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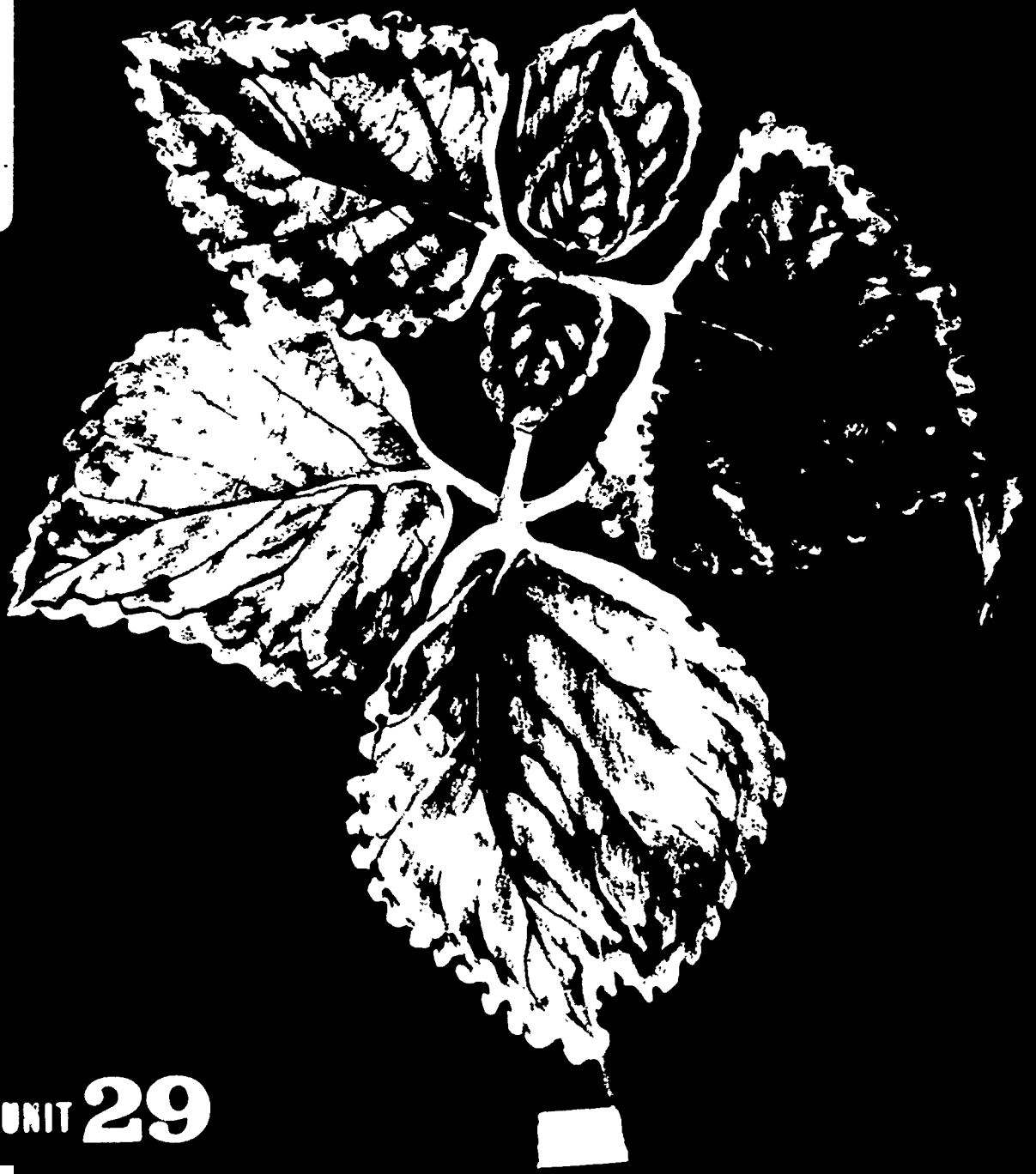
ABSTRACT

This volume is the last in a series of 29 coordinated MINNEMAST units in mathematics and science for kindergarten and the primary grades. Intended for use by third-grade teachers, this unit guide provides a summary and overview of the unit, a list of materials needed, and descriptions of three groups of lessons. The purposes and procedures for each activity are discussed. Examples of questions and discussion topics are given, and in several cases ditto masters, stories for reading aloud, and other instructional materials are included in the book. In this unit, three types of systems are examined. In the section on locomotion, the movement patterns of people, four-legged animals, fish, and birds are compared and contrasted. The functions of different parts of plants in carrying water is studied as an integrated system. The final section concerns the process of erosion, and examines factors related to this process. (SD)

NATURAL SYSTEMS



UNIT 29

MINNESOTA MATHEMATICS AND SCIENCE TEACHING PROJECT

MINNEMAST COORDINATED MATHEMATICS–SCIENCE SERIES

KINDERGARTEN

1. WATCHING AND WONDERING
2. CURVES AND SHAPES
3. DESCRIBING AND CLASSIFYING
4. USING OUR SENSES
5. INTRODUCING MEASUREMENT
6. NUMERATION
7. INTRODUCING SYMMETRY
8. OBSERVING PROPERTIES

FIRST GRADE

9. NUMBERS AND COUNTING
10. DESCRIBING LOCATIONS
11. INTRODUCING ADDITION AND SUBTRACTION
12. MEASUREMENT WITH REFERENCE UNITS
13. INTERPRETATIONS OF ADDITION AND SUBTRACTION
14. EXPLORING SYMMETRICAL PATTERNS

SECOND GRADE

15. INVESTIGATING SYSTEMS
16. NUMBERS AND MEASURING
17. INTRODUCING MULTIPLICATION AND DIVISION
18. SCALING AND REPRESENTATION
19. COMPARING CHANGES
20. USING LARGER NUMBERS
21. ANGLES AND SPACE
22. PARTS AND PIECES

THIRD GRADE

23. CONDITIONS AFFECTING LIFE
24. CHANGE AND CALCULATIONS
25. MULTIPLICATION AND MOTION
26. WHAT ARE THINGS MADE OF?
27. NUMBERS AND THEIR PROPERTIES
28. MAPPING THE GLOBE
29. NATURAL SYSTEMS

LIVING THINGS IN FIELD AND CLASSROOM
(MINNEMAST Handbook for all grades)

ADVENTURES IN SCIENCE AND MATH
(Historical stories for teacher or student)

NATURAL SYSTEMS

UNIT 29

MINNESOTA MATHEMATICS AND SCIENCE TEACHING PROJECT
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Second Printing 1972

NATURAL SYSTEMS

This unit was developed by MINNEMAST on the basis of experiences of the many teachers who taught an earlier version in their classrooms.

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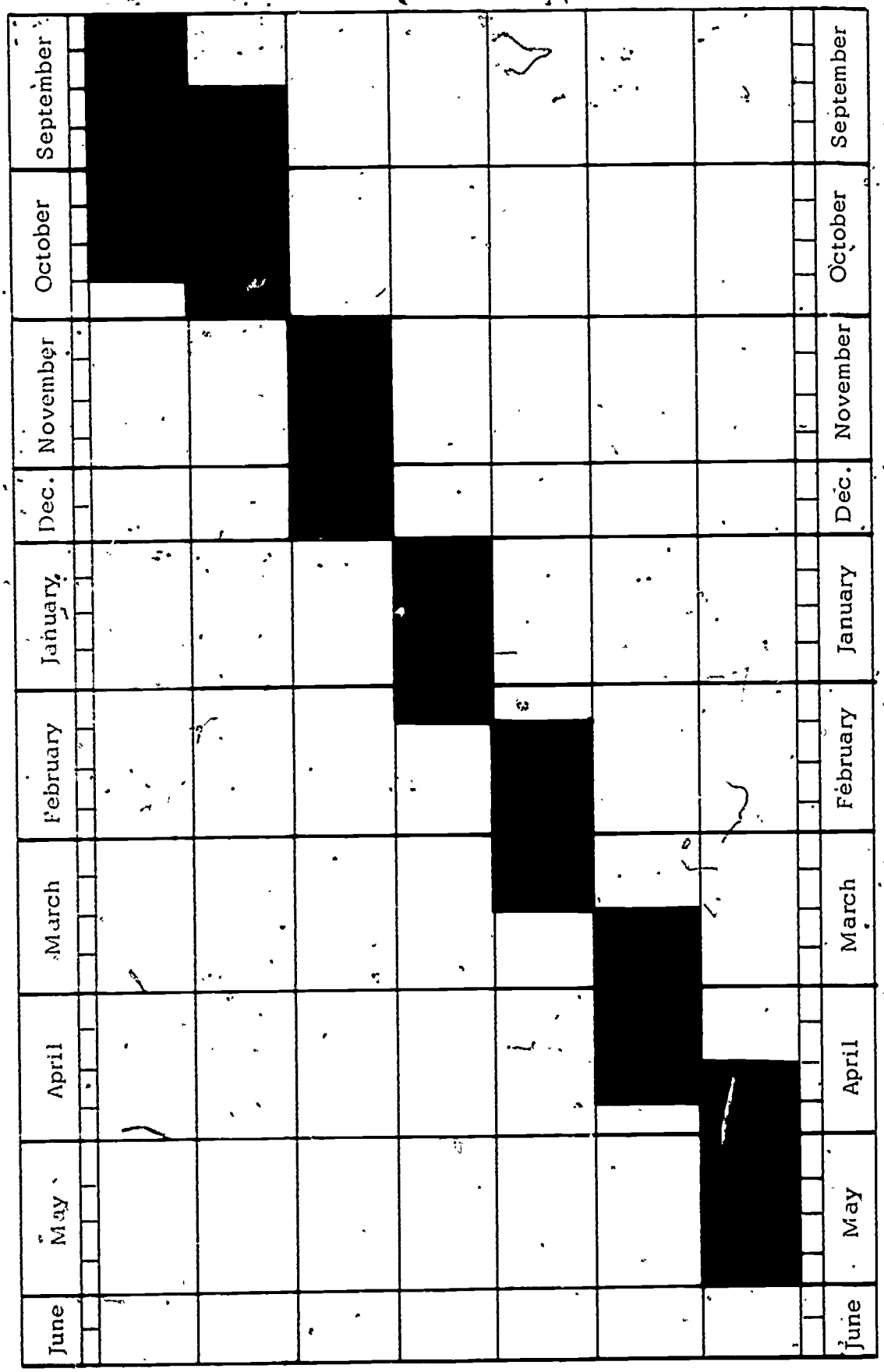
Suggested Teaching Schedule for MINNEMAST Third Grade Units



CONTENTS

Complete List of Materials for this Unit

The materials and their preparation, if any, are described in detail at the beginning of each lesson. Amounts are based on a classroom of thirty children.

total number required to teach unit	item	lessons in which item is used
30	**Student Manuals	2,7,10,15
30	*magnifiers	17,18
	crayons	3
	goldfish	6
15	*plastic shoe boxes	6,15
	*straws	6
	live bird (optional)	7
	stuffed bird (optional)	7
	toy airplane (optional)	7
	*feathers, contour and down	7
4	potted coleus plants, approximately the same size, at least 4"	9,11
	large tray	9
	newspapers	9
	sharp knife or razor	9,10
	wide-mouthed jar	9
30	*16-ounce plastic cups	10,14
1	*roll of masking tape	10,13
1	*roll of plastic wrap	10
1	*bottle of red food coloring	10
30	celery stalks with leaves	10
6	*large Baggies	11
20 or 30	*small Baggies	11
20 or 30	wire twists	11

