but not all fluids are transparent.
- Evaporation is the process by which a liquid becomes a vapor.
- Moving air over the surface of water increases the rate of evaporation.
- Heating water increases the rate of evaporation.
- When water droplets accumulate enough mass through the condensation of water vapor, they fall as raindrops.
- Many forms of plant and animal life are found in water.
- Filtering water helps to purify it by removing dirt particles and tiny organisms.
- Hard water contains dissolved mineral matter.

In the intermediate and upper grades, the children should be led to develop concepts that are more complex and quantitative:

- Some liquids are viscous, that is, they flow with difficulty.
- Heating viscous liquids causes them to flow more easily.
- The density of water can be expressed as either 1 gram per cubic centimeter or 62.4 pounds per cubic foot.
- The boiling point of water at sea level is 100°C. or 212°F. The boiling point will vary depending upon the air pressure above the water's surface—the lower the air pressure, the lower the boiling point.
- The freezing point of water is 0°C. or 32°F.
- Cohesion is the tendency of similar particles to stick together.
- The surface of water acts as an elastic membrane; this elasticity is called surface tension.
- Adhesion is the attraction that unlike particles have for each other; the rise of water in capillary tubes illustrates adhesion.
- A well is a hole sunk in the Earth's crust to reach water. It must be deeper than the water-table level at the well's location.
- Washing soda will soften hard water by precipitating the dissolved minerals out of solution.

4

INVESTIGATING THE ATMOSPHERE

What makes a cloud? Why do some winds blow so fast? What makes it rain? How does a weatherman tell what it is going to be like tomorrow? These are a few of the questions the children may have asked about the atmosphere and about the weather. But just what is the atmosphere?

The atmosphere is the outermost sphere of the earth. Without it, life would be impossible. The atmosphere contains oxygen for us to breathe. Rain and snow form in the atmosphere. Without an atmosphere there would be no winds, no fog, no clouds, or smog.

How thick is the atmosphere and what does it consist of? The atmosphere is really a mixture of several gases. Nitrogen is the most abundant, composing about 78% of the air. Oxygen is next with 21%. There are small amounts of other gases, including carbon dioxide (0.03%). Water vapor is also present in the atmosphere, but in varying amounts.

It is believed that the very outer limit of our atmosphere is about 600 miles above the Earth's surface. At this distance, however, the air is extremely thin. Most clouds occur at altitudes of less than 7 miles.

The atmosphere is divided into four layers: the troposphere, the stratosphere, the ionosphere, and the exosphere. The troposphere extends from the ground up to the height at which the temperature stops becoming lower. This height is about ten miles at the equator and the temperature is about −100°F. At the poles the low temperature of the troposphere is only −50°F., and the height is only about 5 miles. The troposphere is the region of clouds and changing weather conditions.

The stratosphere extends from the troposphere upward to about 50 miles. Ozone, which is a form of oxygen, is found concentrated in this zone. Temperatures may rise to 90°F. or higher in this layer; thus, above the atmosphere the temperature begins to rise. Powerful jet streams of air sometimes reach speeds up to 300 miles per hour in the stratosphere, and the air there is always clear and free of dust. Jet pilots often ride in the stratosphere to be above the stormy weather conditions of the troposphere.

The ionosphere extends from 50 to 300 miles above the earth. This zone has in it electrically charged particles of matter called ions. Because of the presence of these ions, the lower layer of the ionosphere has the ability to bounce radio waves back to the earth and thus transmit them for thousands of miles. The temperature in the ionosphere rises steadily with increasing altitude and may get as high as 4,000°F.

The exosphere is that part of our atmosphere beyond the ionosphere and extending out into space. There is very little air in this zone and thus there is very little air resistance.*

In this chapter the children will carry on Activities concerned with the characteristics of air and air masses, the weather, the nature of clouds, and the types of precipitation.

WHAT ARE THE CHARACTERISTICS OF AIR?

Air is a material, or a form of matter. A material is something that occupies space. There are three states of matter: solids, liquids, and gases. Air is a *gas* and exerts a *pressure*, or a push, on objects it comes in contact with. Special instruments measure the amount of pressure that air exerts. These instruments are called *barometers*. Air, being a material, offers resistance to other materials that pass through it. Resistance is the opposition of movement that one substance has toward another substance. Still another property of air is that it can be *compressed*, or squeezed together, into a smaller space.

*For a further discussion of the atmosphere, its layers, and its connection with space science and exploration, see *Space*, by Arthur Costa (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

These characteristics or properties of air will be illustrated in the following section. Encourage the children to formulate and test their own ideas. Have them work carefully and critically as they make discoveries for themselves.

ACTIVITY 67 (x)

DISCOVERING THAT AIR OCCUPIES SPACE

Purpose: To show that air occupies space

Concept to be developed: Since all matter occupies space and air is matter, air occupies space.

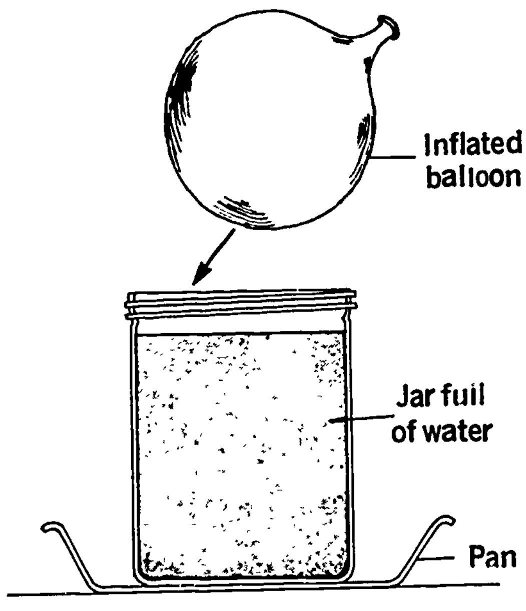
Materials needed:

Wide-mouthed gallon jar or battery jar
Balloon
Water
Receiving pan

INTRODUCTION: Discuss with the children what they think air is. Can they feel it? Does it affect them? How do they know? Suggest that they list their ideas on a chart and use it as a reference as they carry out the Activities given on these pages. Tell the children that the following Activity will help them discover one characteristic of air.

Have one of the children fill the gallon jar or battery jar with water. Place this jar in a pan that will receive the overflow. Have another child partially inflate a long balloon. Have him force the balloon under water so that the entire balloon is under the water surface. Have the children observe what happens to the water in the jar. *(It overflows into the pan.)* Why did the water overflow? *(The balloon took up space and forced the water out.)*

Have the balloon inflated still further and submerge the balloon again. What happens this time? *(Even more water overflows.)* Why did more water overflow? *(More air was added to the balloon.)* What does this show about air? *(Air takes up space.)*



Learning: (x) Air occupies space.

ACTIVITY 68 (y)

CHANGING THE VOLUME OF AIR BY CHANGING ITS TEMPERATURE

Purpose: To show that the volume occupied by a given amount of air varies with its temperature

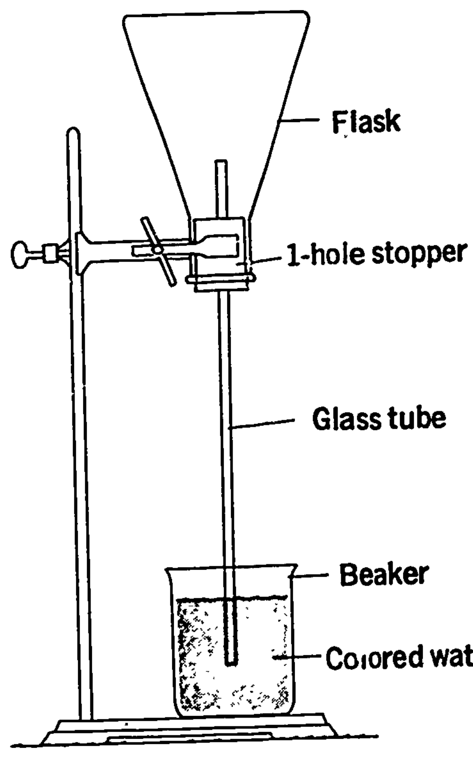
Concept to be developed: A given amount of air takes up more space when it is warmed and less space when it is cooled.

Materials needed:

Glass tube
1-hole stopper
Flask
Thermometer
Hot and cold water
Beaker
Dye or blue ink
Ring stand and clamp (not essential)

INTRODUCTION: Tell the children that they can discover another characteristic of air. Have one of the children set up the equipment as shown in the illustration, using a flask, one-hole stopper, glass tube, and beaker. The water in the beaker should be colored with a dye or with a drop of ink. A ring stand and clamp is helpful to support the flask.

Have one of the children pour some hot water on the inverted flask while the end of the glass tube is submerged in the beaker of water. What happened? *(Bubbles came out of the glass tube.)*

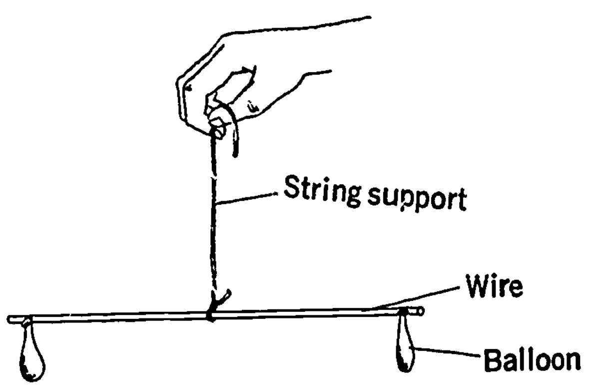


What were these bubbles? *(Air that was in the flask.)* Why did air come out? *(It was warmed by the hot water and took up more space.)*

Allow the apparatus to stand for several minutes. Do not pour any more hot water over the flask. Have a child make certain that the end of the tube is still under the water surface. Discuss the new change that occurs. *(Water rises in the glass tube.)* Why? *(As the air cools in the flask, it takes up less room. The air pressure on the water in the beaker, which is now greater than the air pressure in the flask, forced the water up the tube.)*

The children might speculate about what would happen if they placed some cold water on the flask. Let them try it and see. They might want to measure the number of inches the water rises when they use water of different temperatures.

Learning: (y) Air takes up more space when it is heated and less space when it is cooled.



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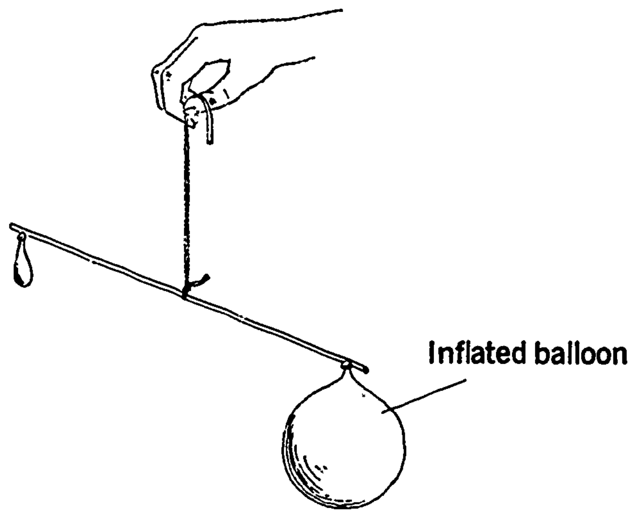


B

ACTIVITY 69 (x,y)

OBSERVING THAT AIR HAS WEIGHT

Purpose: To show that air has weight

Concept to be developed: One of the properties of matter is that its weight can be measured. Since air is matter, its weight can be measured.

Materials needed:

Coat hanger
2 balloons
2 paper clips
String
Thumbtack

INTRODUCTION: Have the children discuss the characteristics that they have discovered about air. Let them check these with the original list. The following Activity will help children to discover that air has weight.

Stretch out a metal coat hanger so that it is one piece of straight wire. Have the children make a balance out of this wire by suspending it with a piece of string tacked to a doorway or bulletin board with a thumbtack. Suspend a balloon from each end of the wire by means of a paper clip. Have one of the children make certain that the balloons have a designated spot on the wire by fastening a piece of scotch tape to the wire to mark the designated spot. (If either balloon is moved from its spot, the system will no longer be in balance.) What does this equal balance show? *(That the weight on each side of the balance is the same, or equal.)*

Now have another one of the children remove one of the balloons and inflate it. He should replace the paper clip so that the balloon will remain inflated and replace the balloon on the same spot on the hanger. What is the appearance of the balloon? *(It is more fully inflated.)* What is now inside the balloon? *(More air than there was before.)* What happens to the arm of the wire having the inflated balloon on it? *(It is lowered.)* Why? *(With more air in it, the balloon has gained in weight.)*

Learning: (x,y) Air has weight.

ACTIVITY 70 (y,z)

SEEING THAT WARM AIR WEIGHS LESS THAN COLD AIR

Purpose: To show that warm air weighs less than an equal volume of cold air

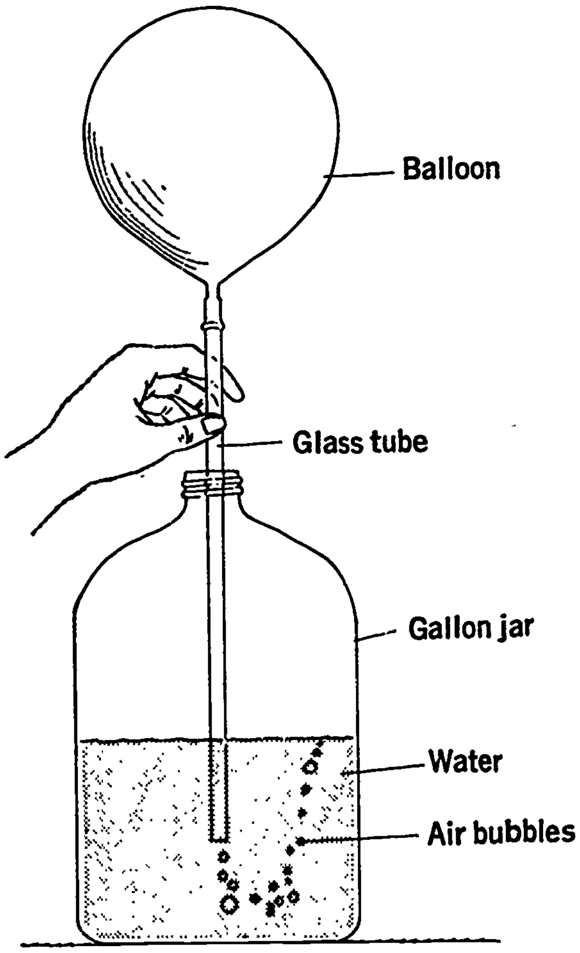
Concept to be developed: There is less matter in a given volume of warm air than there is in an equal volume of cold air; therefore, the volume of warm air will weigh less.

Materials needed:

Two balloons
Glass tube
1-gallon jar half full of water
Beaker of hot water
Paper clips
Coat hanger
Thumbtack
String

INTRODUCTION: Now that the children have seen that air has weight, ask them if they think that equal volumes of air always have the same weight. Remind the children of the Activity they have just finished. Tell them that there is another Activity that will enable them to determine if equal volumes of air always have the same weight.

Suspend the coat hanger in the doorway or on the bulletin board as in Activity 69. Then blow up two balloons to about the same size (about one-half total capacity). Place these on the coat-hanger "balance." Do the equal volumes of air have the same weights? *(Yes.)* How do the children know this? *(The balloons balance on the coat hanger.)* Next have the children take the balloons off the balance (after marking the spots where they were placed) and slip a length of glass tubing into the opening of one balloon. (Caution the children to be careful that they do not dislodge the paper clip that is holding the air in the balloon.) Have them place the opposite end of the glass tube into a one-gallon jar that is half full of water and then pour hot water over the balloon. What happens? *(The balloon becomes larger.)* Why? *(The air in the balloon expands when it is warmed by the water.)* Have the children remove the tube and attach both balloons to the coat-hanger "balance" in their original positions. Are the weights of the two balloons still equal? *(Yes.)* Why? *(Although one balloon has become larger, the amount of air inside it has not changed. Since both balloons contain the same amount of air, their weights are equal.)*



Next have the children remove the balloons from the coat hanger, reinsert the glass tube into the larger balloon, place the tube in the jar of water, and pour warm water over the balloon once again. When the balloon has enlarged to about twice the size of the smaller one, have them remove the paper clip. What happens? *(Air leaves the balloon.)* How do the children know this? *(They can see the bubbles rising from the bottom of the glass tube through the water in the jar.)* When the heated balloon has reached the size of the smaller balloon, have a child replace the paper clip and attach the two balloons to the coat-hanger "balance" once again. Is the weight of the two balloons equal? *(No.)* How do the children know this? *(The balloons do not balance.)* Which balloon is heavier? *(The one in which the air was not warmed.)* Are the volumes of the balloons the same? *(Yes, since they are the same size.)* How can the volumes be the same but the weights different? *(Since the air was seen to leave the heated balloon, the children know that there is less air in this balloon than in the other, even though the two balloons are of the same volume. Therefore, since air has weight, and since there is less of it in the balloon that was heated, this balloon weighs less.)*

Learning: (y,z) Warm air weighs less than an equal volume of cooler air. Equal volumes of air weigh the same amount only if their temperatures are equal.