2	* strips cobalt chloride paper	11
	gooseneck lamp (optional)	11
	green onions (optional)	12
	assorted plant stems	13
12	*large clear plastic straws	13
1	* bottle of green food coloring	13
30	* medicine droppers	13, 15, 18
	* beam balance	14
	lettuce leaves	14
	cabbage leaves	14
	a few leaves of succulents (fleshy-leaved plants such a jade plant, aloe, hen-and-chickens)	14
15	* small styrofoam trays	15
15	*large styrofoam trays	15
30	* paper cups	15
15	* cups sand	15, 22
15	* 1-ounce plastic containers	17
1 cup ea.	assorted soil samples	19
	* modeling clay	19
	popsicle sticks and bright yarn	21
	* radish or grass seed	22
	small piece of sod	22
	small twigs	22
	small rocks	22
	several large cake pans	22
	films: see pages 4 and 5	
	reference books:	
	Blough, Glenn, Bird Watchers and Bird Feeders, Whittlesey House, 1963	7

Darling, Lois and Louis, Bird, Houghton Mifflin, 1962	7
Goldin, Augusta R., Ducks Don't Get Wet, Crowell, 1965	7
Goude, Alice E., Gray Wings, Scribner, 1964	7
Zim, Herbert S., Owls, Morrow, 1950	7
World Book, Vol. 2, Birds (see especially the sections "How Birds Fly," and "Wings in Flight")	7
Kurtz, Edwin B., Jr. and Chris Allen, Adventures in Living Plants, University of Arizona Press, Tucson, Arizona, 1965.	11

*kit items as well as
**printed materials available from Minnemath Center, 720 Washington Avenue S. E., Minneapolis, Minnesota 55455
***available from The Judy Company, 310 North Second Street, Minneapolis, Minnesota 55401

INTRODUCTION

This final unit of the MINNEMAST K - Grade 3 curriculum applies the systems concept to the study of three natural phenomena.

1) The children study the locomotion systems of land, water and air-borne animals.

2) They explore a plant's water carrying system and test various plant parts to see what role they play in the system.

3) They experiment with a model of an erosion system and investigate the interrelationships of soil type, ground slope and water flow. They vary each of these conditions and observe the effects.

Different techniques are required for the study of each system. When the children work with plants they can plan controlled experiments. When they work with animals their activities are mostly observation and analysis. They observe the erosion system in nature, and then build a model in the classroom with which they can experiment. The systems concept, a thread that has run through many MINNEMAST units, ties together the study of these three systems.

THE SYSTEMS CONCEPT

A scientist is concerned with gathering information about the way things happen and with organizing his observations so that they will be meaningful and useful. In order to do this, he must narrow his field of investigation and select a manageable portion to investigate. To study a phenomenon, he focuses his attention on a limited set of objects involved in that phenomenon. This set of objects and the relationships that exist among them is the system he observes and tests.

It is this approach to an investigation that MINNEMAST has developed in its systems thread. Situations are provided in which the children:

1) Select relevant elements to observe.

2) Explore relationships among these elements.

3) Verify the relationships by testing.

The following summary indicates how the systems thread runs through the MINNEMAST program.

Unit 15, Investigating Systems

The systems investigated and the experimental methods used are very simple. The main method of investigation is to observe a phenomenon, think about what objects are involved in producing it, and then remove one object at a time from the system to find out which are necessary for the phenomenon to occur. There are no efforts to quantify experiments.

Unit 19, Comparing Changes

In Unit 19 a quantitative treatment of systems is introduced. The children discover and describe the relation between different elements of a system, such as the height of a corn plant and its age. The changes in these two quantitative properties of the system's elements have a functional relation — that is, as one changes the other changes. As the days pass, the corn plant grows. The children explore functional relations in several different systems.

Unit 23, Conditions Affecting Life

Here there is more emphasis on systems found in nature. The children set up controlled experiments in which they vary a certain condition (light, temperature or moisture) while keeping the others constant. Thus they can see how each of the conditions affects living things. A general method emerges, that of narrowing down to a suitable system of a manageable size, the study of which can reveal the answers being sought.

Unit 29, Natural Systems

This unit rounds out the work with systems. The children observe three natural systems by making detailed analyses of how they work. In each case the children generalize from their classroom experiences. In the locomotion system they

consider what elements are common to all the animals they study and what might also be in common with other things that move, such as cars, boats and airplanes. In the plant and erosion systems they use the information they have discovered to think about what plants are best suited for different environments and about how man can control erosion. Thus they use the systems concept to study three general classes of natural phenomena. This suggests how the systems notion is used in scientific investigation.

OBJECTIVES

Specific objectives are provided with each lesson. The introductions to each section give more generalized objectives, as they apply to the systems being studied. Only a few general objectives for the unit are listed here.

As they do the work outlined in this unit, the children should:

- Use the systems concept as an aid in studying natural phenomena by focusing their attention on just one portion of a complex system. (For example, the locomotion system is just one aspect of the larger system, the whole animal.)
- Examine a phenomenon to decide what the relevant variables in the system are, and then control and change some of those variables and compare and describe the outcome.
- Recognize that there can be many ways of looking at the same system and accept a variety of opinions and ideas.
- Distinguish between speculations and conclusions, based on experimentation.

NOTES ON TEACHING THIS UNIT

The lessons and experiments included have been tested in classrooms and can be relied upon to give children particular learning experiences. Additional activities designed by the children should be inserted where they are appropriate.

Many times in this unit it is recommended that you encourage the children to participate in suggesting and designing experiments. This degree of involvement can capture genuine interest and help the students to formulate ideas about what are

appropriate questions to examine through scientific investigation and what are appropriate means for doing this.

As you read through the unit in preparing to teach it you should decide at what points you will give the children freedom to incorporate their own ideas, so that the activities will be nicely balanced between experiments that are teacher-originated and those that are student-originated.

PREPARATION

The films recommended in this unit are an important part of the lessons. Order them from your regular audio-visual sources well ahead of time. The chart below tells approximately when you will need them. Each time we recommend a film we give at least one alternative. They are dissimilar enough so that if two are available, you should show them both. In the chart numbers refer to lessons; letters refer to films.

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	1: A,B	2	3	3	4
Week 2	5	6: C,D	7: E,F	7	8
Week 3	9	9	10	11	11
Week 4	12	13	13	14	14
Week 5	15	16	17	18	19
Week 6	19	20	21	22	

A. Animals, Ways They Move, Encyclopedia Britannica Films, 16mm, 10 minutes, color (1)

B. How Animals Move, McGraw-Hill, 16mm, 10 minutes, black and white. (1)

C. Looking at Fishes, Encyclopedia Britannica, 16mm, 11 minutes, color (6)

D. How Water Animals Move, film loop, super 8mm., 4 minutes, color (6)

E. Looking at Birds, Encyclopedia Films, 16mm, color, 10 minutes (7)

F. Seabirds, Form and Flight, film loop, super 8mm, color, 4 minutes (7)

Most of the films are available for rental. Film loops must be purchased, but if at all possible we recommend that you use them.

In the locomotion section (Lesson 7) we give optional activities with a live or stuffed bird, dependent upon your success in obtaining one from your city zoo, museum, taxidermists or parents.

Several lessons call for living things that are not provided in the kit. Goldfish (Lesson 6) can be purchased in a pet shop or even a variety store, and coleus plants (Lesson 9) should be available in the spring in variety stores, supermarkets or greenhouses. See Living Things in Field and Classroom for more information on obtaining and caring for the fish and plants.

Most lessons are limited to one day's activities. When a lesson is longer, this is mentioned in the introductory paragraphs. You can refer to the chart on p. 4 for advance scheduling and preparation.

SECTION I ANIMAL LOCOMOTION SYSTEMS

COMMENTARY

The different locomotion systems studied in this section have at least three things in common:

1) All the animals move some parts of their bodies to go forward.

2) The body parts push against something — land, air or water.

3) The energy for moving comes from the food each animal eats.

The decision of what should be included in a system is often an arbitrary one. In the locomotion system one could look at the animal, decide which body parts are involved in its moving forward, and call that the locomotion system. Another way to look at the locomotion system would be to consider the moving parts of the animal which push it forward, the part of the environment — land, water, air — against which the moving parts push, and the energy the animal needs for moving, in this case the energy that it gets from eating food. Both of these approaches are developed here.

To study each animal locomotion system, the children will observe, describe and analyze the animal in motion. Wherever possible they will study live animals — goldfish, bugs, birds and themselves. Several films make it possible for them to watch other animals. Stop-motion diagrams help them make a detailed analysis of how parts of a particular system move.

The purpose of these lessons is not to accumulate information about how animals move. It is rather to give the children experience in studying a complex phenomenon by applying the systems approach. They analyze locomotion, see what parts of the body are involved, and study each part to see how it moves. Studying several apparently different locomotion systems (land, water and air-borne animals) gives the children the additional opportunity, after considering each separately, to discover what they all have in common.

If the children are interested and you are able to take the time, there are many ways in which these lessons can be extended. Encourage the children to continue investigations after school. A few suggestions are made in the lessons; you and the children will think of others.

OBJECTIVES

By the end of this section the children should be able to:

- See that all locomotion systems follow the same basic principle: all animals move forward by pushing with some parts of their body against land, air or water.
- Identify food as the source of energy for locomotion of animals.
- See that different animals depend on different kinds of body parts for getting themselves from one place to another.
- Describe the locomotion systems of people, dogs, fish and birds after making direct observations.
- Recognize bilateral symmetry as it appears in animals' structure and in their locomotion patterns.
- Deduce limited information from examination of traces (footprints) left by a locomotion system that they do not observe directly.
- Describe similarities and differences among various mechanical and living locomotion systems.

Lesson 1: HOW ANIMALS MOVE FROM PLACE TO PLACE

The children discuss different ways that animals move from place to place. They should include animals that move in water, in air and on land. Then they discuss what should be considered parts of the locomotion system of some common animals. They also watch a film showing many kinds of animals walking, flying and swimming.

Whenever it is appropriate in the discussion, tell the children that when we talk about animals moving from place to place we are talking about their locomotion systems. Tell them that this is easier to say than always to say "their systems for moving from place to place," and it means the same thing. If we take the word apart, loco means place, and motion means moving.

MATERIALS

- films: Animals, Ways They Move, Encyclopedia Britannica Films, 16mm, 10 minutes, color.

  How Animals Move, McGraw-Hill 16mm, 10 minutes, black and white.

OBJECTIVES

In the course of this lesson the children should:

- Observe and think about ways that different animals move.
- Try to decide what should be considered parts of different animals' locomotion systems.
- See that the same body parts are not used by all animals to move forward.
- See that all animals move forward by pushing with some part of their bodies against the land, water or air.
- Become prepared to look closely at locomotion systems of living specimens to learn more about them in the following lessons.

PROCEDURE

You will be using film and discussion in this lesson. We describe the procedure for beginning with discussion, then using the film as a source of information, and concluding with more discussion. You may prefer to show the film first, conduct a discussion, and then show the film again to let the children check on their ideas. When you preview the film you will be able to decide which way of teaching the lesson is appropriate for your class.

Every animal has some way to get from one place to another. Have the children describe as many ways that animals move from place to place as they can think of. List on the board all the ways they tell you.

Then ask them what kinds of animals move in these kinds of ways, and list the kinds of animals after each kind of motion. You may have a list similar to this:

- Walk: People, dogs, cats, horses, birds, insects, elephants, lizards.
- Run: All the animals that walk.
- Swim: People, fish, some birds, some four-footed animals, some insects.
- Fly: Birds, bats.
- Hop: Birds, squirrels, rabbits, people, kangaroos.
- Wiggle: Snakes, worms.
- Leap: Horses, kangaroos, deer.

Ask the children if they think that each of the animals that they have mentioned has the same parts in its locomotion system as every other animal they have mentioned. Ask what they think are parts of the locomotion system in a dog, a bird, a person, a snake, and a fish. List their responses under each animal.

The children may add other animals to the list. Insects with six legs and two or four wings are extremely interesting. Until now, the children have been depending on their memories

and imagination in this discussion. They should have opportunities to observe as many kinds of animals moving as possible. For this reason the next lesson includes a field trip. To supplement this and to prepare for it we suggest that you use a film, Animals, Ways They Move, or How Animals Move.

Before showing the film, discuss with the children what kinds of things they are going to watch for particularly. (These will depend on the kinds of things that were talked about earlier.) Ask the children some of the following questions to direct their observations when they watch the film.

HOW DO ANIMALS USE THEIR LEGS?

ARE THERE PARTS THAT ARE USED FOR LOCOMOTION BY SOME ANIMALS AND NOT USED FOR LOCOMOTION BY OTHERS?

DO THEY USE TAILS? DO ALL ANIMALS THAT HAVE TAILS USE THEM IN THE SAME WAY? DO A FISH AND A DOG USE THEIR TAILS THE SAME WAY?

Then show the film. After the children have seen the film, have them look at their original lists of what should be included in animal locomotion systems, and ask if they would like to make any changes based on their observations.

In every locomotion system the animal pushes part or parts of its body against something — against land or air or water — to move itself forward. If the children do not notice this, ask:

WHY DO YOU MOVE FORWARD WHEN YOUR LEG MOVES BACK?

When the children recognize that their feet push backward against the ground, you can ask what a bird pushes against (air) and a fish (water). At this point the children may want to add the ground, air or water to each locomotion system they listed, since this is what the animal pushes against.

Now the parts of the locomotion systems listed may include

body parts and what they push against. To lead the children to recognize a third area to consider, ask them where animals get the power or energy to move. They should realize that all animals need food for energy. This too can be included as part of a locomotion system.

(Remember that a system is arbitrary, and can be broad or narrow according to the individual's choice. It is not necessary to include all the above in every list of parts of a locomotion system, but it helps one remember what all locomotion systems have in common. This point will be made in more detail at the end of this section.)

Lesson 2: FIELD TRIP

On a field trip the children observe as many kinds of animals as possible, paying particular attention to their locomotion systems and numbers of legs and wings. They discover that the animals they find all have even numbers of limbs.

The children should be able to find enough insects and other animals within the school yard and a block of the school to make their observations. Inspect the area beforehand so that you can anticipate what the children will find. The pictures of field trip areas in the MINNEMAST handbook, Living Things in Field and Classroom (pages 100-113) suggest places to look and give an idea of what might be found there.

This field trip relates the locomotion lessons to direct experience and offers the children opportunities to expand their appreciation of their natural environment.

OBJECTIVES

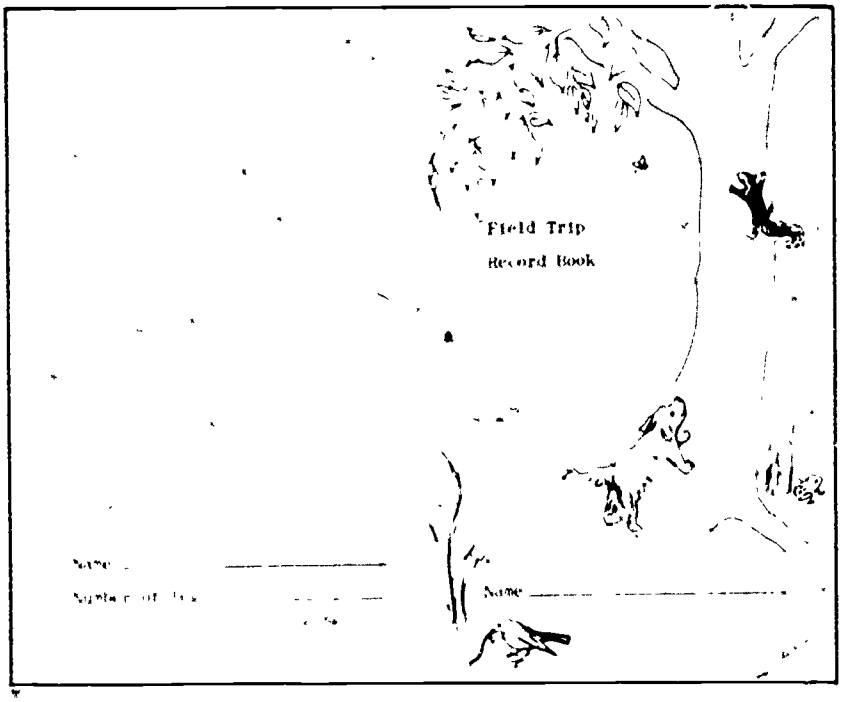
During this lesson the children should discover that:

- There are many kinds of animals to be found in ordinary surroundings.
- Animals have many different kinds of locomotion systems.
- Different animals have different numbers of parts in their locomotion systems.
- All the animals they find will have either no legs at all or even numbers of legs.

MATERIALS

-- for each pair of children --

- pencil
- magnifier
- Worksheets 1 and 2



PROCEDURE

Activity A

Before the field trip have the children tear out Worksheet 1 (two pages) and fold them in half to make their field trip record booklets.

Introduce the field trip by asking the class what sort of animals they would expect to find around the school grounds and where each kind would be found. Recall the field trip in Unit 23, when they looked under rocks and boards. Where else would they expect to find animals?

Usually it is possible to observe some birds, such as sparrows or pigeons. There may be squirrels, dogs or cats within sight. Many of the animals may be small, such as aphids and larvae on bushes, grasshoppers or crickets in the grass, spiders or ants in corners and crevices.

Divide the class into pairs of children who will search together. Assign a special area to each pair. The assigned places will vary for each school yard. Possible areas include tree trunks, bushes, plots of grass, sidewalk cracks, corners of buildings, areas around downspouts, edges of fences, the sky, and the sidewalks.

Tell the children they are to look carefully for any animals, including insects, that may be around. They are to observe their locomotion, count and record the number of legs and wings, and draw a picture of each animal in their field trip booklets. They will need to use their magnifiers to study the very small animals. Caution them not to touch spiders or bees but to observe them quietly.

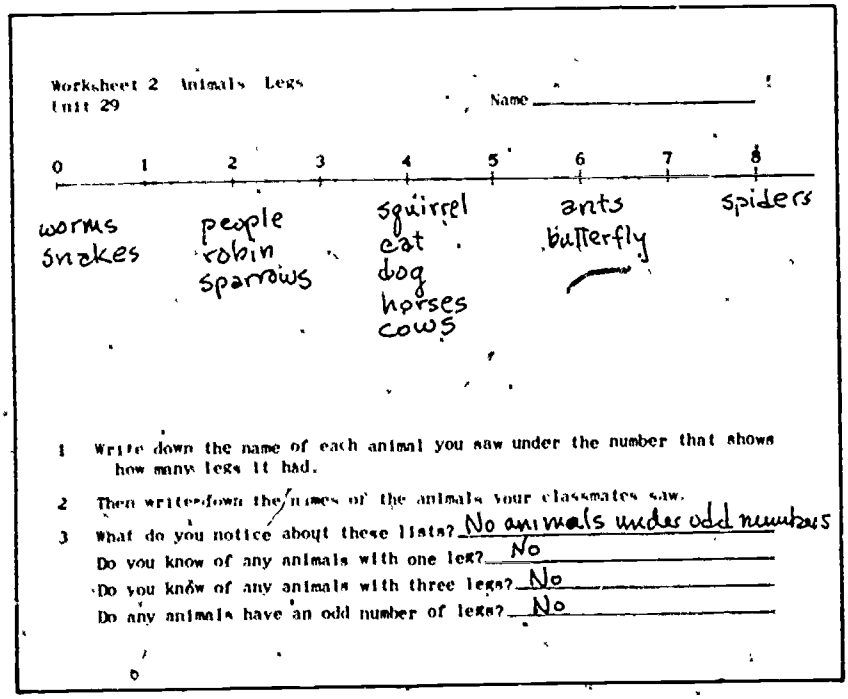
Tell the children that biologists studying animals are very quiet, work close to the ground or the grass to find small animals, and work carefully with the animals.

Have the children pair off and search their assigned area. They are to record their observations, but class discussion should wait until you are back in the classroom.

Activity B

When you return to the classroom let the children report on the animals they have observed. Probably there will not be a great variety, so one child can supplement another's report.

At first ask the children to tell how the different animals moved and what were parts of their locomotion systems. If birds were observed, find out if the children think wings should be part of the system. If so, what do they push against? When animals walk, what do they push against? Establish the idea that in order to move, some part of an animal's body needs to push against something — the earth, the air, or in the case of swimming animals, the water.



Worksheet 2 Animals Legs
Unit 29

Name _____

0 1 2 3 4 5 6 7 8

worms
snakes

people
robin
sparrows

squirrel
cat
dog
horses
cows

ants
butterfly

spiders

1 Write down the name of each animal you saw under the number that shows how many legs it had.

2 Then write down the names of the animals your classmates saw.

3 What do you notice about these lists? No animals under odd numbers

Do you know of any animals with one leg? No

Do you know of any animals with three legs? No

Do any animals have an odd number of legs? No

Activity C

Draw a number line on the board as it is shown on Worksheet 2. Keep the units long enough to allow room for writing. Have the children follow the first instruction on the worksheet. When they have finished writing the names of the animals they saw, call on different children to

tell what animals they saw and how many legs each one had. As they report, write the name of each animal under the number showing how many legs it has. Each child should add all the animals to their own lists. Then ask about other animals the children know about, even though they didn't see them on the field trip.

Ask what they notice about the number line and the way the animals' names are distributed on it. They should discover that they have no animals listed under odd numbers (unless someone saw an animal that had lost a leg). All the animals listed have either an even number of legs or none at all. Ask how these legs are arranged. (They are paired on opposite sides of the body.)

Tell the children that almost all animals have some kind of symmetry. Ask them to think about what kind of symmetry can be found in the way the bodies of all these animals are built. (They all exhibit bilateral or mirror symmetry.)

Ask the children to discuss how having an even number of legs helps the animals move efficiently. They might want to invent imaginary animals with odd numbers of legs and think about how they might move.

Lesson 3: HOW PEOPLE WALK

In the first lesson the children made general observations about the locomotion of animals. In the second lesson they observed living animals. In this lesson they look in greater detail at the way one animal walks — a person. They find out how knees, feet, arms and other parts of the body are used in walking, and think about which of these should be included in a walking system. They discover patterns in locomotion, and compare walking and running.