ACTIVITY 71 (x,y)

DISCOVERING AIR PRESSURE

Purpose: To show some of the things that air pressure can do

Concept to be developed: Air pressure can force water out of a tube or can hold it in under specific conditions.

Materials needed:

Glass of water
Glass tube

INTRODUCTION: Point out to the children that many interesting discoveries can be made about the effects of air pressure by using just a glass tube and a glass of water.

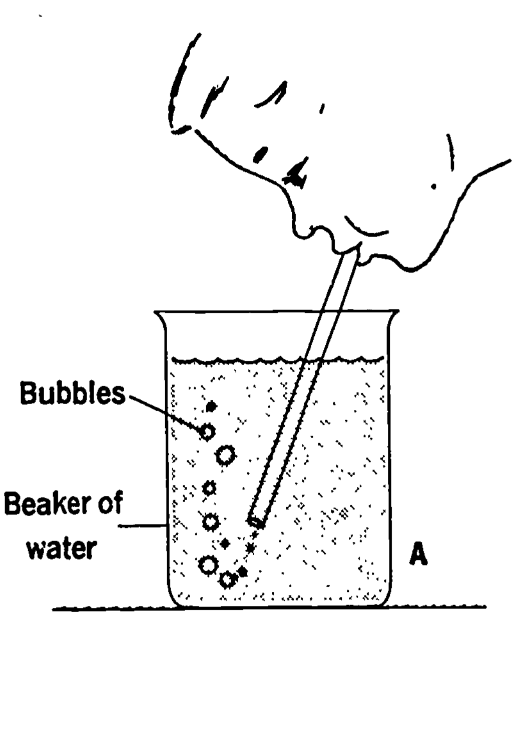
Give the children some clean glass tubes and let them discover different things they can do with the tube and a glass of water. Here are a few possibilities:

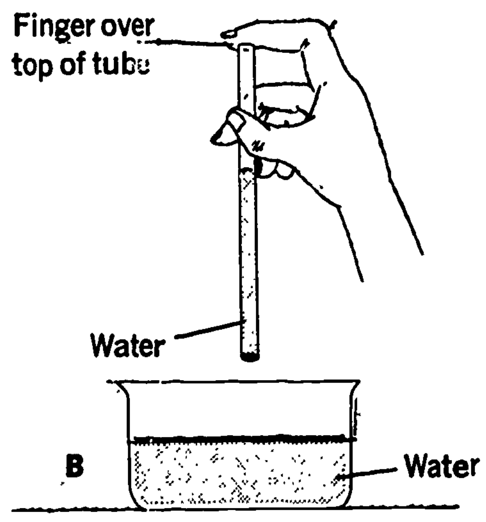
Blow bubbles in the water. Air can be forced into the tube and can rise through the water as bubbles.

Air can be forced part way down the tube and held at that point if the pressure is maintained by blocking the passage of air (the top of the tube) with a finger or the tongue, or sustaining in some other way the pressure that forced the air down.

Water enters the tube and rises to the height of the water in the beaker if the top of the tube is left open. Why? *(Air pressure forces water up the tube.)* Perhaps the level of the water in the tube is slightly higher because of adhesion of water to the sides of the tube.

Water will remain in the tube if the upper end of the tube is blocked by a finger and the tube is lifted from the water. The air pressure on the bottom of the tube holds the water in place.





If the finger is withdrawn, the water flows out. This happens because the air pressure is now equalized on both ends of the tube, so the weight of the water forces the water out.

Water can be forced to rise in the tube if air is withdrawn from the tube. The pressure of the air pushing down on the surface of the water, being greater than the reduced pressure in the tube, forces water up the tube.

Learning: (x,y) Air pressure can force water out of a tube or can hold it in the tube when specific conditions are provided.

ACTIVITY 72 (x,y,z)

MAKING A MINERAL OIL BAROMETER

Purpose: To construct a simple barometer

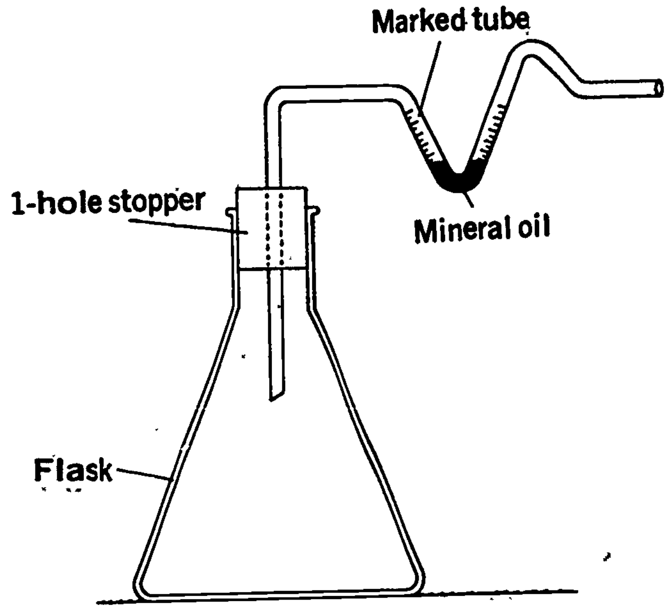
Concept to be developed: Differences in air pressure affect the position of a liquid in a tube sealed at one end.

Materials needed:

Flask
1-hole stopper
Mineral oil
Medicine dropper
S-shaped glass tube

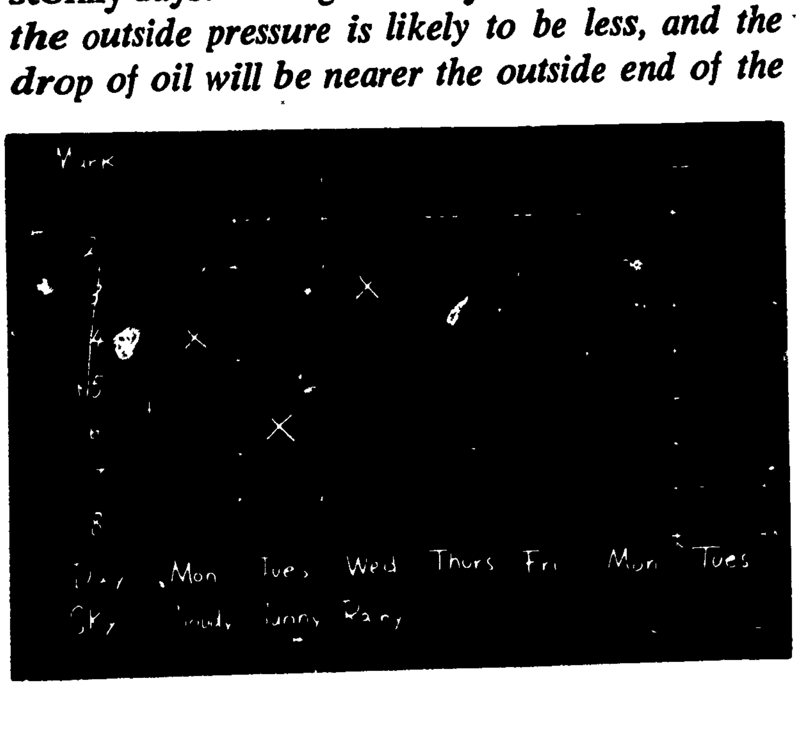
INTRODUCTION: Show the children a barometer and ask them if they can explain how it works. Write the word barometer *on the chalkboard. Encourage their ideas. Bring out in the discussion that a barometer is an instrument that measures the pressure of the atmosphere. Suggest that some children might like to make their own barometer and compare its performance with that of a commercial barometer to verify its accuracy. The following Activity shows a way to make one.*

Have some of the children set up the equipment as shown in the illustration. Insert a one-hole stopper into a flask or jar. Place an S-shaped tube into the stopper. (The S-shaped tube can be



easily made by heating a straight glass tube in a propane burner flame and applying pressure with a tweezer.) Have one of the children drop enough mineral oil into a portion of the tube so that about ½ inch of oil is "trapped" in the tube. Suggest that they mark off the position of the oil. Have a child blow into the tube with only slight pressure. What happens to the oil? *(It moves toward the flask.)* Why? *(The pressure on one side of the oil has become greater than the pressure on the other.)* Then have him withdraw a little air from the tube. What happens to the oil now? *(It moves toward the child.)* Why? *(The pressure on the other side of the oil is now greater.)*

Allow the apparatus to remain for several days. Have the children observe the effect of changing air pressure on the position of the oil and keep a record of their observation. Stress the importance of making careful observations. Does the outside pressure increase or decrease during stormy days? During clear days? *(On stormy days the outside pressure is likely to be less, and the drop of oil will be nearer the outside end of the tube. On clear days the outside pressure is likely to be more, and the drop of oil will be farther from the outside end of the tube.)*



Children should plan how to record their observations. The chart below shows one kind of record they might keep. Help them to summarize their findings. Why are there differences in the position of the oil? What causes these differences? How does the kind of weather condition outside affect the position of the oil?

Learnings: (x,y,z) Differences in air pressure affect the position of a liquid in a tube that is sealed at one end. Sealing the tube keeps the air pressure at this end constant. Movement of the liquid demonstrates that the pressure of atmosphere changes from day to day. (x,y) Stormy weather is usually associated with a lowered atmospheric pressure.

ACTIVITY 73 (y,z)

MAKING A CARTESIAN DIVER

Purpose: To show that air can be compressed by applying pressure to it and expanded by releasing that pressure

Concept to be developed: Compressed air exerts a greater pressure on water than does noncompressed air.

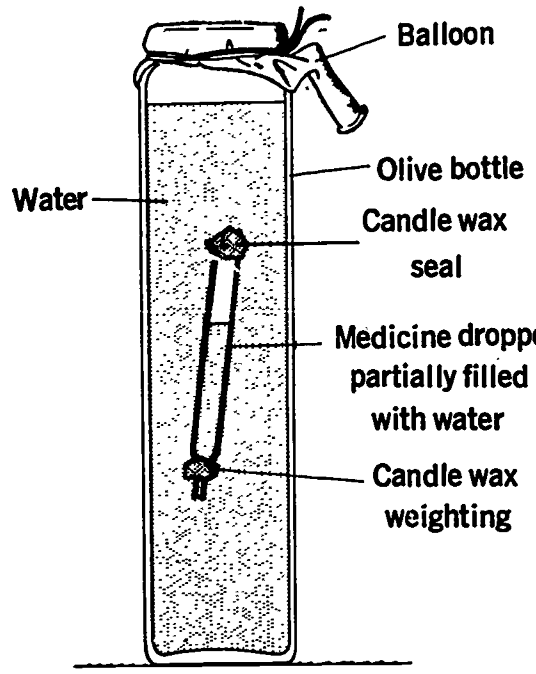
Materials needed:

- Olive bottle
- Water
- Medicine dropper
- Balloon and string

INTRODUCTION: The following Activity will help children gain further understanding of the characteristics of air. They can discover more about the pressure, or force, that air exerts.

Have one of the children remove the rubber bulb of a medicine dropper and fill the dropper with enough water so that it will just barely float in an olive bottle filled to within 1 inch of the top with water. (Seal the wide end of the dropper with wax from a melted candle. It may also be necessary to weight the lower end of the dropper with the melted wax to make the dropper remain in a vertical position.) Stretch a heavy balloon over the olive bottle and secure it with string.

Have the child apply pressure on the balloon with his finger. What happens to the medicine dropper? *(It fills with more water and sinks to*



the bottom of the jar.) Why does it sink? *(It became more dense because water was forced into the dropper.)* What forced the water into the dropper? *(The increased pressure on the balloon increased the pressure of the air above the water; thus, the pressure of the air outside the dropper became greater than the pressure of the air inside the dropper and water was forced in.)*

Have the child release the pressure on the balloon and have him explain the results. *(The dropper rises because the pressure is released. The air in the dropper is able to expand against the lowered air pressure in the jar and the water is forced out of the dropper. This reduces the dropper's density, so the dropper rises.)*

Learnings: (y) Air can be compressed by the increase of pressure and expanded by the release of pressure. (y,z) Compressed air exerts a greater pressure on water than noncompressed air.

ACTIVITY 74 (y,z)

COMPRESSING AND EXPANDING AIR WITH A PUMP

Purpose: To observe some of the effects of the expansion and compression of air

Concept to be developed: Air becomes warmer as it is compressed and cooler as it expands.

Materials needed:

Bicycle pump or ball pump

INTRODUCTION: Bicycle and ball pumps are familiar objects to most children. Discuss this type of pump with them. What does it do? They should be able to state that it is used to force air into a space already occupied by some air. Have several different pumps brought into the classroom. You may want to have the children examine one and take it apart. They should notice on preliminary observation that each has a handle attached to a rod. At the end of the rod there is a disk that allows air to move only in the direction of the hose (a "needle" in the case of the ball pump).

Now have the children examine the pump to see why air can move only in one direction. (Have them examine the movement of the washer surrounding the disk.) Discuss their hypotheses, and test these as the children examine the way the pump works.

Have them work the pump to compress air. What happens to the air as the disk pushes down upon the air column inside the pump? *(The air is compressed and is forced out of the smaller exit.)* What happens to the temperature of the air inside the pump? *(The temperature rises.)* How do you know? *(The pump barrel gets warmer.)*

What happens to the warmed air as it is forced out of the smaller end? *(As it is released it expands and feels cooler.)*

Learning: (y,z) Air becomes warmer as it is compressed and cooler as it expands.

Summing Up Ideas: The class has performed Activities to learn about the characteristics of air as a form of matter. They found out that air occupies space and that the volume of air increases and decreases with changes of temperature. They performed Activities involving weighing air as a material substance. They discovered that air exerts a pressure and can also flow as a current. In addition, they found that air offers resistance and can be compressed.

WHAT ARE THE CHARACTERISTICS OF AIR MASSES?

A knowledge and understanding of *air masses* is essential in the study of weather. Air masses are huge assemblages of air with definite characteristics that can be measured with various instruments. Certain air masses are termed *continental air masses;* these form over land. *Maritime* air masses are those that form over water. An *arctic* air mass forms over arctic regions. A *polar* air mass originates in the polar regions and a *tropical* mass originates near equatorial latitude.

The surface over which air masses rest has certain characteristics it gives to the air masses over it. These characteristics involve the major differences of temperature and water content. A warm body of water may give the air mass over it the characteristics of warmth and moisture. A dry, warm land area may give the air mass over it the characteristics of a warm, dry air mass. Air masses, likewise, could be cold and dry or cold and moist. As air masses remain over the land or water surface for a longer time, they tend to assume to a greater degree the characteristics of the surface features.

ACTIVITY 75 (x,y,z)

POSTING DAILY WEATHER MAPS

Purpose: To familiarize the children with weather maps

Concept to be developed: Knowledge of existing weather conditions is important in weather predictions.

Materials needed:

Daily weather map from the newspaper

Have a member of the class collect and post a daily weather map from the newspaper. Have him point out the changes each day. Some of the changes would involve the following:

Movement of highs and lows: these are areas where the air masses have high pressures or relatively low pressures. They generally move from west to east.

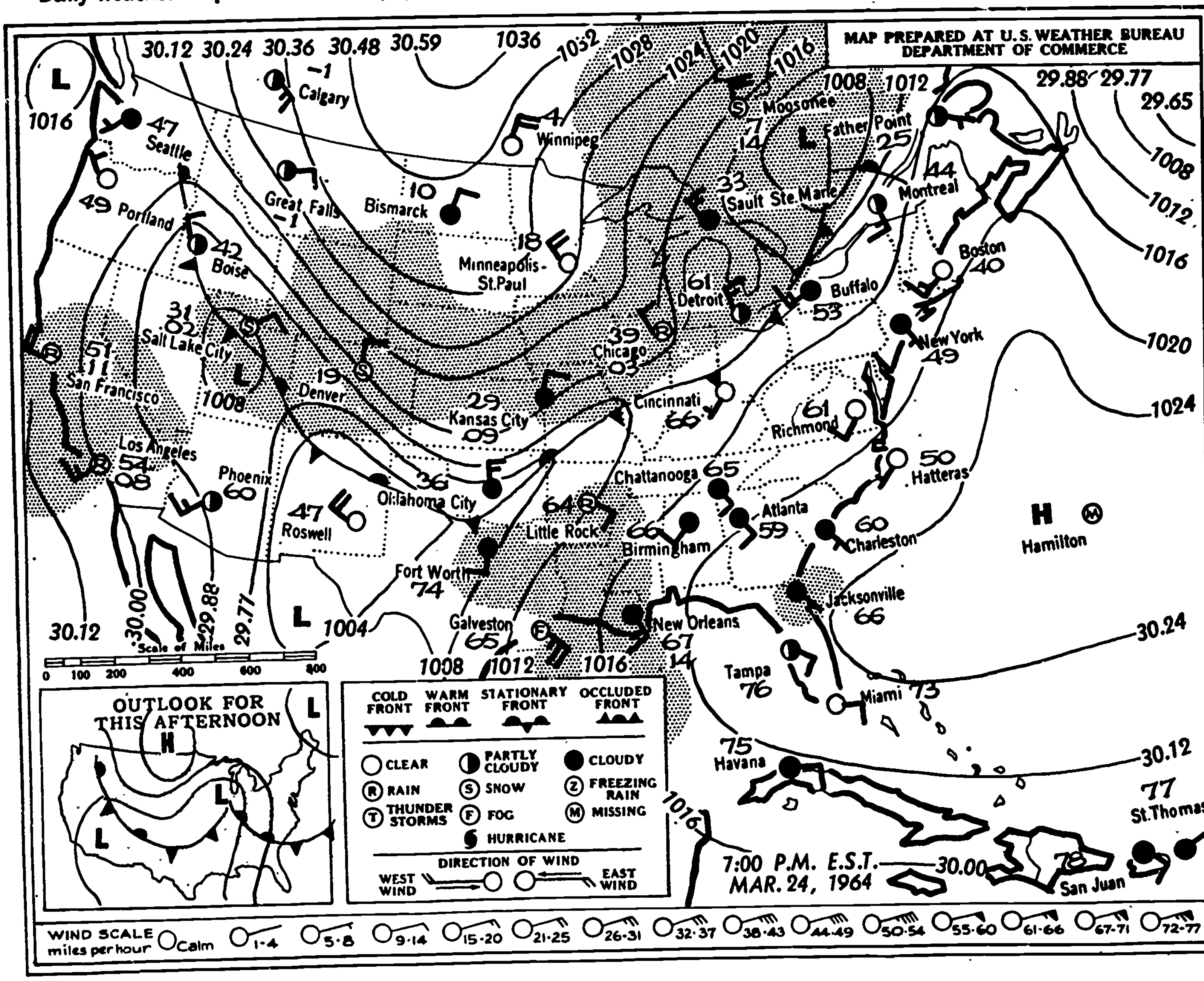
Movement of winds: these are generally indicated by arrows showing the direction of the wind. What is the movement around a high? *(Clockwise.)* Around a low? *(Counterclockwise.)*

Sky condition: a clear circle or area represents a clear sky and a shaded circle or area represents an overcast (cloudy) sky.

Areas of precipitation: shaded areas indicate rain. Dotted areas indicate snow.

Cold and warm fronts: fronts are indicated by a single or double line with the temperature condition generally printed behind the front. Arrows often indicate the direction the front is moving.

Have several members of the class predict



what the general conditions of weather will be the next day, based upon a study of several daily maps. Have them write out and "post" their predictions. Check the predictions the next day to see how many were correct.

Learnings: (x,y,z) Weather maps indicate atmospheric conditions including temperature, pressure, sky conditions, precipitation, winds, and location and movement of cold and warm air masses. (x,y,z) Knowledge of weather conditions is important in weather predictions.

ACTIVITY 76 (y,z)

PRODUCING A MINIATURE COLD AIR MASS

Purpose: To show that a cold air mass flows downward and underneath a warm air mass

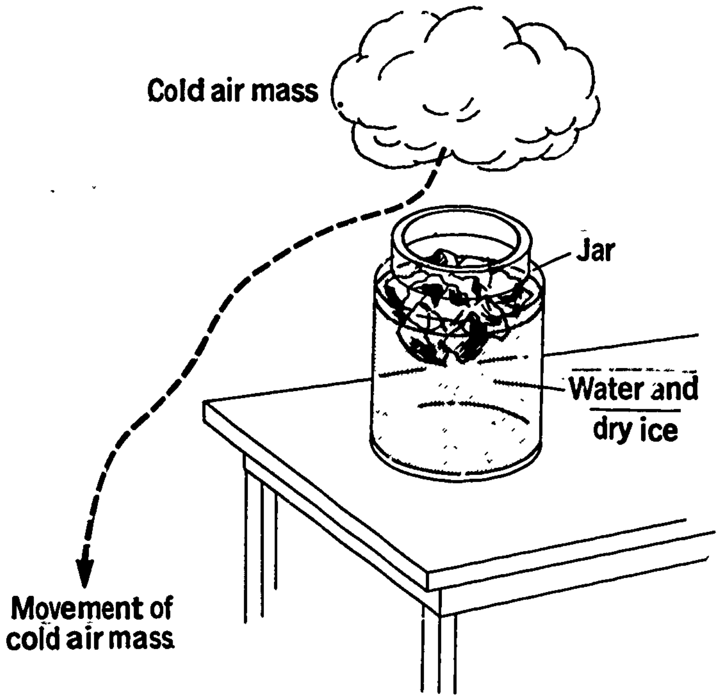
Concept to be developed: A cold air mass takes the temperature characteristics from the surface it flows over.

Materials needed:

Dry ice
Table
Jar of water
Thermometer
Hammer

INTRODUCTION: From their study of weather maps, children will discover the term air mass. *Encourage them to guess how they think warm and cold air masses are formed. Explain that cold air masses in nature are produced over extremely cold land areas or over ice-covered fields. The areas are cold because the angle of the sun's rays is very low or because the sun's rays do not strike them for long periods of time.*

In the following Activity the children will produce their own miniature air mass which will take on the characteristics of the surface it rests over.



Have the class prepare a cold area by crushing a piece of dry ice with a hammer and placing a few chips in a jar of water. (*Caution:* Wrap the dry ice in newspaper before breaking it. Its temperature is −80°C. and direct contact may cause serious skin injury. You and the children should use gloves or tongs in handling the dry ice.) The children should observe what happens over a period of time to the air above the jar. *(The air is cooled and the moisture condenses into "clouds.")* Where is the air mass the highest? *(Just over the cold jar.)* What happens to the air as it cools? *(It flows down over the table top and flows off the edge toward the floor.)* To what tool might the edge of the cold front be compared? *(To a wedge as it flows along under the warmer air.)* Which is denser, warm air or cool air? *(Cool air.)* How do the children know this? *(In Activity 70, the children discovered that a volume of warm air weighed less than an equal volume of cold air. Since density is weight per unit volume, the cold air must be the denser of the two.)* Why does the cold air sink beneath the warm air? *(Because it is more dense.)*

Have one of the children measure the temperature of the cold air mass. Also have him measure the temperature of the warmer air mass above it. What is the difference in temperature?

Learnings: (y,z) A cold air mass takes its characteristics of temperature from the surface it forms over. (y,z) A cold air mass flows downward and underneath a warm air mass.

ACTIVITY 77 (y,z)

LEARNING ABOUT COLD FRONTS AND WARM FRONTS

Purpose: To demonstrate that a denser fluid tends to sink downward and act as a wedge to shove a lighter fluid upward

Concept to be developed: Cold fronts are denser than warm fronts and tend to move down, pushing the warmer air up over the top of the colder air.

Materials needed:

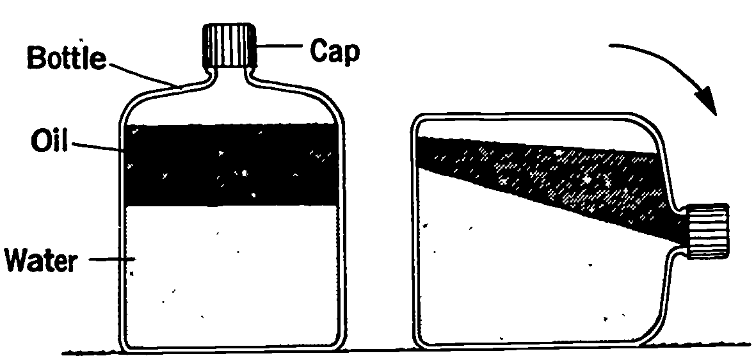
Quart bottle (A flat one with a cork is preferable.)
Pint of heavy motor oil
Water

INTRODUCTION: Point out that the children may have seen the word front *on the weather maps they studied. In this Activity, the class will make a sim-*

ulated cold and warm front to give meaning to the term. Explain that a front is the boundary between two different air masses.

Have one of the children fill a quart bottle half full of heavy motor oil and half full of water. Which liquid is the denser of the two? *(The water.)* How can the children tell? *(The oil rises above the water.)* Point out that the water represents the heavier and colder air.

Have the child cork the bottle and slowly turn the bottle on its side. How does the denser fluid move? *(As if it were a wedge shoving up the less dense fluid.)* What is the final position of the denser fluid? *(Again, it is on the bottom.)* Show the relationship to warm and cold fronts by asking, If the denser fluid moves toward a less dense fluid, would the leading edge of the denser fluid be at the ground or above the ground? *(At the ground—it acts as a wedge.)* If the less dense fluid moves towards a denser fluid, would the leading edge of the less dense fluid be at the ground or above ground section? *(Above the ground.)*



Learnings: (y,z) A denser fluid tends to sink downward and will act as a wedge shoving the lighter fluid upward. (y,z) Cold fronts are denser than warm fronts and tend to move down, pushing the warm air up over the top of the colder air.

ACTIVITY 78 (y,z)

MAKING AN AIR-CURRENT BOX

Purpose: To show how air currents move

Concept to be developed: Winds are caused by the movement of air as warm air rises and cool air sinks.

Materials needed:

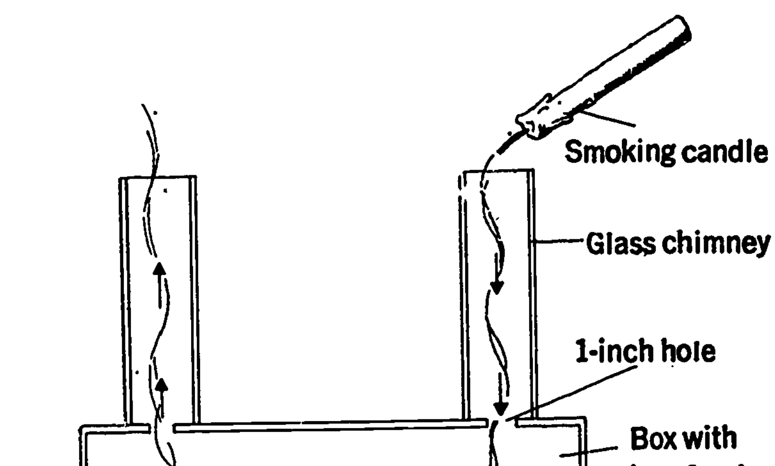
Small box (wood or cardboard)
2 glass chimneys
Pane of glass to fit open side of box
2 candles
Match

INTRODUCTION: Tell the children that they can also experiment with movement of gases to demonstrate the movement of cold and warm air fronts. Obtain a small box similar to a chalk box. Bore two holes on one of the long sides of the box, one near each end. The holes should be about 1 inch in diameter. Place a glass chimney over each hole. Cover the front of the box with the pane of glass, as shown in the illustration.

Discuss with the children the comparison between the box and outdoor conditions. The heat from the candle represents the heated (by the sun) land conditions.

Have the children place a smoking candle over the chimney that is not above the candle in the box. What happens? *(The smoke above the burning candle inside the box goes up; the smoke above the other chimney goes down into the box.)* Why does the smoke go into the box? *(As the burning candle in the box warms the air around it, the warm air rises up the nearest chimney and a current of air is produced. This current of air corresponds to a wind.)* Why does one air current go down? *(The cool air, which is more dense, flows down to replace the warm air that is flowing up; when air goes up in one area, other air must come down to replace it.)* This is a circulation of air called a *convection current.* Warm air rises and cold air comes down to take its place, since the cold air is more dense.

The children may like to guess which would be the most effective way of heating a room — by having a heater on the floor level or a heater



hung at the level of the ceiling. Why? *(It would be best at the floor level, for then the warmed air would rise and the cold air would sink down to the heater to be warmed. This would also result in a better circulation and mixing of the air.)*

Perhaps some children would like to try a candle having a very short wick giving a small flame, and a candle having a long wick giving a larger flame inside the box. Some children might like to try the experiment without chimneys or with even longer chimneys made of cardboard.

Learnings: (y,z) Air currents move because of variable densities of air. (y,z) Heated air is less dense and tends to rise. Cool air is more dense and will sink. (y,z) Winds are caused by convection currents.

ACTIVITY 79 (x,y)

DETERMINING WIND DIRECTION

Purpose: To demonstrate the use of a wind vane

Concept to be developed: Winds are named for the direction from which they are coming.

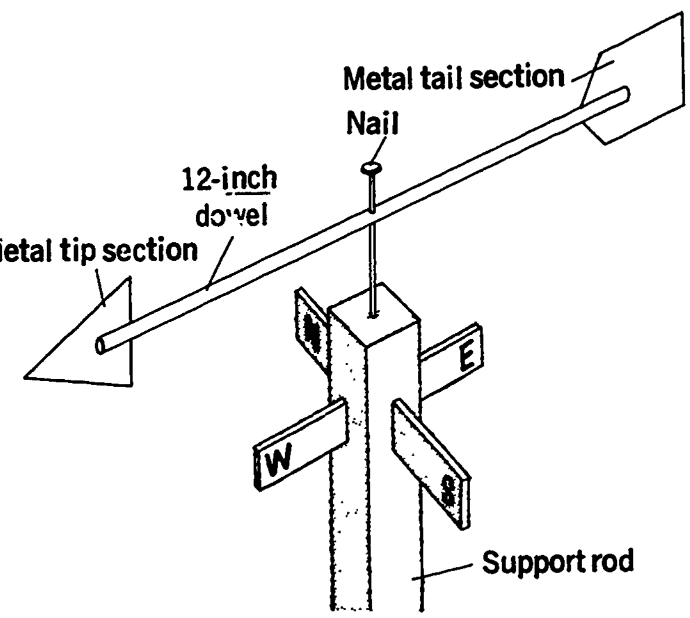
Materials needed:

- Dowel rod
- Drill
- Nail
- Support rod
- Tin can
- Tin snips

INTRODUCTION: Suggest to the children that since they have already made a barometer, they may want to make their own weather station and keep a record of their observations. Here is another instrument they might add to their station, a wind vane.

The children can make the wind vane in the following way. Have them use a tin snips to cut a triangle and tail fin out of a tin can. Have the children insert these into a 12-inch dowel rod, which is separated at each end to receive the metal parts. Next, have them drill a small vertical hole at the balance point of the rod — the fulcrum. Have the children place the wind vane on a nail protruding from a support rod. The rod should be high enough to be in the path of unobstructed winds. The vane should be able to swing freely around the nail.

Have them indicate the compass readings of north, south, east, and west below the wind vane as shown in the illustration.



If the wind comes from the north, it is a north wind; if the wind comes from between the north and east it is a northeast wind and the vane points in that direction. The vane points in the direction from which the wind is coming, and that is the name given to the wind. The children should make a chart indicating the wind direction at a given time each day for several weeks. Have them compare their findings with the official wind direction as printed in the local newspaper.

Learnings: (x) A wind vane indicates the direction from which the wind is coming. (x) Winds are named for the direction that the winds come from.

ACTIVITY 80 (x)

DETERMINING WIND VELOCITY

Purpose: To introduce the children to the Beaufort Scale

Concept to be developed: The velocity of the wind can be estimated by seeing how it affects certain objects.

Materials needed:

- Chart paper

Have the children prepare a chart showing the wind velocity at a certain time each day. They may want to use the Beaufort Scale (named after Admiral Beaufort, who introduced it into the English navy about 1805) in determining the velocity of the wind in their school area.

Encourage the children to make their own observations of other land indications. (The degree to which a flag might wave could indicate the velocity of the wind.) How does the velocity they estimate compare with the wind velocity given in the newspaper for the locality?

MEASURING WIND VELOCITY

Beaufort Scale number	Velocity (in m.p.h)	Wind name	Land indication
0	less than 1	calm	smoke rises vertically
1	1–3	light air	smoke drifts
2	4–7	slight breeze	leaves rustle
3	8–12	gentle breeze	small twigs in motion
4	13–18	moderate breeze	small branches in motion
5	19–24	fresh breeze	small trees sway
6	25–31	strong breeze	large branches move
7	32–38	high wind	whole trees move
8	39–46	gale	twigs break off
9	47–54	strong gale	loose shingles tear off
10	55–63	whole gale	some trees uproot
11	64–75	storm	severe damage
12	Above 75	hurricane	widespread destruction

Learnings: (x) The velocity of the wind can be estimated by observing how certain things move. Winds over 60 miles per hour usually result in considerable damage to trees and buildings.

ACTIVITY 81 (x,y,z)

STUDYING WIND DIRECTION AROUND PRESSURE CENTERS

Purpose: To show the direction of wind flow around air masses

Concept to be developed: The wind travels clockwise around high-pressure areas and counterclockwise around low-pressure areas.