This lesson will take two days, one for each activity.

OBJECTIVES

The children will:

- Identify the parts of a person's walking system from direct observation and analysis of each other's walking.
- Discover that people's walking and running patterns are symmetrical.

MATERIALS

- crayons
- Worksheets 3 through 7

Activity A

Have a child walk back and forth in front of the class where the others will have a clear view of him. Then ask the children what they think are the parts of his walking system. Have the child continue walking and ask him to freeze (stop moving) at intervals so that the children can note the positions of different parts of his body at different times when he is walking.

You might have the children focus their attention on just one part of his body at a time so that they can see that it does different things at different stages in the walking pattern. For example, they might watch one knee to see how it bends and straightens alternately. Then they might watch his foot and see how sometimes just the toes touch the ground, sometimes just the heel touches and sometimes the entire foot is on the ground.

The things the children observe may include the following:

- The left and right legs alternate.
- The legs move forward, bending at the hips.
- The knees bend and straighten alternately.
- The body moves forward because the feet push back against the ground.
- The feet have a heel-to-toe movement as they hit the ground, rock forward and then lift off the ground.
- The arms swing alternately, but opposite to the feet. The left arm goes forward with the right foot, and the right arm with the left foot.

Ask the children to talk about what should be included in the walking system. It will be easy for them to agree that the ground is what a person pushes against, and that he has to have a source of power. There may be some disagreement about which body parts are essential. To give the children the opportunity to make closer observation of a person's walking, have them work in pairs, following the directions on Worksheets 3, 4 and 5.

When they have completed the worksheets, have the children discuss them. Ask how they decided which things were necessary in the walking system and which things were not necessary. Allow several children to share their ideas and methods of decision making. Then have them tell what they included in their lists and describe some of the things that they observed. There will be variations in the lists. The children should give their reasons for including different things in the walking system. Some will include arms, eyes, and the trunk of the body. Others will choose to define the system more narrowly and include only the lower limbs.

Worksheet 3
Unit 29 Name _____

Get a partner

Find a open space to walk where one person can move freely and the other can watch him easily.

You will have a turn to be a walker and a turn to be a watcher

THE WALKER'S JOB

Walk back and forth as the watcher tells you.

Freeze when the watcher tells you, so that he can see which parts you are using to walk.

Walk back and forth at least six times.

THE WATCHER'S JOB

Notice how each part that the walker uses moves when he is walking forward

Does it bend or not?

Does it move forward and backward or sideways?

What does each part of the walking system do?

Worksheet 4
Unit 29 Name _____

THE WATCHER'S RECORD

List the body parts that you think are in the walking system

feet _____ _____
legs _____ _____
eyes _____ _____
arms _____ _____ _____

List other things that could be part of the system.

floor _____ _____
food _____ _____

Now do these three things:

1. Have the walker walk back and forth one time for each part that is on your list. Watch just that part.
2. Then cross out any part on your list that you decide shouldn't be there.
3. Add any other parts that you think are in the walking system.

Worksheet 5
Unit 29 Name _____

THE WATCHER'S RECORD continued

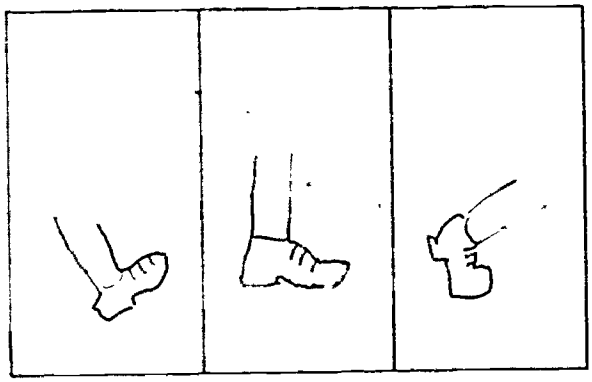
Choose one part of the walking system to look at more carefully.

Write the part you chose here. foot

Watch the walker walk back and forth several times.

Ask him to walk slowly, to walk quickly, and to stop several times so that you can see what the part you are watching does when he walks.

Draw pictures here showing what the part you watched does when someone walks.



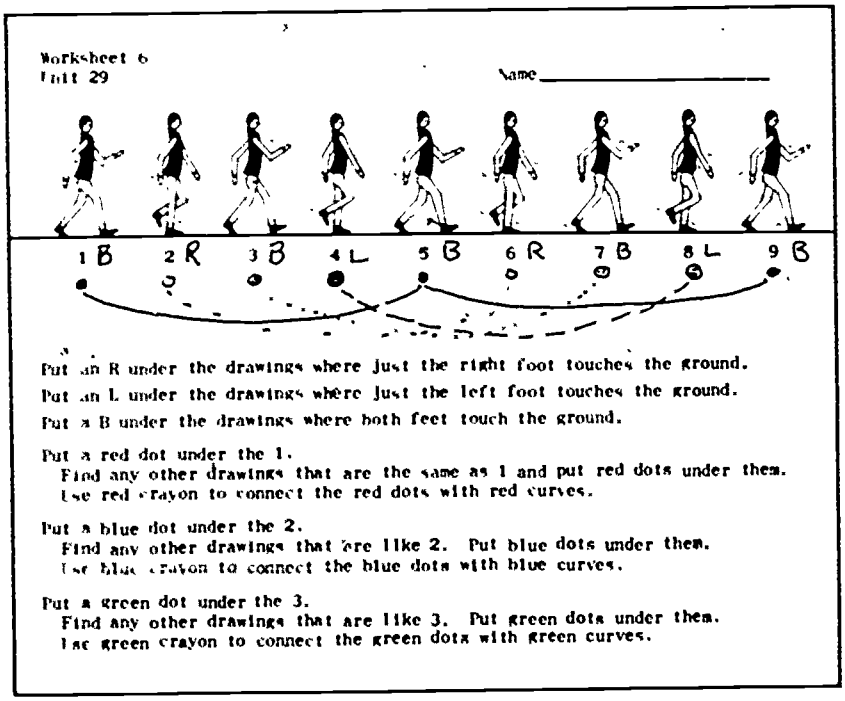
Activity B

It is difficult to watch someone walk and to observe exactly what is happening, because so much is going on at once. Worksheet 6 shows diagrams of the motion stopped or frozen at different stages of the walking pattern. The children may do the worksheet alone or in pairs.

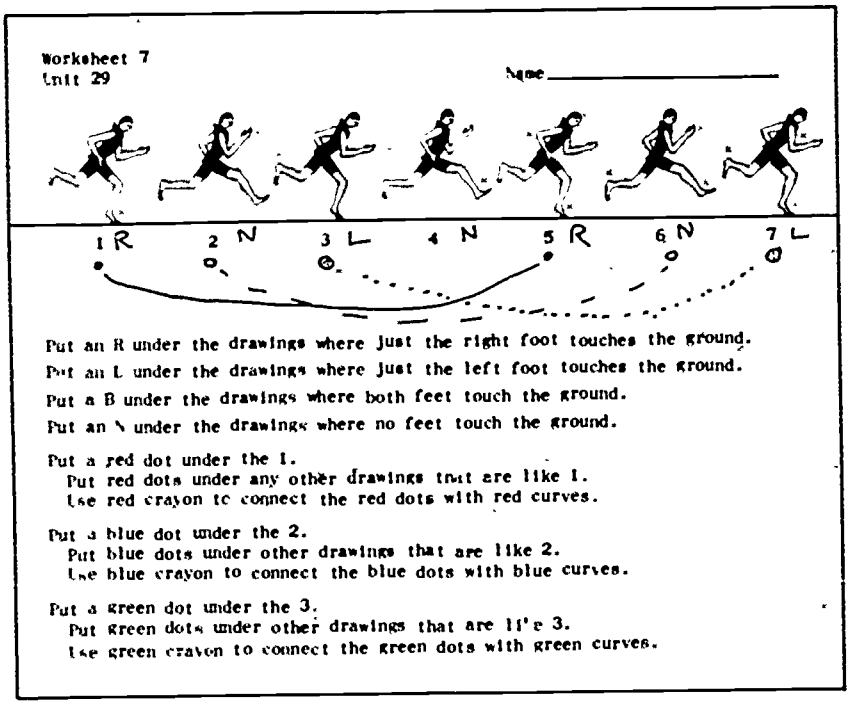
When they have finished the worksheet ask them what they have found out about walking patterns. To begin the discussion you may ask questions similar to the following:

HOW MANY STAGES OF A COMPLETE WALKING PATTERN ARE SHOWN BEFORE THE PATTERN REPEATS? (Four. They are described by the code letters B,R,B,L, meaning "both, right, both, left.")

WHICH STAGE OF THE PATTERN DO YOU SEE MOST FREQUENTLY? (Both feet on the ground.)



The colored curves connecting similar figures on the worksheet make repeating patterns, a form of symmetry that the children have worked with in kindergarten and first grade MINNEMAST units. They might want to color each figure, rather than just the dots under them, to illustrate the symmetry of walking patterns.



Worksheet 7
Unit 29

Name _____

1 R 2 N 3 L 4 N 5 R 6 N 7 L

Put an R under the drawings where just the right foot touches the ground.
Put an L under the drawings where just the left foot touches the ground.
Put a B under the drawings where both feet touch the ground.
Put an N under the drawings where no feet touch the ground.

Put a red dot under the 1.
Put red dots under any other drawings that are like 1.
Use red crayon to connect the red dots with red curves.

Put a blue dot under the 2.
Put blue dots under other drawings that are like 2.
Use blue crayon to connect the blue dots with blue curves.

Put a green dot under the 3.
Put green dots under other drawings that are like 3.
Use green crayon to connect the green dots with green curves.

Have the children do a similar analysis of the running pattern on Worksheet 7.

Then ask them to compare what is similar and what is different about walking and running. If necessary, you may ask questions such as these:

ARE BOTH FEET EVER ON THE GROUND AT THE SAME TIME WHEN A PERSON IS RUNNING? (No.)

ARE BOTH FEET EVER IN THE AIR AT THE SAME TIME WHEN A PERSON IS RUNNING? (Yes.)

ARE BOTH FEET EVER IN THE AIR AT THE SAME TIME WHEN A PERSON IS WALKING? (No.)

DO THE HEELS EVER TOUCH THE GROUND WHEN A PERSON IS RUNNING? (No.)

DO THE HEELS EVER TOUCH THE GROUND WHEN A PERSON IS WALKING? (Yes.)

WHEN DOES THE RIGHT ARM MOVE FORWARD? THE LEFT ARM? (Alternate to the feet.) IS THIS THE SAME IN WALKING AND RUNNING? (Yes.)

Lesson 4: FOUR-LEGGED LOCOMOTION PATTERNS

The repeating patterns of locomotion of four-legged animals are more complicated than two-legged patterns. The children experiment to discover possible patterns of walking on four legs and then discuss animals that they think might use such patterns. They look at eight-stage stop-motion diagrams of a dog's walking pattern and study the footprint patterns of several four-legged animals.