Materials needed:

Daily weather maps

Have the class study a collection of several weeks of daily weather maps. Have them discuss the following questions: How can you tell where high-pressure centers and low-pressure centers are located? *(The words* high *and* low *are indicated on the maps.)* In what direction do these centers generally move? *(Generally from west to east.)* How many days does it take them to move across the country? *(It takes generally about five to seven days, although some centers may remain in the country for several weeks.)*

In what direction do the winds move in a high-pressure area? *(They move around it in a clockwise direction, the direction in which the hands of a clock move.)* How do the winds around a low move? *(They move in a counterclockwise direction.)* If a high is approaching, what kind of winds would probably be approaching? *(Northerly winds.)* Would you expect warmer or cooler weather from that direction? *(Cooler.)* If a low is approaching, what kind of winds would probably be approaching? *(Southerly winds.)* Would you expect warmer or cooler weather from that direction? *(Warmer.)*

Learnings: (x,y,z) Wind spins are clockwise around a high and counterclockwise around a low. (x,y,z) Highs and lows usually move from west to east across the country.

ACTIVITY 82 (x,y)

COMPARING AIR TEMPERATURE AND GROUND TEMPERATURE

Purpose: To establish that there is a difference between air temperature and ground temperature

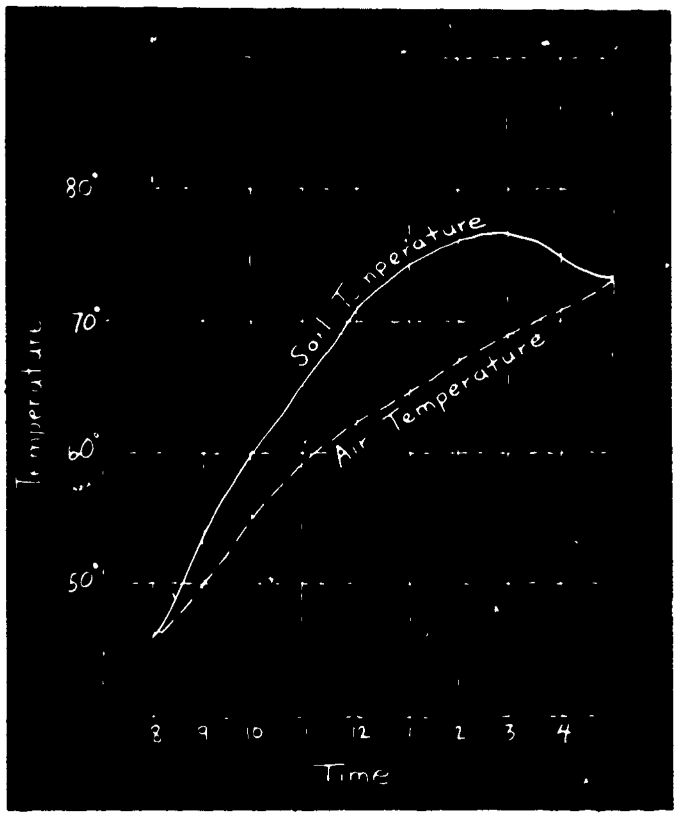
Concept to be developed: The Earth heats up first and then warms the air around it.

Materials needed:

2 thermometers
Chart paper

INTRODUCTION: Suggest the thermometer as another instrument the children might add to their weather station. The Activities that follow will help the children to expand their understanding of temperature and its relation to movements of air.

Have the children push a thermometer into the ground. Another thermometer should be placed so that it is about 5 feet above the ground. Have the class take and record the readings on the two thermometers at one-hour intervals. The



day should be a clear day. You might have them graph the difference between the two readings at hourly intervals.

Which thermometer indicates the higher temperature? *(The ground thermometer.)* Why? *(The atmosphere is heated mostly by the Earth. The atmosphere absorbs only about one sixth of the radiation from the sun; the Earth's surface absorbs about one half of the radiation. The atmosphere is heated as the Earth radiates heat.)*

Learnings: (x,y) There is a difference between ground temperature and air temperature. (x,y) The Earth heats up first and then warms the air.

ACTIVITY 83 (x,y)

COMPARING WATER, SOIL, AND AIR TEMPERATURES

Purpose: To demonstrate that the lithosphere warms faster than the hydrosphere, and that both of these warm faster than the atmosphere

Concept to be developed: Sunlight warms a water surface much more slowly than it does a land surface.

Materials needed:

4 thermometers
2 ceramic bowls of identical size.
Water
Soil
String

INTRODUCTION: Review with the children that light from the sun warms the soil, which in turn warms the air above it. In the preceding Activity the children observed that the soil warms up first. Now suggest that the children compare the heating of soil and water with that of air.

Have the children place some dry soil in one ceramic bowl and some water in the other. Make sure that the soil and water both come up to the same level in the bowls. Place a thermometer in the dry soil, another in the water, and suspend the other two in the air just above the soil and the water. Allow the series to remain in a shaded part of the room until all the thermometers register approximately the same temperature.

Then have the children place both of the setups in the sun. Have them take and record the temperatures at one-hour intervals. They might like to make a graph of the temperatures, as they did in Activity 82.

Which heats the fastest? *(The soil.)* Which heats most slowly? *(The air.)* Why is the water heated more slowly than the soil? *(More heat is needed to warm water than to warm almost any other substance. Soil is opaque and absorbs sunlight at the surface. Water is partially transparent and absorbs only a small part of the solar radiation. Heated water is moved and circulated by water currents. Water conducts heat downward more rapidly than does soil. In addition, heat from the sun causes water to evaporate, and evaporation is a cooling process.)*

The children may want to discuss the effect a large body of water has upon the air above it. Why is it cooler at the ocean in the summer than it is inland? *(The ocean does not get as hot as the land and therefore does not heat the air up as much.)* Why is it warmer at the ocean in the winter than it is inland? *(The water heats up slowly, but it also cools down slowly. The water remains warmer in the winter than the soil and so tends to keep the air above it warmer also.)*

Learning: (x,y) Sunlight warms a water surface much more slowly than a land surface.

Summing Up Ideas: In this section the children were introduced to some of the characteristics of air masses. They learned how air masses are recorded on weather maps and what other types of information can be found on these maps. They worked with hot and cold air masses, saw how these caused convection currents (winds) in the atmosphere, and learned about wind direction and velocity They also saw how the temperature of the atmosphere was affected by the temperature of the lithosphere and by the temperature of the hydrosphere.

HOW DOES MOISTURE GET INTO THE ATMOSPHERE?

The children are aware that there is moisture in the air. In the preceding section they saw how this moisture was recorded on weather maps when it left the atmosphere in the form of rain and snow. The Activities in this section will help them answer the question: How does moisture get into the atmosphere?

ACTIVITY 84 (x)

MEASURING WATER LOSS BY EVAPORATION

Purpose: To show that water can escape into the air

Concept to be developed: Any wet object will evaporate water into the air.

Materials needed:

Sponge
Water
Spring balance

Have the children determine and record the weight of a dry sponge by tying a thread around it and suspending it on a spring balance. (The weight of the thread is negligible.) Then have them soak the sponge in water and allow it to drip until no more drops fall from it. Have them reweigh the sponge and record the weight of the sponge and water. (Some sponges may weigh almost ten times their original weight when they are filled with water.)

Have the children allow the sponge to remain suspended in the air and reweigh it at two-hour intervals. Suggest that they make a graph showing the loss of weight. Discuss why there is this loss of weight. It is the result of the evaporation of the water into the atmosphere. What is the weight of the sponge in 24 hours? *(It should be the same as the original weight.)* What does this show? *(That all the water has evaporated.)*

Learnings: (x,y) A sponge may absorb several times its weight in water. (x) The sponge loses its water through evaporation into the air. (x) Any wet object will evaporate water into the air.

ACTIVITY 85 (x,y)

MEASURING THE WATER LOSS FROM SOIL

Purpose: To show that soils evaporate moisture into the atmosphere

Concept to be developed: Soils lose water to the air through the process of evaporation.

Materials needed:

Flower pot
Soil
Balance scale

Have the children fill a flower pot full of garden soil. Have them feel the texture of the soil. *(The soil should feel moist.)* What is the color of the soil? *(It should look dark in color.)*

Have them weigh the flower pot full of soil and record the weight. This is most easily done on a balance.

In 24 hours have them weigh and record the weight again. How does this weight differ from the first one recorded? *(It is much lighter.)* Why is the soil lighter? *(Because of the water loss.)* How was the water lost? *(Through the liquid water's being turned into a vapor—the process of evaporation.)*

Perhaps the children will think of weighing the soil daily for a week to note any further loss. They might graph this water loss.

What is the texture of the top soil in the flower pot after several days of standing? *(It looks lighter in color and feels dryer.)* Dig under the top layer and make further observations. *(The soil looks more moist farther down.)* Where did more evaporation occur? *(In the upper layers of the soil.)*

Learnings: (x) Soil loses moisture to the air through the process of evaporation. (x,y,z) Most of the evaporation occurs in the upper layers of the soil.

ACTIVITY 86 (x,y)

DETECTING THE MOISTURE LOSS FROM PLANTS

Purpose: To show that plants lose water to the atmosphere

Concept to be developed: Plants lose water through their leaves; this water enters the air as water vapor.

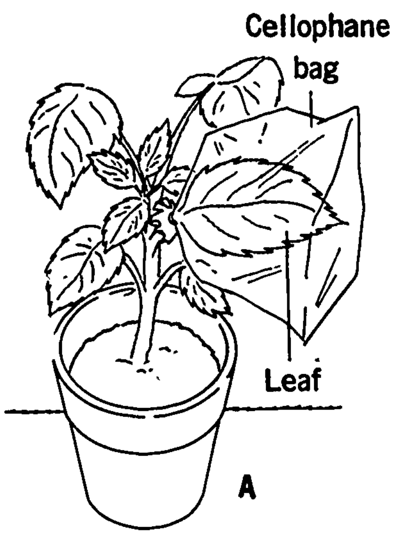
Materials needed:

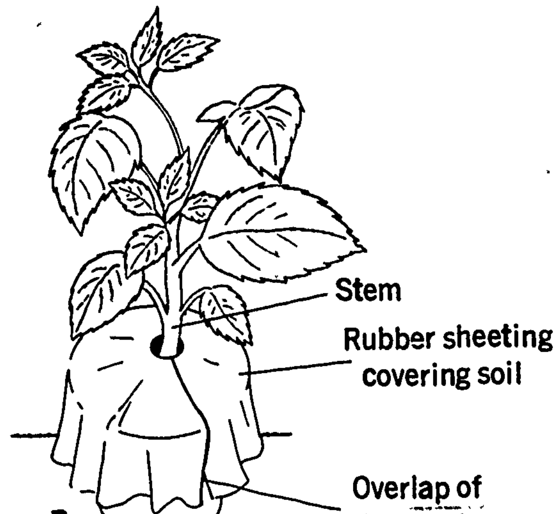
Bean plant in pot
Cellophane bag
Rubber sheeting (from a balloon)
Large beaker or jar

INTRODUCTION: Discuss wtth the children some of the ways that they have observed that moisture gets into the atmosphere. Can they think of any other ways? This Activity will show them another way.

Have the children tie a cellophane bag over one of the leaves of the bean plant. Have them note the bag at the beginning of the Activity and then again after several hours. *(The bag should have condensed moisture within it.)* You may want to discuss where the moisture came from and why the moisture condensed on the sides of the bag.

Next have one of the children cover the soil area of the pot by placing a piece of rubber sheeting over the soil and the pot. This might be accomplished by slitting the sheeting to the center and then running it close to and around the stem of the plant, and overlapping both ends as illustrated. Cover the plant with a clean, dry glass jar or large beaker and after several hours note what has happened. *(Moisture should have formed on the side of the glass.)* Where does the plant get its water from? *(From the soil, by means of its roots.)*





Learnings: (x,y) Plants lose water through their leaves. This water enters the atmosphere in the form of water vapor. (x,y) Plants can influence the amount of moisture in the air.

ACTIVITY 87 (x,y)

DETECTING MOISTURE PRODUCED IN CERTAIN CHEMICAL CHANGES

Purpose: To show still another way moisture enters the atmosphere

Concept to be developed: Certain chemical changes produce water as a product of the reaction, and this water may enter the atmosphere as water vapor.

Materials needed:

Candle
Glass
Match

INTRODUCTION: In this Activity the children will learn how moisture gets into the air through certain chemical changes. Explain to them that when a candle burns, energy in the form of light and heat is given off and new substances are formed. When a new substance is formed, a chemical change is said to have taken place.

Have one of the children light a candle with a match. Discuss with the class the many changes that they see. What visible energy is now given off by the burning of the candle? *(Light energy is given off.)* Why is there a difference in temperature near the candle? *(Heat energy is given off.)* How does the solid wax of the candle change? *(It melts and becomes a liquid.)* Where does the liquid wax go? *(It goes up the wick through capillary attraction.)* What happens to the liquid wax? *(It turns to a gas.)* Blow out the flame and quickly bring a lighted match near the wick. What happens? *(The flame ignites the candle again.)* What does this show? *(That there is a gas that burns in the wick.)*

Place a cold glass over the candle. What happens inside the glass? *(A film of moisture appears.)* Where did it come from? *(From the burning wax and possibly from the burning wick.)* Why does the moisture go away from the glass after several minutes? *(The condensed moisture evaporates.)* Try placing a hot glass over the candle. Is the result the same? *(The vapor does not condense as rapidly.)*

Learning: (y,z) When a candle burns, there are many changes that take place. The production of water is one.

RELATIVE HUMIDITY IN PERCENTAGES

Dry-bulb temperature (degrees Fahrenheit)	Difference between wet-bulb and dry-bulb readings																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30	32	34	36	38
22	86	71	58	44	31	17	4																				
24	87	73	60	47	35	22	10																				
26	87	75	63	51	39	27	16	4																			
28	88	76	65	54	43	32	21	10																			
30	89	78	67	56	46	36	26	16	6																		
32	89	79	69	59	49	39	30	20	11	2																	
34	90	81	71	62	52	43	34	25	16	8																	
36	91	82	73	64	55	46	38	29	21	13	5																
38	91	83	75	66	58	50	42	33	25	17	10	2															
40	92	83	75	68	60	52	45	37	29	22	15	7															
42	92	85	77	69	62	55	47	40	33	26	19	12	5														
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4													
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8	2												
48	93	86	79	73	66	60	54	47	41	35	29	23	18	12	7	1											
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5											
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19	14	9											
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22	17	12	3										
56	94	88	82	76	71	65	60	55	40	44	39	34	30	25	20	16	7										
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27	23	18	10	1									
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	13	5									
62	94	89	84	79	74	69	64	59	54	50	45	41	36	32	28	24	16	8	1								
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26	18	11	4								
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29	21	14	7								
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	31	23	16	10	3							
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	25	19	12	6							
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34	28	21	15	9	3						
74	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36	29	23	17	11	5						
76	96	91	87	82	78	74	70	66	62	59	55	51	48	44	41	38	31	25	19	13	8	3					
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	33	27	21	16	10	5					
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	35	29	23	18	12	7	3				
82	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42	36	30	25	20	14	10	5				
84	96	92	88	84	80	76	73	69	66	62	59	56	52	49	46	43	37	32	26	21	16	12	7	3			
86	96	92	88	84	81	77	73	70	66	63	60	57	53	50	47	44	39	33	28	23	18	14	9	5	1		
88	96	92	88	85	81	77	74	70	67	64	61	57	54	51	48	46	40	35	30	25	20	15	11	7	3		
90	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47	41	36	31	26	22	17	13	9	5	1	
92	96	92	89	85	82	78	75	72	68	65	62	59	56	53	50	48	42	37	32	28	23	19	15	11	7	3	
94	96	93	89	85	82	79	75	72	69	66	63	60	57	54	51	49	43	38	33	29	24	20	16	12	9	5	1
96	96	93	89	86	82	79	76	73	69	66	63	61	58	55	52	50	44	39	35	3(	26	22	18	14	10	7	3

Using the Table: Read the dry-bulb and the wet-bulb thermometers. Determine the difference between the readings.

In the left-hand column find the reading of the dry-bulb thermometer. Then read across until you reach the column representing the differences between the wet-bulb and dry-bulb readings. The number you find is the relative humidity expressed as a percentage.

For example, if your reading on the dry-bulb thermometer is 76°F, and on the wet-bulb is 65°F, the difference between the readings is 11°, and the relative humidity is 55%.

ACTIVITY 88 (y,z)

DETERMINING RELATIVE HUMIDITY

Purpose: To introduce the concept of relative humidity

Concept to be developed: Relative humidity is the amount of moisture in the air compared to the amount of moisture it could hold at that temperature.

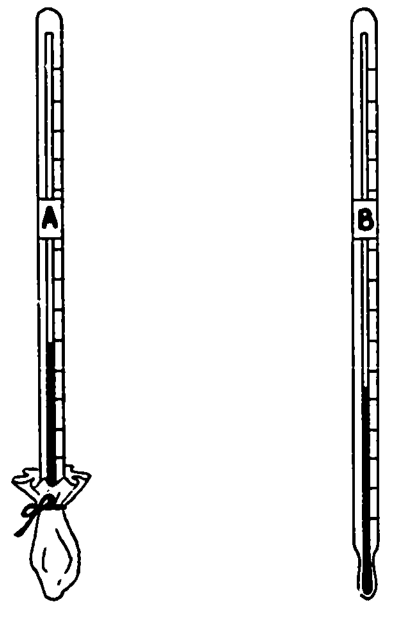
Materials needed:

2 thermometers
Cloth
Water

INTRODUCTION: Tell the children that now that they have studied about how moisture enters the atmosphere, there is a way actually to determine how much moisture there is in it. This Activity will show them one way. It may also suggest another instrument they might make and add to their weather station.

Explain to the children that relative humidity is the amount of moisture present in the air compared with the maximum amount of moisture that the air at a particular temperature could hold. In order to determine the relative humidity, the class must first determine the moisture content of the air. Point out to them that on a dry day much moisture can evaporate into the air. As they know, evaporation causes a cooling effect, which can be measured using a thermometer. On the other hand, on a humid day moisture cannot evaporate into the air as quickly. This effect of little evaporation causes little cooling as measured by a thermometer.

Have the children tie one wrapping of cloth around the bulb end of a laboratory thermometer and mark it *A*. Place another thermometer, marked *B*, beside *A*. Have the children observe and record the temperature of each. *(They should be the same.)* Have them then wet the cloth and fan both thermometers. Have them observe the readings on both. *(The temperature of* A *should be lower than that of* B.*)* Why is the temperature of *A* lower? *(Evaporation causes a*



cooling effect.) Why would there be more of a cooling effect on a drier day? *(There would be a greater loss of water.)* Why would there be less cooling on a more humid day? *(Less moisture can evaporate into a humid air mass.)*

The relative humidity can be determined on a chart, such as the one shown here, if the dry-bulb reading is known and the difference between the two readings is known. Some children might like to graph the relative humidity daily for several weeks. (The humidity in a classroom should also be compared with the humidity outside.)

Learnings: (x,y,z) Relative humidity is a factor that varies daily and can be measured. (y,z) When the air is humid, evaporation takes place with difficulty and objects tend to remain damp. When air is dry, water evaporates very rapidly. (y,z) Relative humidity is the amount of moisture in the air compared with the amount it could hold at that temperature.

Summing Up Ideas: In this section the children were introduced to some of the ways water vapor enters the atmosphere. They learned of evaporation from soils and plants, and of the production of water vapor in some chemical reactions. They were also introduced to the concept of relative humidity and shown how it could be measured.

WHAT ARE THE CHARACTERISTICS OF DIFFERENT FORMS OF PRECIPITATION?

In this section the class will discover some of the characteristics of various forms of precipitation. They will also determine how these forms precipitate from the atmosphere. When a chemist talks about precipitation, he generally refers to a substance being separated from a solution. When a meteorologist or weatherman refers to the term, he is speaking of how a form of water is condensed and falls to the ground. In order for condensation to occur there must be sufficient moisture, a cooling effect, and particles for the moisture to condense on.

A cloud is a mass of condensed water vapor. The condensed vapor may be in the form of droplets, ice crystals, or both, depending upon the temperature. There are three major types of clouds: cirrus, stratus, and cumulus. The prefix *alto* means high, and the prefix *nimbo* or suffix *nimbus* means stormy. The following chart may be useful in discussing cloud types.

Height of Clouds	Name	Symbol
18,000–40,000 ft.	cirrus	Ci
	cirrocumulus	Cc
	cirrostratus	Cx
6,000–18,000 ft.	altocumulus	Ac
	altostratus	As
	nimbostratus	Ns
Below 6,000 ft.	stratus	St
	stratocumulus	Sc
	cumulus	Cu
	cumulonimbus	Cb

ACTIVITY 89 (y,z)

DETERMINING THE DEW POINT

Purpose: To illustrate the meaning of **dew point**

Concept to be developed: The dew point of the atmosphere is the temperature at which moisture begins to condense.

Materials needed:

Shiny metal cup
Thermometer
Ice
Water
Hot plate
Kettle

INTRODUCTION: Discuss with the children the idea that there is a temperature at which water vapor condenses. This Activity will help them to discover what this temperature is.

Have a member of the class fill a shiny metal cup (a shiny empty tin can will work satisfactorily) half full of water and stir the water with a laboratory thermometer. Have him observe and record the temperature of the water. Have him place a few pieces of ice into the water, stir constantly, and note when moisture appears on the outside of the container. A cloudy film of moisture will dull the surface. Have the children record the temperature at which the moisture forms. Develop the idea of *dew point*, bringing out that it is the temperature at which the moisture condenses on the tin can. Then ask: If there were a great deal of moisture in the air, would the water have to be cooled a great deal or just a little? *(Just a little.)* Why? *(Because the many particles of water in the air would condense or come together more easily because of their number with just a little cooling.)*

Suggest that some children can make a chart showing the dew point of the atmosphere at a certain time each day for a period of several days. The dew point may vary from day to day, depending upon the amount of moisture in the atmosphere at that particular time.

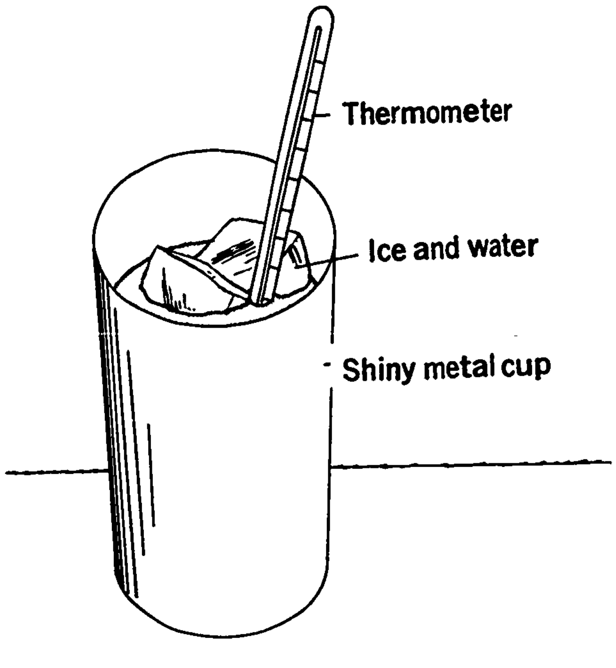
Perhaps some children would like to try a similar Activity using other liquids. *(Suggest alcohol, salt water, or sugar water.)* Other children might try cooling the water with another cooling agent, like dry ice. (Caution the children on the use of dry ice.)

To extend the Activity, a group of the children might compare the dew point of the air in a dry room and in a humid room.

Select a small room, such as a storeroom, which is relatively free from moisture. Have the children determine the dew point as before, by filling the shiny cup half full of ice and room-temperature water and noting the temperature of the water when moisture condenses on the outside of the container.

Next, have the children boil a quart of water in a kettle placed on a hot plate in the storeroom. This should give a great deal of moisture to the limited amount of atmosphere in the small room. Repeat the procedure of finding the dew point. (The children should start with room-temperature water to which ice has been added.) Have the children discuss why the dew point is now much higher in the same room. *(The atmosphere is laden with moisture and needs to be cooled relatively little before the moisture condenses on the metal can.)*

Bring out in your discussion of the dew point that dew often forms outside during the night.



Why? *(Because the temperature drops below that of the dew point and the water condenses into liquid droplets.)*

Learnings: (x,y,z) The dew point of the atmosphere can be measured by determining the temperature at which moisture condenses on a surface. (y,z) The dew point is higher in an atmosphere of high moisture content.

ACTIVITY 90 (x,y)

MAKING MODELS OF CLOUD TYPES

Purpose: To familiarize the children with the shapes of some cloud types

Concept to be developed: The names of clouds are based on each cloud's shape, height, and composition.

Materials needed:

Blue construction paper
Cotton
Glue

Take the class outside for a look at the clouds. They may see several of the cloud types mentioned on page 78. From their observations of clouds have them tear cotton into forms representing what they saw and glue these pieces on blue construction paper. Small tufts can represent the cirrus clouds, which are high clouds composed of ice crystals. Flat layers can represent the low stratus clouds. Large fluffy masses can represent the cumulus clouds. The children might see the tall and towering cumulonimbus clouds.

You may wish to write to the United States Department of Documents, Washington, D.C., and ask them to send you the Cloud-type Chart.

This chart gives pictures of cloud types along with their symbols.

Suggest that some children might represent the clouds from the chart on blue construction paper. Other children might like to show how clouds change shape as the clouds get smaller or build up. Several pieces of cotton would represent the stages in cloud formation. What might cause clouds to build up? *(Further condensation of moisture particles.)* What makes the clouds move? *(Moving air currents—winds.)* What makes them get smaller? *(They might move into a drier area and evaporate.)*

Learnings: (x) Clouds are formed from condensation of water vapor. (x,y) Their names are based upon their shape, height, and composition. (x,y,z) Clouds can change shape because of changing atmospheric conditions such as more or less condensation. (x,y) Clouds move because of air currents, or wind.

ACTIVITY 91 (y,z)

OBSERVING HOW CLOUDS ARE FORMED

Purpose: To demonstrate how clouds are formed

Concept to be developed: Clouds are formed by the condensation of water vapor.

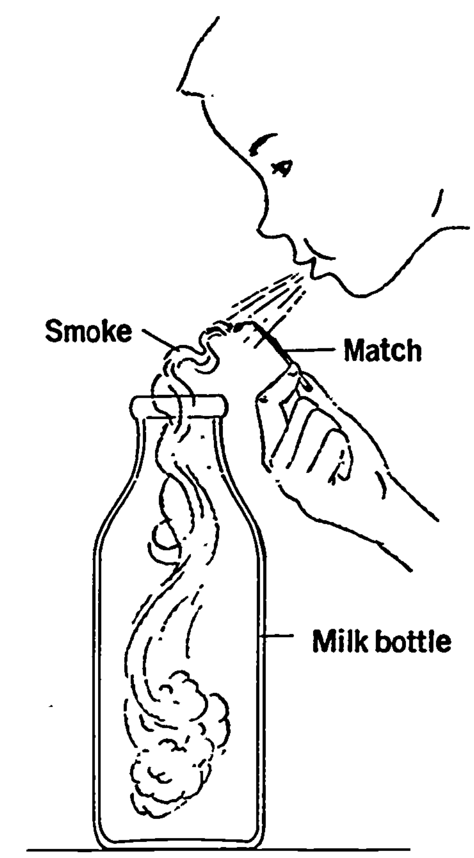
Materials needed:

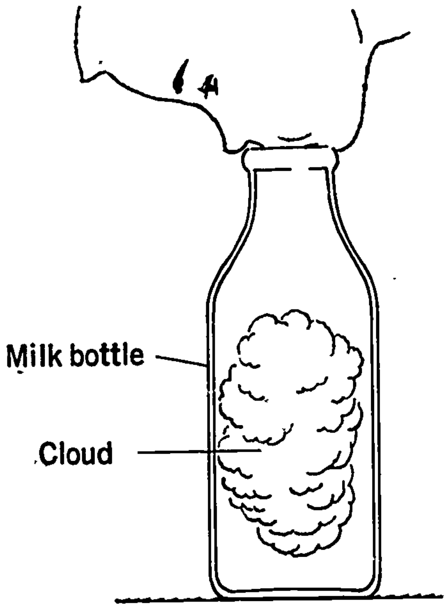
½-gallon milk bottle
Water
Match

Have a child pour a cupful of water into the half-gallon milk bottle, shake the water around, and pour it out. This procedure nearly saturates the air inside the bottle with moisture. Have him blow hard into the bottle while pressing his lips tightly against it. Point out that air is warmed through compression. Then have him release the pressure suddenly and have children note the little, if any, cloud formation that occurs. Have the child repeat the process of adding water, shaking it, and pouring it out. But this time have him blow smoke, from a smoking match or candle held near the neck of the bottle, into the bottle. Have him blow into the bottle and then release the pressure suddenly. Have your class notice the production of a cloud this time.

Ask the following questions: What three things were necessary in the cloud formation? *(Moisture, cooling effect, and particles on which the moisture could condense.)* How did the moisture get in the bottle? *(From the water placed in the bottle and from the child's breath.)* How was a cooling effect produced? *(By a sudden release of pressure.)* Where did the small particles come from? *(From the match or candle smoke.)*

Why is the Activity more effective if the first part (without adding the smoke) is performed? *(To show that without the smoke there would be little cloud formation.)* Why might there have been some cloud formation without smoke? *(The air always contains some dust particles around which moisture can condense.)* Why might a cloud have been produced even if water





had not been poured into the bottle first? Have someone try this with a dry bottle. *(Some moisture is always present in the air; in addition, a great deal of moisture is present in the breath.)*

Learning: (y,z) A cloud is produced when moisture is cooled sufficiently and condenses on small particles in the atmosphere.

ACTIVITY 92 (x,y,z)

OBSERVING HOW IT RAINS

Purpose: To demonstrate how precipitation takes place

Concept to be developed: Precipitation takes place when enough water vapor has condensed around a particle in the atmosphere to make it dense enough to fall.

Materials needed:

Beaker
Water
Ice
Thermometer
Hot plate
Transparent custard cup

INTRODUCTION: Ask the children how they think rain is formed. Suggest that they can discover how to produce precipitation (rain) under controlled settings in the classroom. Have them set up the equipment as illustrated, with the custard cup on top of the beaker of water, which rests on the hot plate.

Have the children take and record the temperatures of the water in the beaker and the water in the custard cup before the hot plate is turned on and before the ice is added to the cup. What are their findings? *(They should be the same temperature.)*

Have the children turn on the hot plate and add ice to the custard cup. Have them wait a few minutes, then take and record the temperatures again. How do the temperatures differ now? *(The water in the beaker is warmer and the water in the cup is cooler than before.)* As the water in the beaker becomes warmer and the water in the cup becomes cooler, have the children observe what forms on the bottom of the cup. *(Water droplets form.)* Why do the droplets form? *(The water evaporates from the beaker and turns to vapor. The vapor is cooled by the cold cup and condenses upon it.)* What happens to the droplets? *(When enough form they come together and drop back into the water.)*

Suggest that some children try the experiment again, but without heating the water. They might also try it without adding ice to the cup. Does condensation occur? *(It might if there is enough moisture in the beaker and if the water in the cup is cool enough.)* Why is there not as much condensation as there was in the first experiment? *(The necessary conditions of enough moisture and cooling are not being met as well.)*

Learning: (x,y,z) Condensation occurs when water vapor is cooled sufficiently. Precipitation occurs when enough condensation takes place around a particular particle to make it dense enough to fall.

ACTIVITY 93 (y,z)

PRODUCING FROST ON A SURFACE

Purpose: To illustrate the formation of frost

Concept to be developed: When water vapor is cooled sufficiently, the vapor crystallizes to form ice.

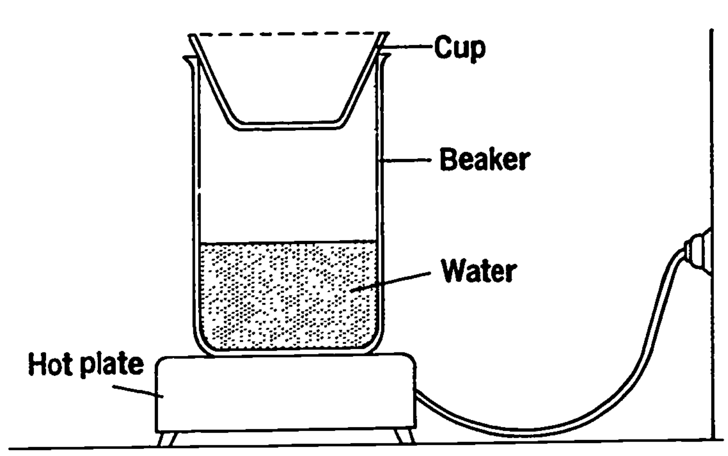
Materials needed:

Dry ice
Metal cup
Alcohol
Water
Tongs

INTRODUCTION: Mention that the children have probably seen frost form on the insides of refrigerators and freezers or on streets and sidewalks when the weather is cold enough. In this Activity the children can make frost form on the outside surface of a metal container.

Have the children put the dry ice in a clean, shiny metal container, using gloves or tongs. *(Caution:* Dry ice has a temperature of −80°C. and may cause severe damage if touched directly.) Then have them pour enough alcohol into the container to fill it half full.

Have the children notice the frost that forms on the side of the cup. Ask where the crystals of ice came from. *(From the water vapor in the air.)*



What made the vapor particles crystallize? *(The cooling effect of the dry ice.)* Why does frost not form on all surface areas of the cup? *(The upper portion is not as cold as the lower portion.)* How can they find out how long the frost will remain on the cup? *(By allowing the cup of alcohol and dry ice to stand in the same position for a long time and observing it at regular intervals.)* Suggest that some of the children try the experiment using water instead of alcohol with the dry ice.