OBJECTIVES

By the end of this lesson the children should be able to:

- Observe that the locomotion systems of four-legged animals include body parts that push against something, and something that they push against.
- Identify possible four-legged patterns and experiment with them.
- See that all four-legged animals don't necessarily use similar walking patterns.
- See that the same animal can have more than one way of walking.

MATERIALS

- Worksheets 8 and 9

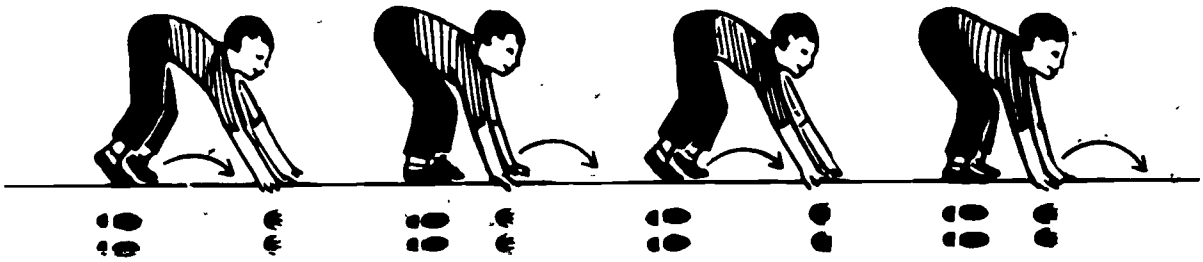
Activity A

Remind the class that they have seen that people walk with an alternating right-left pattern. Ask how the children think four-legged animals walk. Have a child get down on hands and feet and demonstrate a possible four-legged pattern. Have other children describe other possible patterns and demonstrate them.

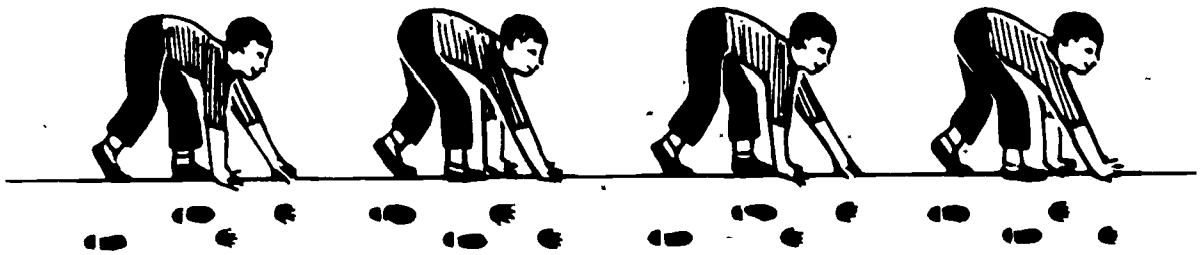
As each new pattern is described draw it on the board or have a child draw it on the board in stick figures. Have the children draw what they think the footprint pattern would be for each four-legged style of walking. Then give a few children at a time opportunities to try walking these ways, using the diagrams on the board as guides. Some of the patterns will be comfortable for the children and others will be awkward.

The following patterns will probably be among those suggested.

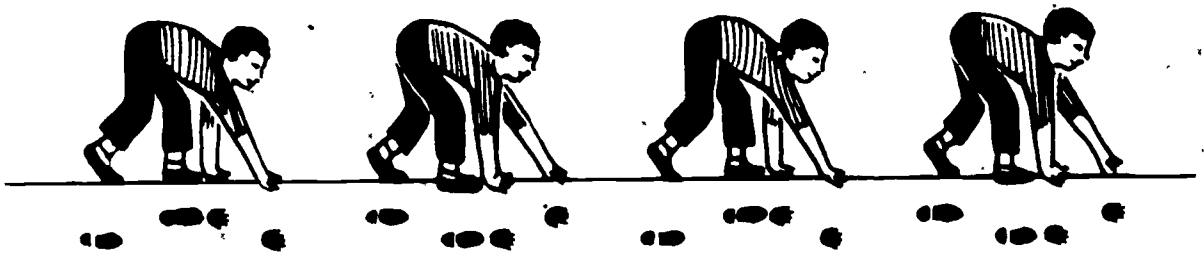
1. Both front limbs move forward together, then both back limbs move together. This is essentially a hopping form of motion, with two limbs at a time moving through the air while the other two are on the ground.



2. Right front and rear limbs move at the same time, then left limbs move at the same time.

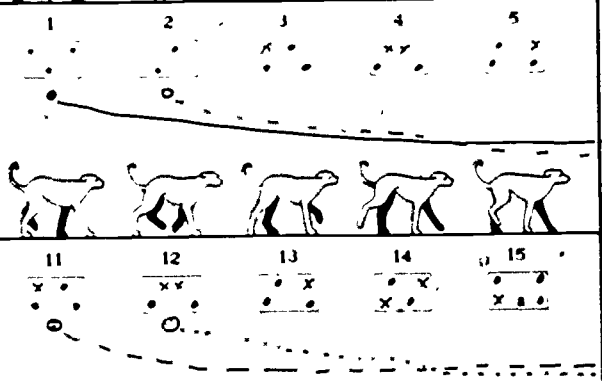


3. Right rear and left front move at the same time, then left rear and right front.



Worksheet 8
Unit 29

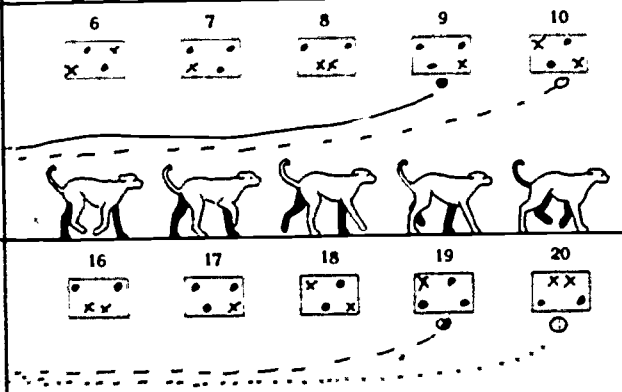
DOG WALKING



Place a red dot under the box below picture 1.
Find the next picture that is like 1
Place a red dot under it What number is it? 9
Can you find another picture like 2? yes
What number is it? 10 Put blue dots under both.
Connect the red dots with red curves.
Connect the blue dots with blue curves
Use two other colors to connect pictures 11 and 12 with other pictures that match them.

Name _____

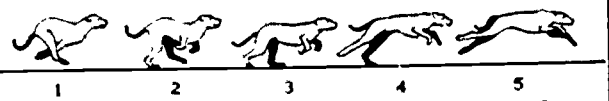
PATTERN

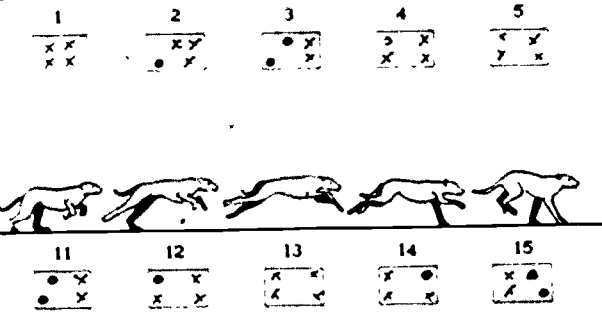


The pictures of a person's walking pattern had four stages before they began to repeat.
How many stages are shown of the dog's walking pattern before they repeat? 8
Which pattern is more complicated? Person ☐ Dog ☑
Try to draw a dog's footprint pattern in the boxes under the drawings.
Use dots to show where the feet touch the ground.
Use x's to show where feet are in the air.

Worksheet 9
Unit 29

DOG RUNNING

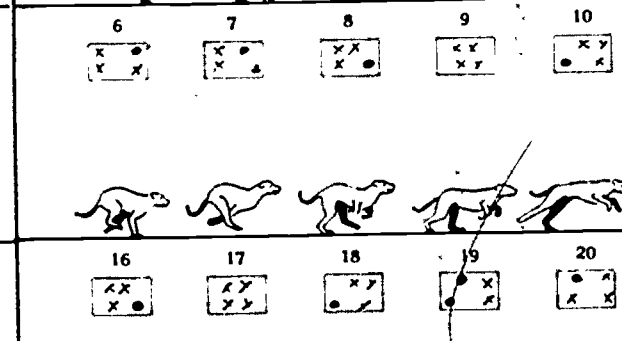




Look at these pictures of a dog running.
Find where the pattern repeats.
1 is the same as 9 and 17
2 is the same as 10 and 18
3 is the same as 11 and 19
How many stages are shown in the dog's running pattern? 8

Name _____

PATTERN



Draw the running footprint pattern under each picture.
Use o's for the feet that are touching the ground.
Use x's for the feet that are in the air.
Look at the footprint pictures of walking and running.
Look for things that are the same.
Look for things that are different.
Discuss them with the class.

After trying some of the patterns, have the children get ready for a short discussion at their seats. Point to the diagrams on the board and ask what animals the children can think of that might use these patterns sometimes.

Activity B

Have the children turn to Worksheets 8 and 9 and follow the directions, working alone or in pairs.

When they have finished the worksheets discuss them briefly with your class. Have the children compare walking and running patterns. They should look for similarities and for differences. Ask how many feet are usually on the ground at one time for walking, and how many for running. Does the animal ever have all his feet in the air when walking? When running? Is the distance between footprints greater in walking or in running?

Activity C

All the walking patterns that have been investigated have repeating symmetry. Ask the children to try to walk in a way that does not have repeating symmetry. An example of this might be three hops on the right foot, one step on the left, one step on the right, two hops on the left — a continually changing pattern. The children will observe that their usual symmetric patterns are quicker, more comfortable, more efficient and require less concentration. It is natural for them and for other animals to move forward in a repeating pattern.

Lesson 5: MAKING DEDUCTIONS

Sometimes one can tell things about a system from indirect evidence, even though one doesn't see any part of the system itself. Footprints are evidence of a locomotion system that has walked or run over soft ground. Here the children make speculations based on indirect evidence. They have an opportunity to distinguish between freewheeling guesses and guesses that have a logical foundation.

Another aspect of this lesson is very important in science — that is, that often evidence may be interpreted in several ways, and the observer must keep an open mind until he is able to make conclusive observations or experiments to support a particular interpretation.

OBJECTIVES

During this lesson the children should use what they learned in the first four lessons of this section to:

- Interpret indirect evidence of a system that operated when they were not observing it.
- Recognize the limitations of indirect evidence that might be interpreted more than one way.

MATERIALS

- Worksheets 10 and 11

PROCEDURE

Tell the children that sometimes it is possible to get information about a system without seeing the system at work. Ask if they can think of any way that they might be able to tell that an animal had passed by a certain place when the animal itself was nowhere in sight.

If the children do not think of footprints as possible evidence, ask them if they know what kind of evidence Indians used to help them decide if people or animals had passed by a certain place. What kinds of things do they think that Indians could

tell about an animal's locomotion system from observing his footprints? The children may talk about:

- Identity of the person or animal. Evidence could include shape and number of feet, distance between footprints as indication of size, depth of footprints as indication of weight.
- Direction of movement, evidenced by which way toes point. (Someone might suggest that this could be interpreted another way. The animal might have been walking backwards.)
- Speed. Evidence might include distance between footprints, depth of footprints, presence or absence of human heel marks, pattern left by four-legged animal.

After the discussion have the children turn to Worksheets 10 and 11 and follow the directions. When they have completed the worksheets they may want to share their stories and pictures.

[See worksheets on next page.]

After this discussion the children may enjoy knowing about a footprint activity to do at home. They could take a pan of water outside, wet their bare feet and make footprint patterns on a dry sidewalk. One child could hide his eyes while the other makes a pattern. Then the first child could try to tell how he did it. They can try walking slowly or quickly, forward or backward, etc.

Worksheet 10
Unit 29

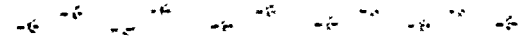
Name _____

Footprints Made by Two-legged Animals

A person running →

Someone with shoes ←

A little kid ←



A bird →

Draw arrows to show the direction each animal went.

Which do you think was moving fastest? the first one

Why did you pick that one? The footprints are further apart Just the toes show.

Write in each space the animal you think made the prints.

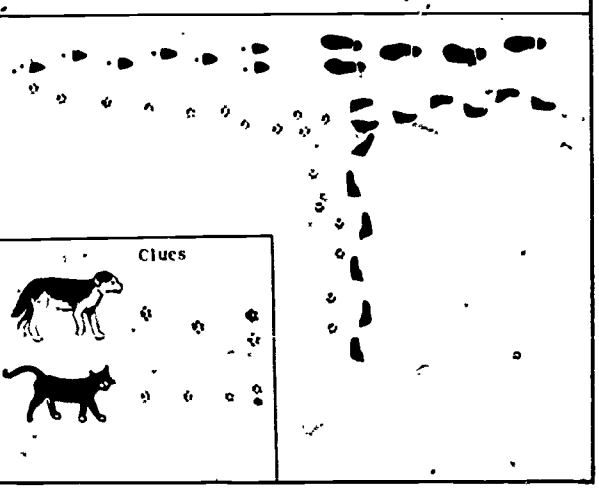
How can you tell? From the size and the shape of the footprints

Worksheet 11
Unit 29

Name _____

Footprint Stories

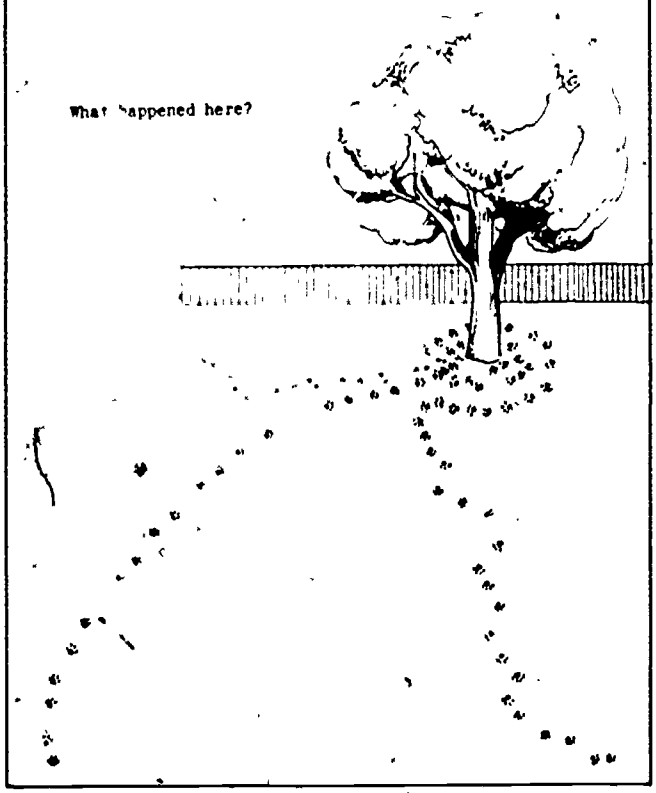
Choose one of these sets of tracks. Write a story and draw pictures about who passed here and what happened.



Clues

Worksheet 11 (continued)

What happened here?



Lesson 6: HOW ANIMALS SWIM

Except for the animals in the films, those that we have discussed in most detail have legs as the most important parts of their locomotion systems. Here the children look in more detail at animals that swim. They observe a goldfish and note the parts of its locomotion system. Then they see films about fish, which will provide them with further experiences and observations. They also consider other animals that swim. This lesson is just an introduction and is not intended to be a comprehensive study.

Determine the size of your groups by the number of goldfish you are able to provide.

OBJECTIVES

Through class discussion and individual observation, the children should:

- Agree on what to call different parts of the fish's body.
- Describe how different parts move when the fish swims.
- See that fish move by pushing against the water with some parts of their bodies.
- Observe that other animals that swim use other parts of their bodies to move forward in water.

MATERIALS

-- for each group --

- goldfish in a plastic shoe box
  (See Living Things in Field and Classroom, p. 55, for notes on obtaining goldfish.)
- straw

-- for the class --

- films: Looking at Fishes, Encyclopedia Britannica, 16mm, 11 minutes, color.

  How Water Animals Move, film loop, super 8mm, 4 minutes, color.
- Worksheets 12 through 16

PREPARATION

Fill the plastic shoe boxes with water at least 24 hours before teaching this lesson in order to allow the tap water to lose its chlorine and come to room temperature. The next day put a fish into each shoe box. (See Living Things in Field and Classroom, pp. 26-28 and 55-56, for details on caring for the fish after the lesson is over.)

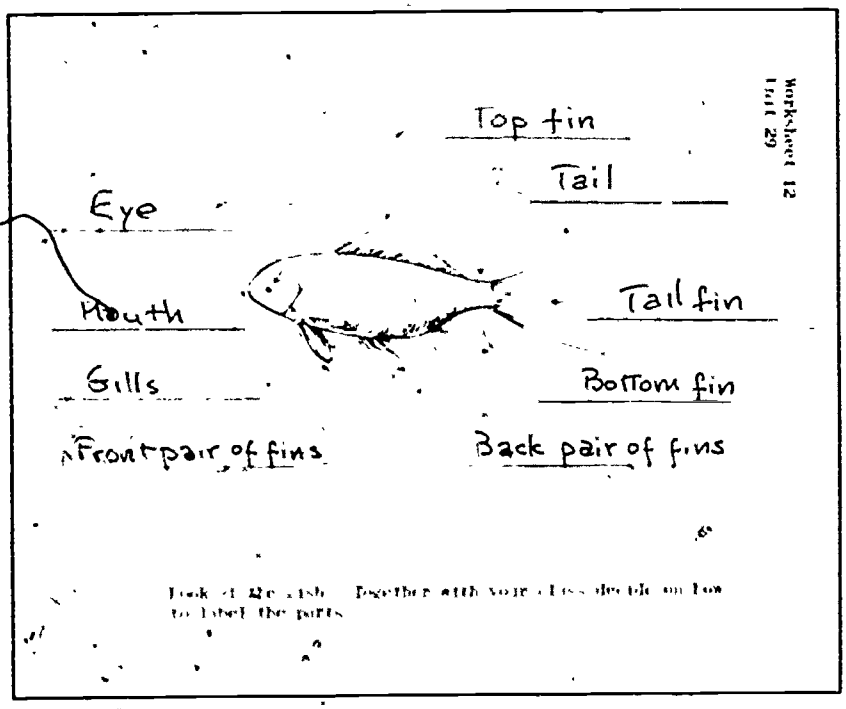
PROCEDURE

Activity A

Begin by saying that we have looked at some animal locomotion systems that have legs as parts of the system, and now we will look at a goldfish to find out the parts of its locomotion system and how it uses them.

Have the class turn to Worksheet 12. Together they should agree on what to call each part of the fish that is indicated. Some children may want to use technical terminology for the dorsal, ventral and pectoral fins, and others may prefer to say "back fin," "bottom fin" and "front pair." The class should agree on the terminology the majority is comfortable with.

The purposes of this worksheet are:



1) To decide on uniform labeling so that each child knows what the other is talking about.

2) To draw attention to the specific parts of the fish's body the children should observe.

To guide the filling in of this worksheet, you may want to use the following questions. But the names do not have to be the ones we provide.

First find the eye, mouth and gills and label them.

HOW MANY FINS DOES YOUR FISH HAVE? (7)

ARE THEY SINGLE OR IN PAIRS? (Both.)

WHAT IS THE BACK END CALLED? (The tail.)

IS THERE A FIN ON IT? (Yes.)

WHAT SHALL WE CALL IT? (The tail fin.)

WHAT IS THE TOP OF THE FISH CALLED? (The back.)

IS THERE A FIN ON IT? (Yes.)

WHAT SHALL WE CALL IT? (The back fin.)

IS THERE A FIN ON THE UNDERSIDE OF THE TAIL? (Yes.)

WHAT SHALL WE CALL IT? (Bottom fin.)

WHERE IS ONE PAIR OF FINS? (In front.)

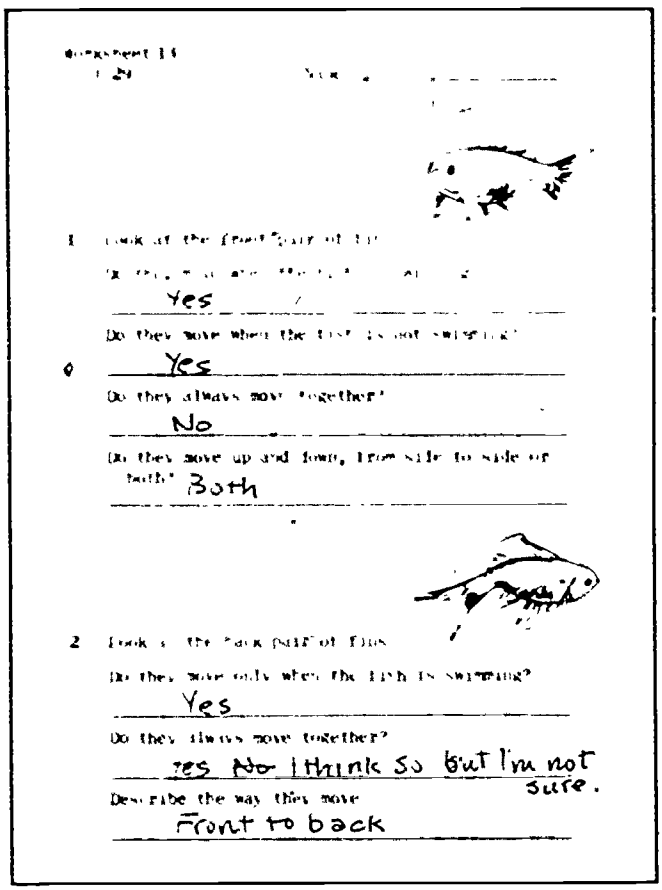
WHAT CAN WE CALL THEM? (Front pair.)

IS THERE ANOTHER PAIR OF FINS? (Yes.)

WHAT SHALL WE CALL THEM? (Back pair.)

Depending upon the number of goldfish you have, the children can work in pairs or fours, either all at the same time or taking turns. Give the children a fish in a container, and have them follow the directions on Worksheet 13.

Group children who have reading difficulties with those who read well. If you have casette equipment you may want to tape the questions on Worksheet 13 for some children to use as a guide for individual observation.



Worksheet 13

1. Look at the front pair of fins

Do they move when the fish is swimming?