During your discussion with the class, emphasize how frost forms out-of-doors: what conditions are necessary, what harm it can do to crops, and how it is controlled by smudge pots.

Ask the children what they think happens if the temperature in the atmosphere becomes so cold that the water droplets crystallize (freeze) before they fall to the ground. *(The water droplets precipitate as crystals, and they are called snow. If the temperature is very cold and the crystals become very large, then they are called hail. If the temperature is so cold that some of the water droplets crystallize before they reach the ground but warm enough so that some of them can still precipitate as rain, the mixture is called sleet.)*

Learnings: (y,z) When water vapor is cooled sufficiently, it crystallizes to form frost. (x,y,z) Snow, hail, and sleet are forms of precipitation in which the water droplets have crystallized before reaching the surface of the Earth.

Summing Up Ideas: In this section the children became familiar with the various forms of precipitation. They should have become aware of why clouds form, and of the names and shapes of cloud types. They were introduced to the idea that precipitation is the result of condensation of the water vapor around particles in the atmosphere, forming water droplets that fall when they become too dense. They were also shown that snow, hail, and sleet are forms of precipitation caused by the crystallization of water droplets while they were still in the atmosphere.

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary, and intermediate grade children, the ideas with the most meaning and application are the following:

- Air occupies space.
- Air takes up more space when it is heated and less space when it is cooled.
- Air has weight.
- Air pressure can force water out of a tube or hold it in the tube when the conditions are right.
- A barometer measures air pressure.
- Winds are named for the direction that they come from.
- Winds move clockwise around a high-pressure area and counterclockwise around a low-pressure area.
- The Earth heats up first and then warms the air above it.
- Any wet object will evaporate water into the air.
- Relative humidity is a factor that varies daily.
- The dew point of the atmosphere can be measured by determining the temperature at which moisture condenses on a surface.
- Clouds are formed by the condensation of water vapor.
- Clouds move because of air currents, or wind.
- Snow, hail, and sleet are forms of precipitation in which the water droplets have crystallized (frozen) before reaching the surface of the Earth.

In the intermediate and upper grades, the children should be led to develop concepts that are more complex and quantitative:

- Warm air weighs less than equal volumes of cooler air that are at the same pressure.
- Equal volumes of air have the same weight only when they are at the same temperature and pressure.
- Air can be compressed by increased pressure and expanded by the release of pressure.
- Air becomes warmer when it is compressed and cooler as it expands.
- An air mass takes its characteristics of temperature from the surface over which it forms.
- A denser fluid tends to move downward beneath a less dense one.
- Cold fronts are denser than warm fronts and tend to move downward, pushing the warm air up over the top of the colder air.
- Winds are caused by convection currents.
- Relative humidity is the amount of moisture in the air at a particular moment compared to the amount of water the air could hold at that temperature.
- A cloud is formed when moisture is cooled sufficiently and condenses on small particles present in the atmosphere.

5

INVESTIGATING THE WAYS THE EARTH CHANGES

Did the Earth always look the same as it does today?

It did not always have mountains and valleys, and the oceans once covered much of the land.

The Earth's surface is constantly changing, because it is constantly being acted upon by various physical and chemical forces. Most of the changes are hardly noticed from year to year. However, a few are very noticeable at the time they take place, such as those changes caused by earthquakes and erupting volcanoes.

The three spheres of the Earth interact with one another to bring about changes. Weather, which originates in the atmosphere, greatly alters the lithosphere, or rock surface. Likewise, the hydrosphere also alters the rocks—each year, pounding oceans and rushing streams wear down more and more land; as the streams slow down, they deposit this material, forming deltas and other deposits. It is the atmosphere that helps to form the hydrosphere, and the two spheres continuously interact with each other, as is evidenced in the hydrologic, or water, cycle.

But what are some of the changes that occur on the Earth and what are some of the forces causing them? Maybe the children have asked some of these questions concerning these changes: What makes mountains and valleys? Why are some mountains really high and steep while others are only small rounded hills? Why do some places have no mountains at all? What makes earthquakes? Why do volcanoes erupt? What is a glacier? Is there going to be another earthquake sometime in the future? What makes the sand on the beach? Where do fossils come from?

The Earth is being changed by many forces. Gravity may cause rocks to fall down slopes and mud to creep and flow. Rivers continually wear away the land, making valleys and canyons. Oceans pound upon the shore, breaking the rocks and changing the shoreline. Winds blow sand and dirt into dunes. Ice and snow carve out mountains and valleys and produce gouges and scratches in the rocks. Earthquakes may cause sudden movement in the Earth's crust and erupting volcanoes can even produce mountains overnight. And how do we know about all this? Fossils have been one of the main clues telling us about the history of the Earth.

In this chapter, Activities are presented that will show how some of these forces can change the Earth's surface.

WHAT IS EROSION?

Erosion is the wearing away of the Earth's crust by water, wind, or ice. The rocks and soil of the lithosphere are carried from one place to another during erosive processes, enriching the land in one place while deteriorating it in another. Running water dissolves tiny particles of the material it flows over, carrying these particles with it over great distances and then depositing them in new locations. The wind blows the soil from one location to another, carrying it the way the water does, to change the composition of the Earth's crust at a particular location. And during the ice age large ice sheets tore up the Earth's crust and moved large volumes of soil and rock.

In the following Activities, the children will be introduced to erosion and learn some of the ways it affects the Earth.

ACTIVITY 94 (x,y)

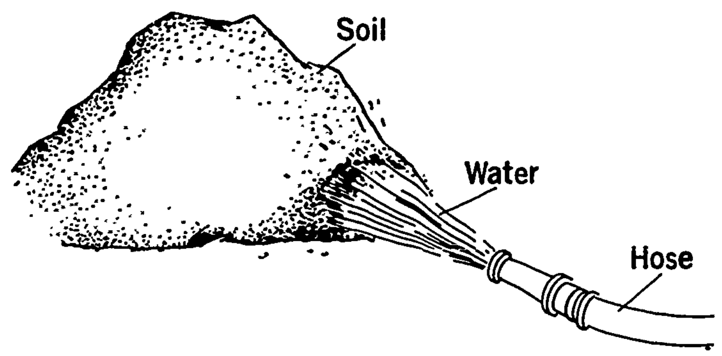
CREATING A SMALL LANDSLIDE

Purpose: To show how landslides can be caused

Concept to be developed: Landslides are rapid falls of dirt and rocks often caused by streams undercutting their banks.

Materials needed:

Shovel
Garden hose connected to water outlet



INTRODUCTION: Perhaps the children have seen rocks, mud, and debris on a road or highway after a rain. Discuss with the children how this material might have arrived there. Explain to them that gravity pulls objects downward. Perhaps the children know that when rocks weather and loosen on the top of a slope, they will tend to tumble down to the bottom of the hill. These sudden movements of large quantities of rock down mountainsides are called landslides. *The movements of mud down steep slopes are called* mudflows. *These occur after hard rains in areas where there is little or no vegetation to hold the soil. A slow movement of soil down a slope, a very common occurrence on most soil-covered hills. is called* soil creep.

Have the children build a mound of dirt about 1 or 2 feet high. Turn the water on gently and aim the hose at the base of the dirt mound along one of the edges. As the stream of water undercuts the mountain of dirt, what happens? *(The dirt begins to slump or slide down.)* Why? *(Gravitational attraction pulls it toward the ground when the base has been undercut.)*

Explain to the children that the stream of water from the hose could be compared with a stream in nature. As the stream undercuts its bank, material from above "landslides" down into the valley where the stream is flowing. Suggest that the children may want to find evidences of landslides or soil creep around them. Mention that tilted telephone poles and fences are results of slow soil movements. So are the small terraces or cracks seen on slopes.

Learnings: (x) Gravity can cause changes in the Earth's surface. (x,y) Landslides are rapid falls of rock and dirt often caused by streams undercutting banks. (x,y,z) Soil creep is a very slow, imperceptible movement of soil down a slope.

ACTIVITY 95 (x,y,z)

MAKING AN EROSION TABLE

Purpose: To show how running water causes erosion

Concept to be developed: Rivers carry much debris and dirt with them as they travel downstream.

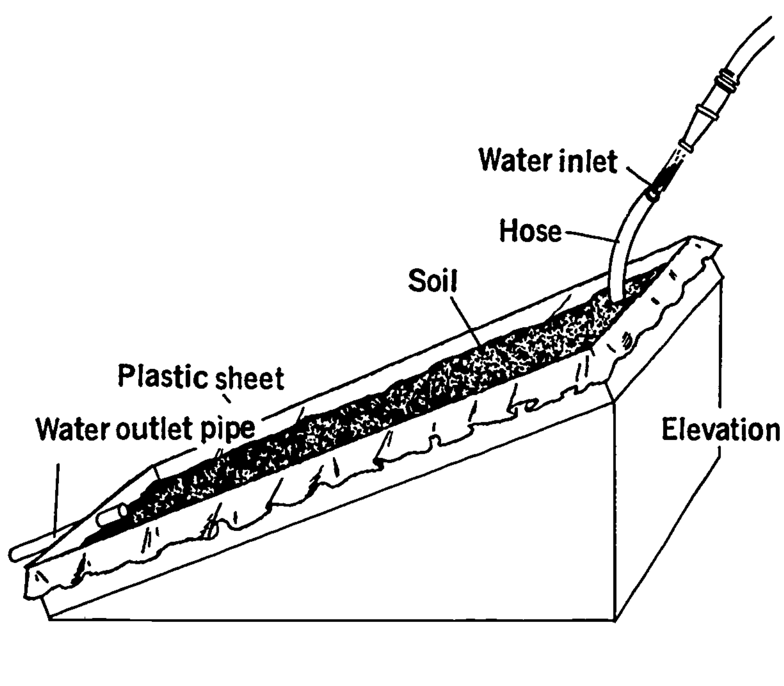
Materials needed:

3 foot x 5 foot x 6 inch wood box
Hose for water outlet
Plastic cloth 4 x 6 feet
Hose for water inlet
Sandy soil
Wood for support

INTRODUCTION: Mention to the children that streams are very important in altering the surface of the Earth. Can the children tell why? Perhaps they will realize that streams help to carve the Earth's surface into mountains and valleys, canyons and gorges. Explain that every year tons of debris are removed from the mountains and highlands and dumped in the lowlands or oceans, forming alluvial fans *or* deltas. *Alluvial fans are fan-shaped deposits of debris formed at the base of mountains; deltas are triangular deposits formed where rivers enter the ocean.*

Suggest that a group of the children build an erosion table using a metal sand box or a wood box, as shown in the illustration.

Have them lay the plastic cloth in the box to make it waterproof. A drain might be made by use of a metal tube placed in a hole in the wood at the lower end. Pack the sandy soil tightly into the box. Have the children elevate one end of the



erosion table to a height of about 10 inches. Allow water to flow in through the inlet hose at the elevated end and out the drain. The children can observe "streams" being formed in the sandy soil. These could be related to the streams being formed out-of-doors and a map could be used to show how they drain into lakes or rivers.

Are the streams clear or muddy? *(They are muddy and laden with debris.)* Erosion is the removal of soil from the surface of the land by means of running water. Erosion, then, can be seen taking place on this table.

Where are the soil and debris being deposited? *(At the end of the stream.)* Why? *(Because the stream slows down and can no longer carry the load.)*

What kind of course does the stream take? *(A winding or twisting course.)* This curving is called *meandering* and is typical of all streams and rivers. You might show the children maps that illustrate the courses followed by streams or rivers to demonstrate this typical meandering characteristic.

Suggest that another chance to observe excellent streams-in-miniature would be after a rainstorm. Have the children observe some of the tiny rivulets that develop on open soil and note the typical meandering, or winding, of the streams and that they cross in a peculiar interbraiding pattern. This same braided pattern of streams can be observed on the beaches of oceans or large lakes after the water has been washed up and is just returning to the body of water after the breaking of a wave.

Ask the children if they can discover what happens to the surface of the Earth after the little streams have formed. *(Little valleys develop where the streams travel.)* Explain that it is streams that carve out valleys in the Earth's surface. Most valleys are the result of streams that once traveled through them.

Learnings: (x) Erosion is the removal of soil and debris from the surface of the land. Erosion usually occurs after a rain, especially when the soil is exposed. (y,z) Rivers carry much debris and dirt with them as they travel downstream. They will deposit this debris at the end of their course when they slow down and can no longer carry it. (y,z) All streams have a typical meandering, or winding, pattern. This is caused by chance altering of the course because of tiny objects in the way. (y,z) As they flow, streams cut out valleys by cutting downward. They widen the valley by undercutting the banks. (y,z) Many streams traveling together usually produce a typical pattern that has a braided appearance. This is most often observed when streams are near their end, for example, the lower portion of the Mississippi River.

ACTIVITY 96 (x,y)

DEMONSTRATING THE EFFECT OF PLANTS UPON EROSION

Purpose: To show the effect plants have upon erosion

Concept to be developed: Plants have a holding effect upon the soil and help to prevent erosion.

Materials needed:

3 foot x 5 foot x 6 inch wooden box
Hose for outlet
Plastic cloth, 4 x 6 feet
Hose for water inlet
Sandy soil
Grass seed
Wood for support

INTRODUCTION: If possible, take the children to observe an area where the soil has eroded because of lack of plant cover. Discuss what they see and have them give their ideas about why the area looks as it does. What might stop the soil from blowing or washing away? Can they demonstrate their ideas?

The children will be able to discover the effect that plants have upon erosion, or removal of the soil, in this Activity. Have the children plant grass seed in a section of the sandy soil in the erosion table set up in the preceding Activity. When the grass has a network of roots, try the same Activity with the hose and erosion table as before. Do the roots have any holding effect on the soil? *(Yes.)* Pull up some of the sprouting grass and have your children change the amount of water coming out of the hose by regulating the water valve. Have the force of the water changed by regulating the opening of the outlet. What are the effects upon erosion? *(The greater the force of the water, the greater the erosion.)*

Learnings: (x) Plants have a considerable holding effect upon the soil and help to prevent erosion. (x,y) The harder the force of the water, the greater the amount of erosion. Flash floods, therefore, would be more destructive than gentle rains.

ACTIVITY 97 (x,y)

MAKING A SPLASH STICK

Purpose: To emphasize the effect of force upon the magnitude of erosion

Concept to be developed: The force of the water directly influences the quantity of soil it can erode.

Materials needed:

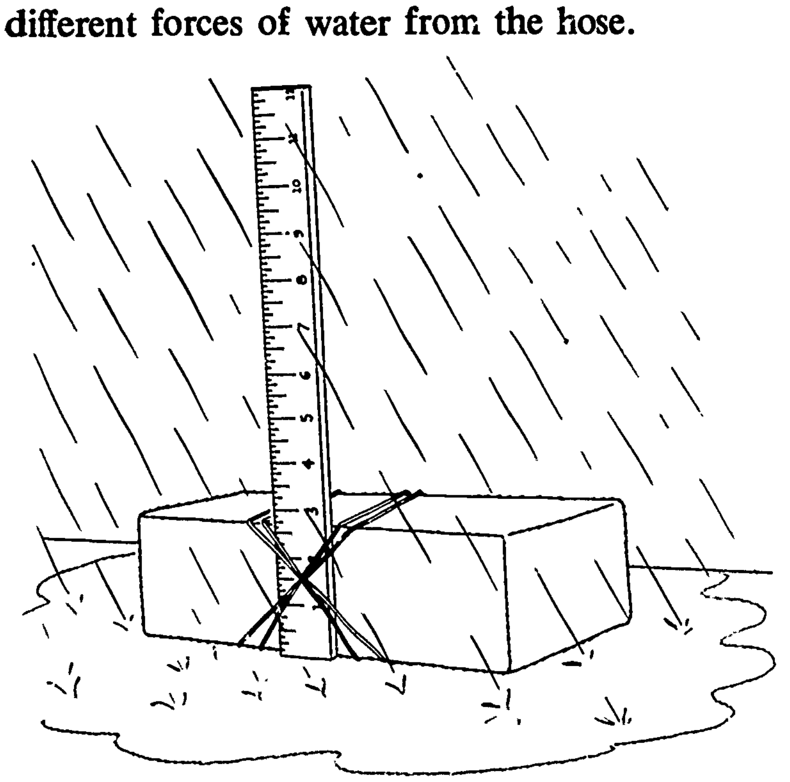
Several yardsticks
Chart paper
Rubber band
Brick

This is another Activity in which the children can observe the effect of water upon soil. Have the children paint several yardsticks white (so that mud splashes will show up plainly) and place the white sticks outdoors in various areas. Support each stick with a brick and rubber band as shown in the illustration. After a rainstorm, have the children observe the height to which mud splashed on each stick. Make a chart showing the height to which mud splashed on a stick in a grassy area, a sandy area, a garden area, and other locations you might think of.

Why did the mud splash less in the grassy area? *(Grass roots hold the soil in place.)* Why was there a greater splashing of mud in certain locations? *(Wherever the mud was free to move, there was a greater amount of splashing.)*

You could try this Activity using a nozzle and hose for your "rain" supply.

Do all rainstorms produce the same effect in the same location? Have the children repeat the Activity during different rainstorms or by using different forces of water from the hose.



Learning: (x,y,z) Movement of soil is partially dependent upon the type of soil and the covering of the soil. It is also partially dependent upon the strength or the amount of the rainfall.

ACTIVITY 98 (x,y)

COMPRESSING SNOW CRYSTALS TO FORM ICE

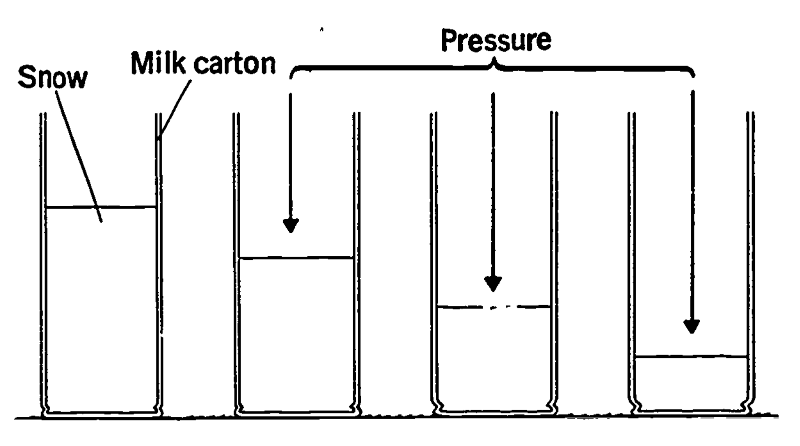
Purpose: To illustrate the way glaciers are formed

Concept to be developed: Ice can be formed by the compacting of snow.

Materials needed:

4 milk cartons
Snow or ice shavings
Wood block
Magnifying glass
Scissors
Ruler
Balance scale

Have the children fill the four milk cartons with snow or very fine ice shavings. Put one carton aside. Have a child use a block of wood and press down the snow in the remaining three cartons until there is half the volume of snow and



put one of these three aside. Have him continue pressure on the snow in the third and fourth cartons until the third has less volume than the second and the fourth has less volume than the third, as shown in the illustration.

Cut away one side of each carton with scissors and examine the contents with a magnifying glass. What differences do you notice in the four columns? *(The snow was packed more closely together as pressure was increased.)* How does the one look that had the most pressure placed upon the column of snow? *(Its contents look more like ice.)*

Now develop with the children the following definitions: A glacier is a huge mass of compact snow and ice that covers the land. There are two main types of glaciers. One is called a mountain glacier and is found on the higher mountains especially in the north. The second type of glacier is called a continental glacier and covers whole continents. At present there are only a few remnants of the continental glaciers that once covered much of the Northern Hemisphere. One such remnant is the glacier on Greenland.

Learning: (x,y) Compacting snow can cause the formation of ice. The greater the pressure applied to the snow, the more compact the ice.

ACTIVITY 99 (x,y)

OBSERVING A GLACIAL EFFECT

Purpose: To show how glaciers can cause erosion

Concept to be developed: As glaciers move down slopes, they scratch the surfaces of rocks and gouge away the land.

Materials needed:

Sand
Aluminum foil
Water
Refrigerator
Clay or plasterboard

INTRODUCTION: As the children will realize by now, glaciers have had a considerable effect in eroding and wearing away the land. The following Activity will demonstrate the wearing action of a glacier, or block of ice.

Form a 12-inch square of aluminum foil into a box about 2 inches high. Place fine sand in the bottom of the box, fill it with water, and place the box in a refrigerator until the water is frozen. Remove the foil and have the children feel the bottom surface of the ice block. How does it feel? *(It feels rough.)* Have a child rub this block over some clay or plasterboard. Have the children observe the rubbed surface of the clay closely. What does the ice block do? *(It scratches lines on the clay. The lines are parallel to each other.)*

Repeat the Activity, but do not add any sand. Does the ice block without sand scratch the clay? *(No.)*

Suggest to the children that the ice block with sand could represent a glacier. Glaciers usually have much sand, rock, and debris trapped within the ice. As a glacier moves, it scratches rock and wears away soil.

Learnings: (x) Glaciers are huge masses of ice that carry large amounts of sand and debris. (x,y) As glaciers move down slopes, they scratch the surfaces of rocks and gouge away the land.

ACTIVITY 100 (x,y,z)

OBSERVING HOW WIND CHANGES THE APPEARANCE OF THE SOIL

Purpose: To demonstrate how the wind causes soil erosion

Concept to be developed: Wind blows sand into dunes and ridges.

Materials needed:

1 quart of fine, moist sand
1 quart of fine, dry sand
1 quart of flour
Fan
Chart paper
Yardstick
3 pie tins

INTRODUCTION: Review with the children that they have seen the effects of water and ice upon the Earth's surface. Wind can have a considerable effect in changing the Earth's surface. Ask the children if they have ever felt the effects of strong wind. What happens? (Dry sand, dust, and soil can be blown into small ridges and dunes.) *The following Activity will demonstrate to the class how the wind can alter the Earth's surface.*

Have the children fill one pie tin with a quart of moist sand, the second with dry sand, and the third with flour. Then have them place the tins 25 feet from the fan, which is directed to blow toward the tins. Where is the force of wind the greatest? *(Near the fan.)* Move each pan toward the blowing fan until there is the slightest movement in the pile of material.

On a chart indicate the three materials and the distance at which each showed movement as a result of the "wind." Which moves at the farthest distance? *(The flour.)* Which moves at the least distance? *(The moist sand.)* Why? *(The sand is heavy and thus requires more force to move it. The flour is very light and thus needs less force to move it.)* The children may notice a pattern in the way the materials have blown. The lightest is the farthest away and the heaviest is the closest. Many mixtures of particles are separated in this way. Explain that this is called *sorting*, and it is a frequent occurrence in nature.

Suggest that the children try to create small sand dunes by using the fan and the dry sand.

Are they able to create any patterns of ridges in the sand? What causes sand dunes in nature? If a sandy area is available, the children might enjoy studying this for any evidence of wind forming dunes or ridges.

Learnings: (x) The degree to which wind can move objects depends upon the objects and the force of the wind. (y,z) The arrangement of particles by winds, that is, the piling of the lighter particles together and the heavier particles together, is known as sorting. (x,y,z) Vegetation has a holding effect upon the sand and soil, and tends to prevent movement. (x) Wind blows sand into dunes and ridges.

Summing Up Ideas: In this section the children were introduced to erosion as a means of changing the surface features of the Earth. They learned how erosion can undercut portions of the Earth's crust to cause landslides, how running water and moving ice wear away rocks and soil, and how winds blow sand and soil from one place to another. They also learned of the sand dunes and deltas and the meanderings and mudslides that alter the appearance of the Earth's surface.

HOW DO CHEMICAL CHANGES AFFECT THE EARTH?

In certain areas of the country the rocks of the crust are largely limestone. These areas frequently have underground caverns and large sunken areas or depressions called *sinks*. Both of these features result from the dissolving of the rocks. Perhaps the children are curious as to how such a process can occur. The following Activities will help to demonstrate this important process and also to show how chemical changes alter the atmosphere.

ACTIVITY 101 (x,y)

CHANGING THE APPEARANCE OF LIMESTONE WITH AN ACID

Purpose: To show how limestone can be dissolved

Concept to be developed: Underground caves are formed when dilute acids dissolve underground limestone formations.

Materials needed:

Limestone
Dilute acid, such as hydrochloric
Beaker
Blue litmus paper
Water

Some of the children may be interested in testing a liquid to see if it is an acid. An acid will turn blue litmus paper red. Have the children place some blue litmus paper in water. What happens? *(There is no color change because water is not an acid.)* Have them dip one end of the litmus paper into vinegar or some dilute hydrochloric acid. What color does the paper turn? *(Red.)*

Have the children drop a piece of limestone the size of a kernel of corn into a beaker of dilute hydrochloric acid. Have them observe what happens. *(Bubbles come from the limestone, which eventually dissolves in the acid.)*

Apply these observations to the study of the Earth's surface. Limestone rock covers much of the United States. In these areas it is possible for dilute acids to dissolve parts of the limestone. Underground caves and caverns are examples of this dissolving of rocks. Have the children find some pictures of limestone caves.

Learnings: (x,y) Dilute acids will dissolve limestone. (x,y) Underground caves are formed by dilute acids dissolving limestone deposits.

ACTIVITY 102 (x,y,z)

CHANGING WATER INTO AN ACID

Purpose: To demonstrate how acids can be formed in nature

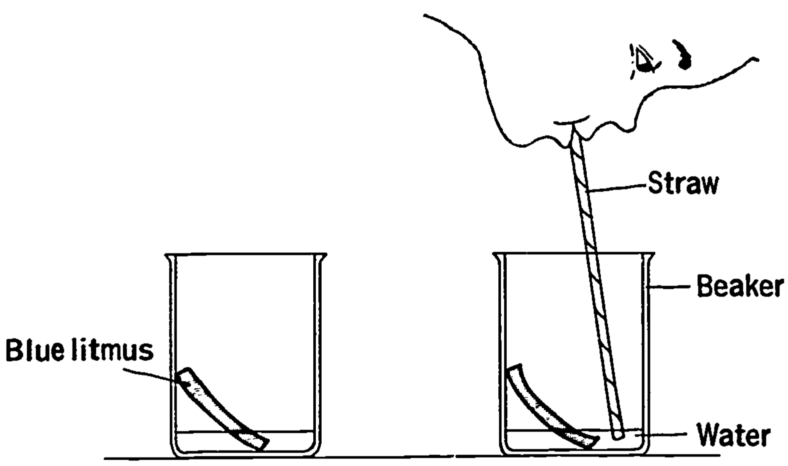
Concept to be developed: The air we exhale contains something (carbon dioxide) that turns water into an acid.

Materials needed:

Blue litmus paper
2 beakers
Straw
Water

INTRODUCTION: This Activity will help the children gain a better understanding of the source of the acid and the chemical action on the rocks in the formation of underground caves.

Have the children place similar strips of blue litmus paper in each of two similar beakers and put a teaspoonful of water in each beaker. Use one as a control and set it aside. Have one of the children blow through a straw into the water of the other beaker. He should blow about ten deep long breaths or more. Does the litmus paper change color? *(The paper turns a pink or reddish color.)* Why? *(The exhaled air turned the water into an acid.)*



CONTROL APPARATUS TEST APPARATUS

Some of the children might be interested in doing research to find out what it is in the air they exhale that turns water into an acid. They will find that exhaled air is a mixture of several gases, among them oxygen, nitrogen, water vapor, and carbon dioxide. Only carbon dioxide, of all the gases present in the atmosphere, can turn water into an acid. The carbon dioxide combines with the water to form carbonic acid. It is this acid that can slowly dissolve limestone rock.

Learnings: (x,y) Something in the air we exhale can cause water to become an acid. (y,z) Carbon dioxide dissolved in water forms a dilute acid, called carbonic acid. Carbonic acid occurs in nature and can dissolve limestone.

ACTIVITY 103 (y,z)

OBSERVING HOW LIMESTONE CAN FORM IN WATER

Purpose: To show how chemical reactions can help build up the Earth

Concept to be developed: The addition of carbon dioxide to water that contains dissolved lime may cause the precipitation of limestone.

Materials needed:

Straw
Beaker of water
Limewater tablets
Filter paper
Funnel

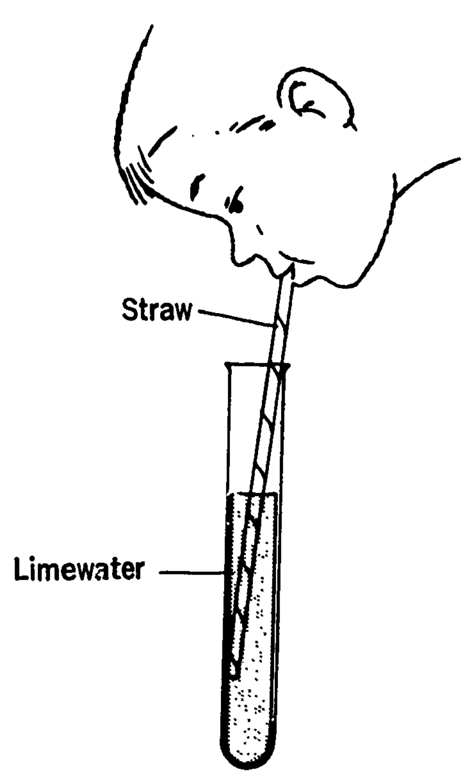
INTRODUCTION: Show the children a piece of limestone. Have them tell what they think it is made of. (Limestone is made of the chemical compound calcium carbonate. This substance can be formed in water if conditions are favorable.)

Now show the children a limewater tablet and dissolve it in water. Stir until the solution becomes clear. You may have to pour the water through filter paper to strain out the larger particles. Fold the circular paper into a funnel-shaped cone and put it in a funnel. Pour the limewater through the cone and collect the clear solution.

Divide the solution into two equal parts in two different test tubes. One part acts as a control. Have a child blow through a straw into the second tube. What happens? *(The clear solution turns cloudy.)* Why? *(The cloudiness is due to the presence of calcium carbonate, finely divided limestone, which is produced by the action of the carbon dioxide in the child's breath on the lime dissolved in the limewater.)*

Now relate the children's findings to the action of water on limestone. Explain that water containing considerable lime forms limestone when carbon dioxide is added. The limestone is insoluble in the water and precipitates. Limestone deposits can form in nature under these conditions. Many of the cave deposits, such as stalactites and stalagmites, are examples of limestone deposits. Limestone rock can also be formed by precipitation of lime from water.

Learning: (y,z) The addition of carbon dioxide to water containing dissolved lime may cause the precipitation of limestone.



ACTIVITY 104 (y,z)

TESTING AIR FOR CARBON DIOXIDE

Purpose: To show how chemical reactions can affect the composition of the atmosphere

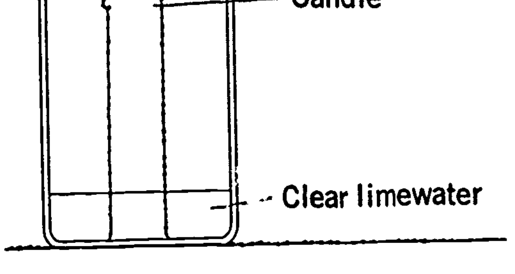
Concept to be developed: A burning substance will add carbon dioxide to the atmosphere.

Materials needed:

Limewater
Candle
Jar with cap

INTRODUCTION: To help the children become aware of the presence of carbon dioxide in the air, have them perform the following Activity. Tell the children the purpose of this Activity is to test one of the gases present in the air. The Activity is useful in pointing out the value of a control — and the value of a known test. The test for carbon dioxide is the white substance (calcium carbonate) produced in the presence of limewater and the gas carbon dioxide (see Activity 103).

Have a child place a teaspoonful of limewater in the jar. Have him cap the jar and shake it. Why is there no change in the appearance of the limewater? *(There was no large amount of carbon dioxide in the air.)* Have another child place an unlit candle into the jar, cap the jar, and let it stand for several minutes. Then have him remove the candle, recap the jar, and shake it. Does the limewater turn cloudy? *(No.)* Next, have a third child place a lighted candle in a jar containing a teaspoonful of limewater. Have him cap the jar and let the candle burn until it goes out. Then have him quickly remove the candle, recap the jar, and shake it. What is the appearance of the limewater now? *(It is milky.)* Why? *(It contains a large amount of carbon dioxide which reacted with the limewater.)* In what way did the two jars differ? *(One jar had a burning candle in it.)* What does this show? *(Th... the burning candle introduced carbon dioxide into the air.)*



Learning: (y,z) Carbon dioxide is naturally present in the air. A burning substance, such as a candle, will add additional carbon dioxide to the atmosphere.

Summing Up Ideas: In this section the children learned of some of the ways chemical changes alter the Earth. They saw how limestone reacted with acids and learned that this was a way underground caves could be formed. They saw how the hydrosphere could absorb carbon dioxide from the atmosphere to form a weak acid, carbonic acid. And they saw how the composition of the atmosphere could be altered by chemical change.

HOW DO EARTHQUAKES CHANGE THE EARTH?

One of the most spectacular changes of the features of the Earth is an earthquake. Because they can be observed as they take place and because they often cause much destruction, these events receive a large amount of newspaper space and public attention. In the Activities in this section the children will be given experiences that will help them to develop understanding of these violent changes.

ACTIVITY 105 (x,y,z)

DEMONSTRATING THE ACTION OF AN EARTHQUAKE

Purpose: To illustrate the cause of earthquakes

Concept to be developed: Earthquakes are produced by a long-continued strain on the Earth's crust, which finally gives way and fractures, or snaps.

Materials needed:

Table surface
Dry stick

INTRODUCTION: Some of the children may have experienced an earthquake and have asked what caused it. Earthquakes are caused by a sudden breaking of the rocks in the Earth's crust. The following Activity will help to demonstrate to your children how and why earthquakes occur.