Yes

Do they move when the fish is not swimming?

Yes

Do they always move together?

No

Do they move up and down, from side to side or both? Both

2. Look at the back pair of fins

Do they move only when the fish is swimming?

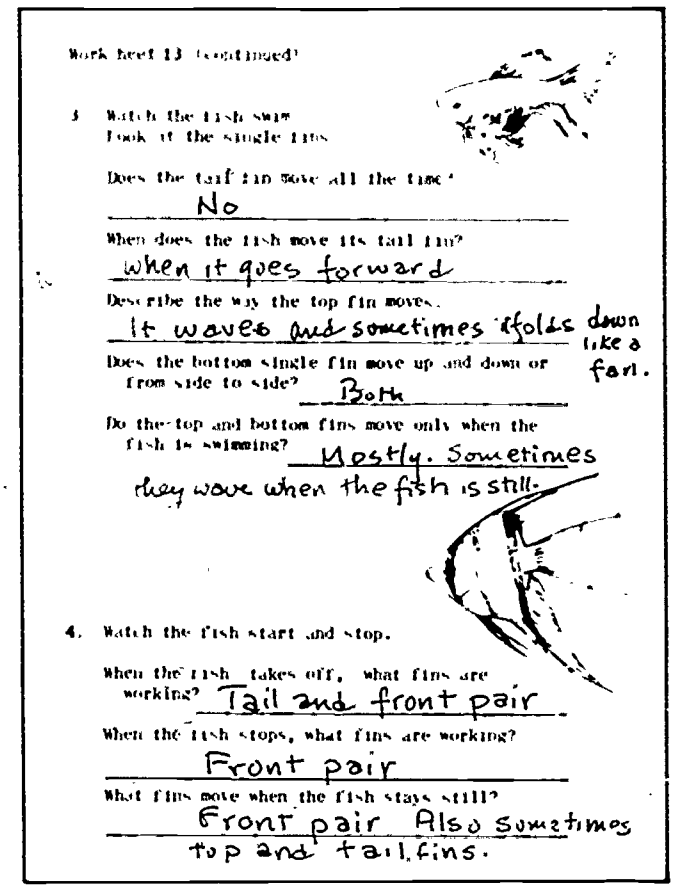
Yes

Do they always move together?

Yes No I think so but I'm not sure.

Describe the way they move

Front to back



Work Sheet 13 (continued)

3. Watch the fish swim
Look at the single fins

Does the tail fin move all the time?

No

When does the fish move its tail fin?

when it goes forward

Describe the way the top fin moves.

It waves and sometimes it folds down like a fan.

Does the bottom single fin move up and down or from side to side? Both

Do the top and bottom fins move only when the fish is swimming? Mostly. Sometimes they wave when the fish is still.

4. Watch the fish start and stop.

When the fish takes off, what fins are working? Tail and front pair

When the fish stops, what fins are working?

Front pair

What fins move when the fish stays still?

Front pair Also sometimes top and tail fins.

When the children work with a fish, if it is not swimming they can gently encourage it by touching it very lightly near the tail with a straw. If it is moving too quickly they will have to do some other work for a while to give it time to calm down.

After all the children have observed the goldfish and filled in their worksheets the class should have a short discussion of what they found out about the goldfish's locomotion system. Worksheet 13 is intended simply to help the children make detailed observation of one part of the fish's body at a time. The discussion should bring out a few specific facts about how the fish's locomotion system operates. Ask:

WHY DOES THE FISH MOVE FORWARD WHEN IT MOVES ITS TAIL FIN? (Because the tail fin pushes back against the water.)

WHY DOESN'T THE FISH FALL OVER ON ITS SIDE? (The top and bottom fins and the paired fins help it keep its balance.)

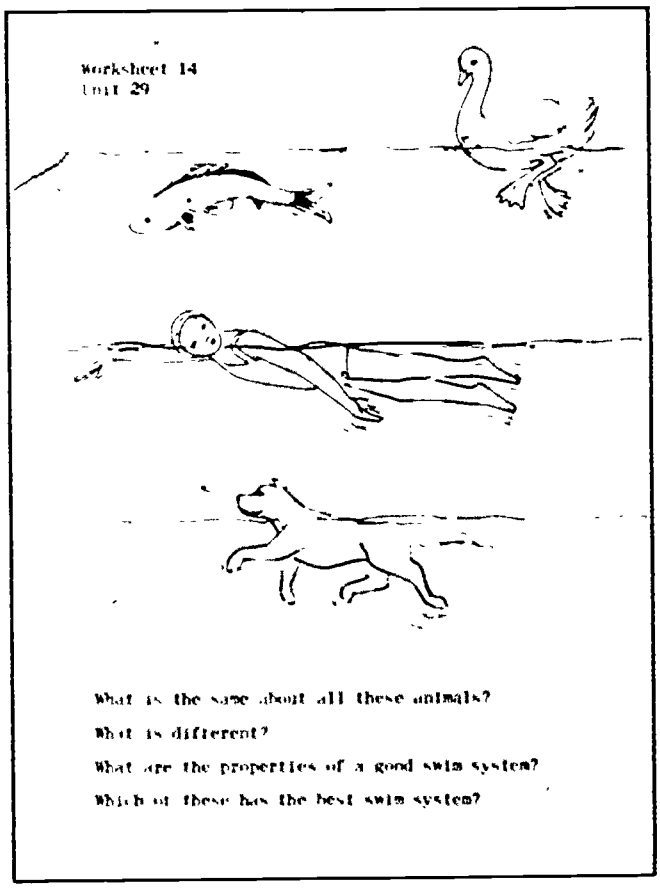
HOW DOES THE FISH TURN? (The fish uses the paired fins to steer.)

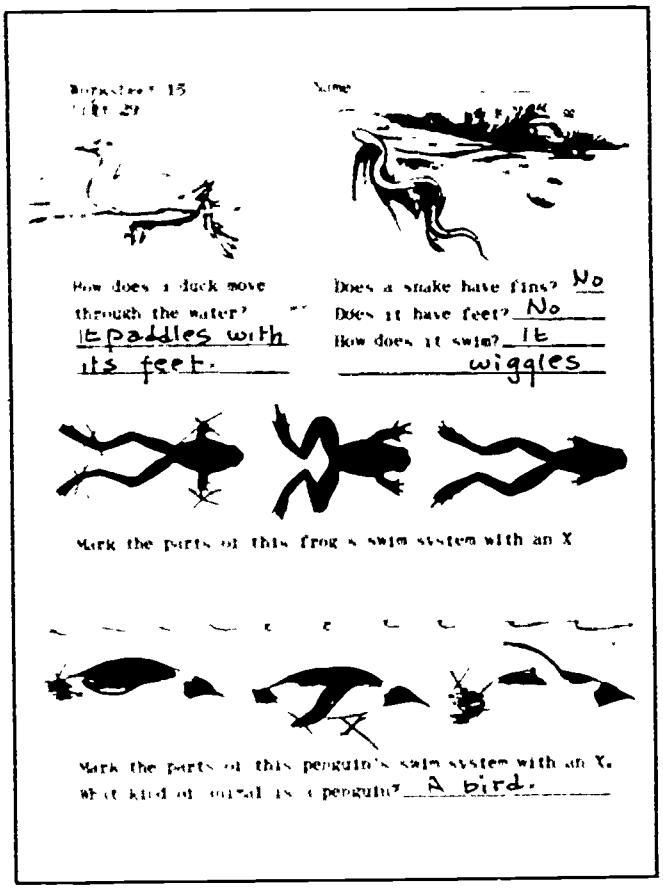
Activity C

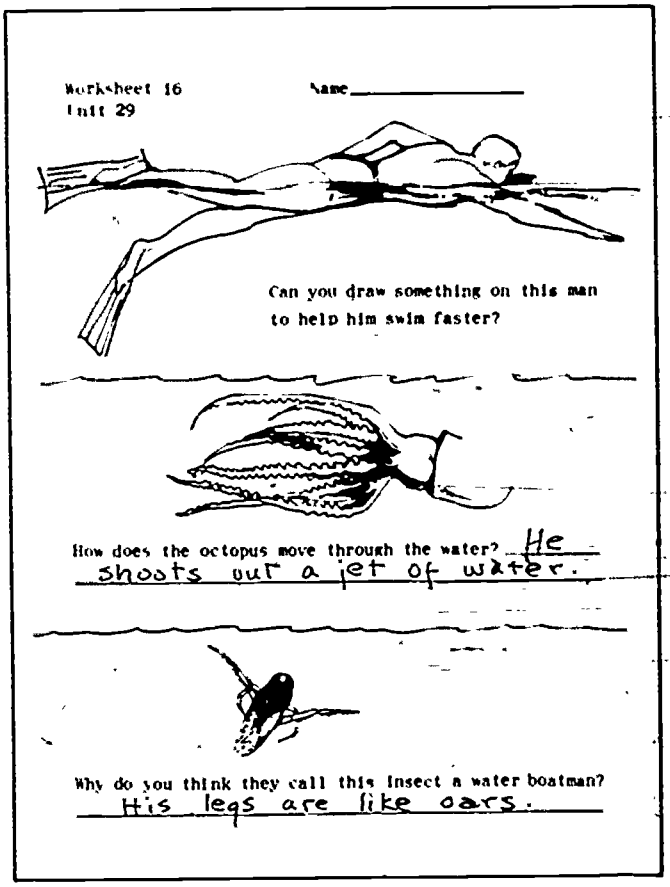
Show the suggested films. Have the children watch to compare the way their goldfish swam with the ways that other fish swim.

Activity D

Worksheets 14, 15 and 16 show other animals swimming. Worksheet 14 is designed to serve as the basis for class discussion. All the animals are swimming. To swim, each of them pushes against the water with some part of its body. The parts they use are different. The fish uses its fins, the bird and dog their feet, and the child his hands and feet. The fish's body is best adapted for locomotion in water. It can swim the fastest and for the longest time. Birds that swim have webbed feet. (Birds that do not have webbed feet can't swim because there is nothing for them to push against the water with.)







On Worksheets 15 and 16 have the children fill in the answers independently. Encourage them to write answers even if they are not sure. Then discuss each question. These worksheets are intended to stimulate discussion and speculation. Your library may have some books that will supply additional information for children who want to follow the subject further.

PREFACE TO NEXT LESSON

Tell the children that tomorrow they are going to study the flight system of birds, and on the way home from school today they should watch birds to see how they fly, take off, and land. If anyone has a pet bird at home he can make a more detailed study and share his observations with the class.

Lesson 7: A BIRD'S FLIGHT SYSTEM

The children will watch birds in a film and will consider what parts of their bodies are part of their locomotion systems. The film gives the children a chance to watch many kinds of birds and to see them moving in slow motion. But a film cannot provide the same excitement as a real bird can. Check to see if your local zoo sends personnel with live animals to the classroom. Short of that, try to borrow a stuffed bird from a museum or a parent. The children will enjoy looking at the structure of the feathers and the way they are arranged.

Several worksheets require the children to look in books for information about birds. These will extend the activities beyond the scope of the lesson itself.

This lesson may take two days, one for the film and discussion, and one for optional activities.

OBJECTIVES

During this lesson the children should:

- Observe birds in flight.
- Understand that flapping wings push against the air.
- Identify parts of the locomotion system which may include wings, tail, feet, eyes, etc.