Place a dry stick upon a table top so that half of it hangs over the edge. Have one of the children support the end firmly on the table top. Let another child press down on the stick gently, causing it to bend. Have him continue pressing down. What eventually happens? *(The stick snaps in two.)* What happens when the stick snaps? *(The stick vibrates back and forth.)* Explain to the children that earthquakes are caused when rocks of the Earth's crust are under continued strain. Eventually the rocks snap, relieving the pressur hen this happens, a certain amount of mc .t.nent usually occurs. When there is breakage, considerable vibration of the Earth's crust occurs. This is transm ted along the surface of the Earth and through the underlying rocks by means of *earthquake waves.** It is these earthquake waves that the seismograph (an instrument used to detect earthquakes) picks up and records.

Point out that the intensity of earthquakes varies considerably. The effects are more intense toward the center of the earthquake. Mention to the children that a scale has been established to indicate the intensity of earthquakes in numbers from 1 to 12. The scale is known as the Modified Mercalli Scale. The children might be interested in knowing what the scale is and trying to simulate the intensities on model buildings on a table top. You may want to put the scale on a chart, which the children can use as a reference as they make their investigations.

Modified Mercalli Scale

1. Rarely felt by anyone.
2. Felt by a few persons at rest on upper floors. Delicately suspended objects may swing.
3. Vibrations like those caused by a passing truck.
4. Sensation like that of a heavy truck striking the building. Dishes and windows may be disturbed.
5. Some dishes and windows broken. Some cracked plaster; unstable objects overturned.
6. Heavy furniture moved. Many people frightened. Fallen plaster and damaged chimneys.
7. Well-constructed buildings slightly damaged. Chimneys broken and poorly constructed buildings damaged.
8. Falling factory stacks, chimneys, and columns. Panel walls thrown out.
9. Damage considerable even in well-constructed buildings. Ground cracked. Pipes broken.
10. Landslides in riverbanks and water sloshed over the banks. Ground badly cracked. Foundations and frame structures destroyed.
11. No structures remain standing. Underground pipelines completely out of service. Bridges destroyed.
12. Objects thrown into the air. Total damage.

* For a fuller discussion of waves and how they travel see *Energy in Waves,* by Louis Cox (Investigating Science with Children Series; Darien, Conn., Teachers Publishing Corporation, 1964).

Learnings: (x,y,z) Earthquakes are produced by long-continued strain on the rocks of the Earth's crust, which finally give way and fracture, or snap. Accompanying this breakage is considerable vibration, which can be measured by seismographs. (y,z) The intensity of the earthquake varies with the closeness to the disturbance and the original intensity of the earthquake. Areas that are farthest away will suffer the least amount of damage. (x,y,z) Earthquakes are usually accompanied by dislocations in the Earth's crust. (x,y,z) Earthquake waves travel along the surface of the Earth and under the surface.

ACTIVITY 106 (z)

MAKING SEISMOGRAPH MODELS TO RECORD "EARTHQUAKE" WAVES

Purpose: To show how a seismograph can be used to detect earthquake waves

Concept to be developed: Earthquake waves can be detected by a seismograph.

Materials needed:

For the horizontal recording seismograph
(dimensions are approximate)
Base board, 1 x 12 x 24 inches
Brick supports:
- 2 sides, 1 x 2 x 24 inches
- 1 top, 1 x 2 x 12 inches
- 1 top diagonal, 1 x 2 x 18 inches
- 2 side braces, 1 x 2 x 18 inches

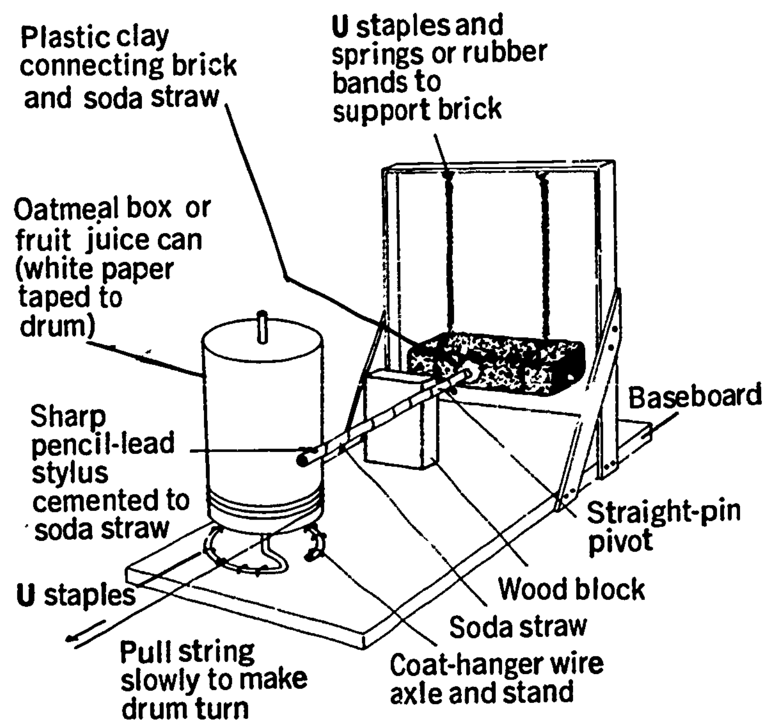
Pivot block, 2 x 4 x 6 inches
Round oatmeal box or fruit juice can
Brick
Soda straw
Straight pin
½-inch pencil lead
Lump of plastic clay
Cement (Pliobond or Duco)
String
Coat hanger
U-staples (16)
1½- or 2-inch thin nails (24)
Tape
Saw
Hammer
Wire-cutting pliers

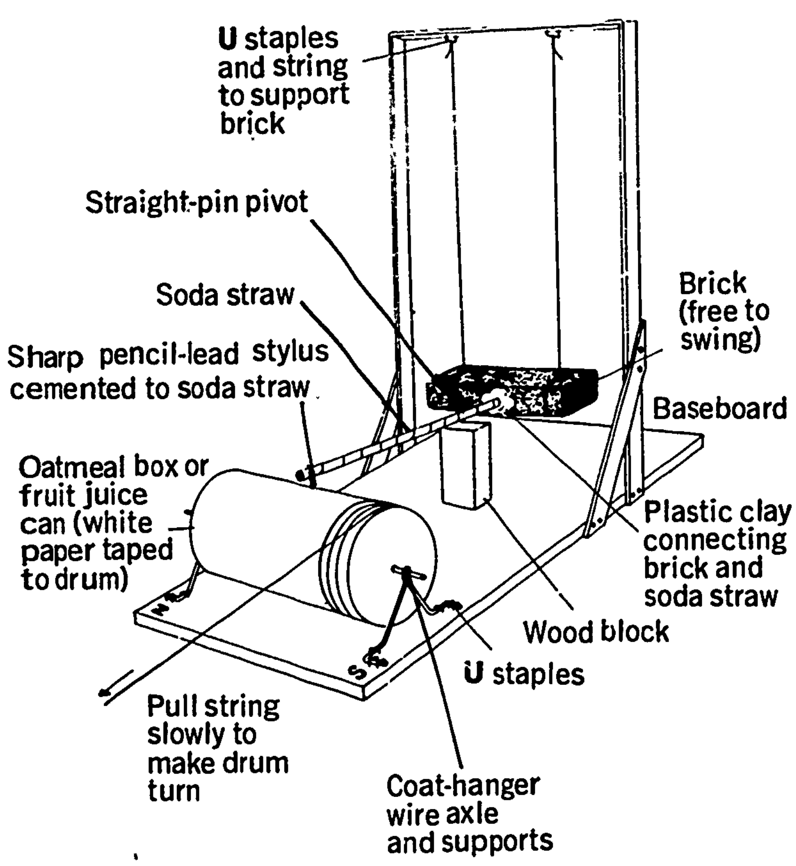
For the vertical recording seismograph
Same as above except add rubber bands or springs to support brick. Brick-support sides can be less than 24 inches. Experiment to see how far the rubber bands or springs stretch. Diagonal on top of brick support can be omitted if support is made lower.

INTRODUCTION: Sometimes great forces build up in the Earth's crust because of erosion that lightens one section and is accompanied by deposition of millions of tons of sediment on another section. When the forces become great enough, the crust may break suddenly along its weakest line and the sections on either side of the break quickly slip to new positions, relieving the forces. Earthquake waves are produced at the break and move outward through the Earth, as the solid crust "twangs" after the break. Earthquake waves, including the artificial ones made by explosives, are recorded by seismographs. Geologists use these records to learn more about the interior of the Earth.

Help a small group of children obtain materials and construct models of two kinds of seismographs as shown in the illustrations. The models will record transverse and longitudinal waves of "tablequakes" the children can produce.

In the horizontal recording seismograph model the brick suspended by the long strings tends to remain stationary when the Earth (table) shakes in the north-south direction marked on the base. The base shakes with the Earth, so the stylus draws a shaky line on the turning drum. At least two seismographs are needed to record quakes from all directions, one set north-south and one set east-west.





To record a "tablequake," help the children adjust the soda straw on the pivot pin and in the clay so the stylus presses firmly on the drum. Have one child begin to pull the string wrapped around the drum so it turns very slowly. Then have another child jar the table gently in the north or south direction marked on the base. Children can see the "quake" recording made by the stylus on the drum. In the vertical recording seismograph model, the brick is suspended by springs or rubber bands and tends to remain stationary when the Earth (table) shakes up and down. The base shakes with the Earth so the stylus draws a shaky line on the turning drum.

To record a "tablequake," again help the children adjust the stylus so it presses against the drum and place the end of a yardstick under the table leg. Have one child pull the string slowly to turn the drum. Then remove the yardstick so that the table leg drops to the floor and a vertical shock is recorded on the drum.

Learnings: (x) Earthquakes cause waves to travel through the rocks of the Earth. (x) Earthquake waves can be recorded on a seismograph.

Summing Up Ideas: In this section the children learned how earthquakes affect the surface features of the Earth. An earthquake is caused by the shifting of the Earth's surface under stress. When the surface shifts, earthquake waves are produced that travel through the lithosphere and can be recorded on seismographs.

WHAT CAN FOSSILS TELL US ABOUT THE EARTH AND CHANGE?

What are fossils? Fossils are evidences of prehistoric plants or animals preserved in the rocks. The fossil might be an evidence of life, such as a burrow, or hole, of a marine worm. The fossil might be part of the original preserved shell or animal, such as some of the mammal remains preserved in ice for millions of years in Siberia. The fossil might be an impression of a plant or animal, such as a fern or shell imprint.

What does a fossil tell us? Fossils tell us of the kinds of plants and animals that lived millions of years ago. Fossils also tell us about the conditions at the time the rocks were formed. Many rocks that contain fossils of fish or other marine organisms must have been deposited and formed under water, even if they are no longer near any body of water. Why are the rocks no longer under water? Changes have occurred in the Earth's crust. Certain areas that were once covered with seas may have been uplifted high above the ocean.

Again, fossils of tropical plants and animals have been found at the South Pole, which is now completely covered with ice and snow. What has happened? We know that millions of years ago the climate of the South Pole must have been different from what it is now. The climate at that time must have closely resembled the climate of South Africa or Australia. The Earth, then, has not always been the same as it is today.

The following Activities with fossils will help your children gain some understanding of how fossils are formed and what they indicate.

ACTIVITY 107 (x)

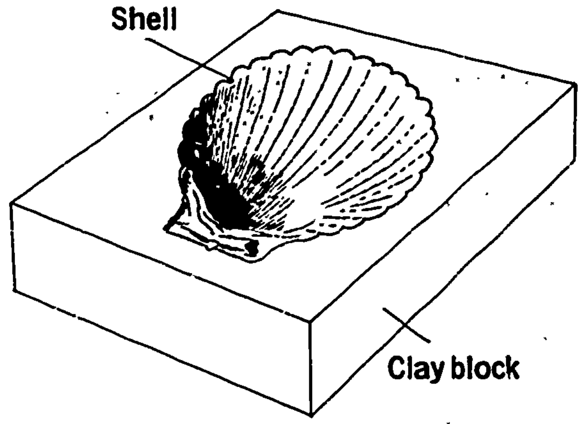
MAKING A "FOSSIL"

Purpose: To introduce the topic of fossils

Concept to be developed: Fossil impressions are made by plant or animal remains being pressed upon soft sediments that later harden.

Materials needed:

Clay
Fern or animal shell



Have the children mold a small block of clay into a rectangular shape about one-half inch thick and slightly larger than the object you wish to fossilize. Be sure that the surface is without bumps or impressions. Next, have the children press the object they wish to make the "fossil" with on the smooth surface of the clay, as shown in the illustration. Have them press the object down firmly until it makes an impression on the clay. Now allow the clay to harden by baking it in the sun. What is the result? *(A preserved imprint in the baked clay of the plant or animal.)* What was necessary to make the fossil? *(The following things were needed: a soft sediment, the clay; a hard part of a plant or animal, a shell or leaf for example; and the sediment had to be turned into rock by some means without too much heat or pressure that might disturb the fossil imprint.)*

These are the conditions that are also necessary for the formation of fossils in nature. We do not have many fossil remains of animals that did not have hard parts such as skeletons or shells. Let the children speculate on the possibility of getting a fossil of a jellyfish. Likewise, fossils are found only in sedimentary rocks, since metamorphic and igneous rocks are formed under extremes of temperature and pressure that could not preserve the fossil imprint.

Learnings: (x) Fossil impressions are made by plant or animal remains being pressed upon soft sediments that later harden. (x) Hard parts of the plant or animal are necessary for preservation.

ACTIVITY 108 (x,y)

MAKING A CAST FROM A FOSSIL IMPRINT

Purpose: To show how to make a cast of a fossil imprint

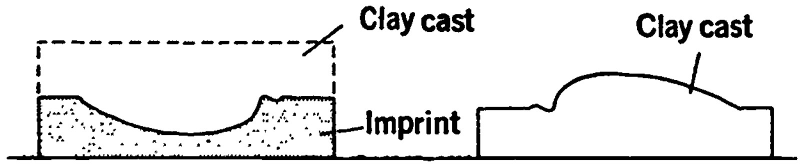
Concept to be developed: The cast of a fossil imprint has the same shape as the plant or animal remains that made the imprint.

Materials needed:

Fossil imprint
Water-base clay
Tempera color
Talcum powder
Fine brush

INTRODUCTION: Perhaps some child has a fossil imprint, or perhaps you could obtain one from a local museum. The imprint is just the opposite shape of the living thing that made it up. A cast is the shape of the original plant or animal.

To make a cast, have one of the children dust the imprint with talcum powder using a fine brush. The powder makes the clay easy to remove from the fossil. Then have the child gently but firmly press the clay into the imprint. Have him pull the clay from the imprint and trim off any excess clay. After the clay has air-dried, have the children paint the cast or the border with tempera color for contrast.



What do the children notice about the shape of the cast as compared to the shape of the imprint? *(The cast is reversed, like a mirror image.)* The cast is the same shape as the original living part. The imprint was the negative impression from the living part.

Learning: (x,y) The cast of a fossil imprint has the same shape as the plant or animal remains that made the imprint.

Summing Up Ideas: In this section the children were introduced to the existence of fossils. Fossils are the imprints made by animal or plant remains in rocks. They are used by geologists to determine the changes that have occurred since the Earth was first formed.

IMPORTANT IDEAS IN THIS CHAPTER

For the kindergarten, primary, and intermediate grade children, the kinds of ideas with the most meaning and application are the following:

- Gravity can cause changes in the appearance of the Earth's surface.
- Erosion refers to the movement of soil and debris from one place to another.
- Plants have a considerable holding effect on the soil and help to prevent erosion.
- The movement of soil is partially dependent upon the type of the soil and the covering of the soil. It is also partially dependent upon the strength or amount of rainfall.
- Compacting snow can cause the formation of ice; this is how glaciers are formed.
- Glaciers are huge masses of ice that carry large amounts of sand and debris.
- Wind blows sand into dunes and ridges.
- The degree to which the wind can move objects depends upon the kinds of objects moved and the force of the wind.
- Underground caves are formed by dilute acids dissolving limestone deposits.
- Earthquakes are produced by long-continued strain on the rocks of the Earth's crust.
- Earthquake waves travel through the lithosphere and can be recorded on seismographs.
- Fossil impressions are made by plant and animal remains being pressed upon soft sediments that later harden.
- The study of fossils is very important in determining the ways the Earth has changed since it was formed.

In the intermediate and upper grades, the children should be led to develop concepts that are more complex, such as the following:

- Rivers carry much debris and dirt with them as they travel downstream. They deposit this debris at the end of the course when they slow down and can no longer support it.
- Streams cut out valleys as they flow by cutting downward.
- The arrangement of particles by winds, that is, the piling of the lighter particles together and the heavier particles together, is called sorting.
- Carbon dioxide dissolves in water to form carbonic acid.
- Burning a substance, such as a candle, will add carbon dioxide to the atmosphere.

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