MATERIALS

-- for the class --

- films:
  Looking at Birds, Encyclopedia Films, 16mm, color, 10 minutes.

  Seabirds, Form and Flight, film loop, Super 8mm, color, 4 minutes.
- live bird (optional)
- stuffed bird (optional)
- toy airplane (optional)

- reference books:

  Blough, Glenn, Bird Watchers and Bird Feeders, Whittlesey House, 1963.

  Darling, Lois and Louis, Bird, Houghton Mifflin, 1962. (Teacher reference. See especially chapter on feathers, pp. 111-122, and chapter on flight, pp. 217-235.)

  Goldin, Augusta R., Ducks Don't Get Wet, Crowell, 1965.

  Goude, Alice E., Gray Wings, Scribner, 1964.

  Zim, Herbert S., Owls, Morrow, 1950.

  World Book, vol. 2, Birds (See especially the sections "How Birds Fly," and "Wings in Flight.")

-- for each child --

- feathers (contour and down)
- magnifier
- Worksheets 17-19

PROCEDURE

Activity A

Ask the children what they observed on the way home from school yesterday about how birds fly. Ask what they think are the parts of a bird's locomotion system. Write their suggestions on the board. Then tell them that you will show them a film in which they will be able to see many different kinds of birds flying. They will also be able to watch slow motion flight to get more details. Suggest that they watch carefully for some of these answers:

WHAT DOES THE BIRD DO TO TAKE OFF? (Watch the feet.)

HOW DOES IT USE ITS WINGS?

WHAT PART OF ITS BODY DOES IT USE TO CHANGE DIRECTION?

HOW DOES IT LAND? WHAT PARTS OF ITS BODY DOES IT USE? (Watch the tail and feet.)

Show the film. Then, after the film, hold a discussion. See if some children want to make changes in the list of parts of the bird's flight system they compiled earlier. Ask for reasons for including each part on the list.

Activity B (optional)

If you have been able to get a live bird or a stuffed bird, now is the time to look at it. (If not, go on to Activity C.) Ask the children to think about how the different parts are suited to the jobs they do. Following are some things to observe:

1) The wings:

HOW FAR DO THE WINGS SPREAD?

COMPARE THE WING'S SHAPE TO THE TOY AIRPLANE WING. (Both have rounded, thick leading edges and thin trailing edges. The top surface is curved more than the bottom.)

2) The feet: Some birds have webbed feet, some do not.

WHAT CAN THE FEET TELL US ABOUT THE BIRD'S HABITS? (Webbed feet help a bird swim or take off from water. Clawed feet help a bird perch and take off from a branch.)

3) The tail: Note its shape.

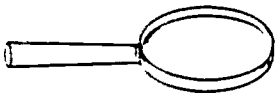
IN HOW MANY DIRECTIONS CAN THE TAIL MOVE? (Compare it with the rudder and elevators on the toy airplane's tail. The rudder steers the plane right and left, the elevators guide it up and down. The tail can also be pointed down sharply to help the bird brake when it wants to slow down and stop.)

Worksheet 17
Unit 29

Take a contour feather

Take a down feather.

Take a magnifier.



Hold the quill of the contour feather tightly. Blow on the feather. See if you can blow cracks in it.

Now pull some barbs apart with your fingers.

What makes the barbs hold together so well? Look at them through the magnifier.

Now try to mend the crack again. Could you do it? Yes

What did you see along each barb?
Tiny hooks.

Worksheet 17 (continued)

Does the down feather have hooks on its barbs? (Use your magnifier.) No.

Which kind of feather would be better for flying?
Contour
Why? It holds together to push the air.

Which kind of feather can keep a bird dry?
Contour

Which kind of feather would be better for keeping the bird warm? Down
Why? It is like a fuzzy blanket.

Which kind of feathers would you expect to find on the wings and tail? Contour.

Where would you expect to find down feathers?
All over, close to the bird's skin.

If you have a real bird, look at it.

If you don't have a bird, look in books to find out more about birds and bird feathers.

Activity C (optional)

Set the materials for this activity on a table together with reference books, and let those children who are interested do it in their free time. Worksheet 17 is self-instructional. The children should examine and play with the feathers freely. They should discover how hard it is to break the surface of the vane of a contour feather and how easy it is to repair it by smoothing the barbs.

Activity D

Call attention to Worksheets 18 and 19. Tell the children to write their ideas down first and then look them up. This is a good activity for small groups. Encourage the children to use the encyclopedia (especially World Book) and the reference books.

Activity E

If the children are interested in watching birds further, suggest that they can go on their own field trips after school. They can sprinkle breadcrumbs to attract sparrows, starlings or other birds native to your area.

Give the children tips on how to behave and what to look for when they are bird watching. Remind them that birds' sight and hearing are very keen, and the birds will fly away if the children make sudden noises or quick movements. When the birds do fly, the children should try to see how they move the different parts of their bodies. They should watch them take off and land.

Worksheet 18
Unit 29

Name_____

Guess if you don't know these answers.
Then tell why you guessed the way you did.

Which bird can swim?
The duck.
It has webbed feet.

Which one runs the fastest?
The ostrich.
It has the longest legs.

Which do you think is the best flyer? The hawk
Why? It has the biggest wings.

Worksheet 19
Unit 29

Name_____

Look-it-up Page

Guess first, then find out:

	Guess	Answer
How high can birds fly?	a mile	6 miles mostly they stay below the clouds
How fast can birds fly?	a mile a minute	100 miles an hour in short dashes. Mostly less a mile a minute
How far can some birds fly without stopping?	100 miles	3000 miles

Lesson 8: COMPARING LOCOMOTION SYSTEMS

Locomotion systems may be considered in several ways. The main attention in the lessons up to now has been focused on the parts of different animals' bodies and how they help to move the animals forward. From another point of view, the parts of the body make up just one subdivision of a locomotion system. The other subdivisions are the source of energy that make it possible for the body parts to move, and what they push against in order to move forward — the land, water or air.

This way of looking at the locomotion systems illustrates what animate and inanimate locomotion systems have in common. In this lesson the children concentrate on comparing many kinds of locomotion systems. They see that all animals have the same source of energy — food. But machines have different energy sources — gasoline, jet fuel, electricity, etc.

OBJECTIVES

During this lesson the children should bring together the information of the unit and make generalizations about locomotion systems. They should be able to:

- State that all locomotion systems have parts that push against something in order to move forward.
- Speculate on what those parts are in locomotion systems they have not studied.
- Tell what the parts push against in familiar systems and speculate for unfamiliar ones.
- See that all animals depend on food for their energy source. Some children may know that the more immediate source of motive power is the muscles.
- Speculate on what the energy source is for locomotion systems they have not studied.

MATERIALS

- Worksheet 20

PROCEDURE

Ask the children what they can think of that is the same for every locomotion system they have studied. Do not try to elicit the specific answers discussed in the introductory paragraphs, but give the children opportunity to develop some of their own generalizations.

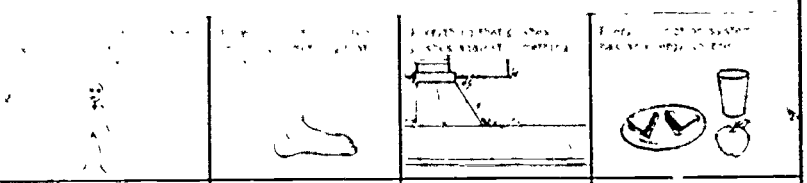
Then ask the children to name all the things they can think of that have locomotion systems. If they do not get around to mechanical systems suggest the category to them, but keep the suggestions coming until it is clear that the children's imaginations have been sent off in many directions. Then have them turn to Worksheet 20 and work on it independently. They may add other sheets of their own if they wish.

After the worksheet has been completed, give the children opportunities to share their ideas.

Worksheet 20
Unit 29

Name _____

Locomotion Systems -- What is the same?
What is different?



car	wheels	the street	gasoline
	jets	the air	fuel
rowboat	oars	water	the man who is rowing
a bird	wings	air	food
ants	legs	the ground	food

SECTION 2 A PLANT'S WATER CARRYING SYSTEM

COMMENTARY

Most children know that plants need water to live. In this section they explore the most basic aspects of the plant's water carrying system. They learn that water enters the plant from the soil through the roots, that there are tubes that carry the water from the roots up the stems and into the leaves, and that water comes out of the leaves into the air in the form of water vapor. They also learn that there are many different-looking roots, stems and leaves that may be adapted to different environments.

The upward movement of water through plants is only partly understood by botanists. They cannot entirely explain the tremendous pull that is necessary to carry water to the top of a tall tree, but the pull is there. The water enters the roots through root hairs, which are usually too small to be seen with the naked eye. It is pulled up through tubes that pass through the stems and connect with the veins in the leaves. The water is used by the plant in many ways. Some of it passes into the leaf tissue and through microscopic holes in the leaves called stomates. It goes into the air in the form of water vapor. This stage, the passage of water from the leaf into the air, is called transpiration. The rate of transpiration is affected by conditions of light, temperature, moisture and the structure of the leaf itself.

Through several activities the children identify the path that water takes through plants. They observe that the water from the soil enters through the roots. Then they see that the stem has tubes through which the water passes from the roots into the leaves. They collect water vapor from the air around the leaves and conclude that water comes out of the plant through the leaves.

OBJECTIVES

As they work with plants in this section the children should be able to:

- Identify wilting as an indication that the water carrying system is not functioning properly.
- Help devise and carry out experiments with different parts of the plant to find out if they are parts of the water carrying system.
- Discuss the system, drawing on evidence from their experiments rather than relying on unsupported opinion.
- Draw a diagram or describe the parts of a plant's water carrying system, indicating the order of the parts and their relationship to each other.
- Recognize that different plants take up water at different rates and that their water carrying systems vary.
- See that plant tissue consists of a large proportion of water.
- Learn that plants use water to make food.

NOTES ON TEACHING THIS SECTION

Before the children begin experimenting with plants it is necessary for them to have an opportunity to talk about the ethics of using plants in this way. Some children are reluctant to "hurt" plants. They should understand that plants do not get hurt as animals do, but that we won't destroy any more than we need to in the experiments. At least one plant should be left after the experiments for the class to enjoy. There should be a sense of balance between using plants for experimental purposes and enjoying them in other ways.

You will need four coleus plants for the experiments described here. Three of the plants may be small, but it would be helpful if one has some branches. They should be healthy, with many leaves in proportion to the size of the plants. Each should be in its own pot. The coleus is an inexpensive plant that can be bought at florists, variety stores or supermarkets. It comes in several color combinations besides the one shown on the cover.

Lesson 9: THE ROOTS

From their experiences in Unit 23 the children should be aware that temperature, light and moisture influence plant survival. They discuss these factors briefly, and then consider moisture in more detail. They talk about the usual procedure for watering potted plants, that is, putting water on the soil. Then they examine the plant parts that are under the surface of the soil, and set up experiments to find out if roots play a part in the plant's getting water.

One experiment is to cut the roots off a plant and see what happens to the top. This plant is kept side by side with a control, a plant with its roots intact. Both plants are kept without water until both are wilted. Then they are watered. The control revives quickly, but the rootless plant does not.

This activity demonstrates that a plant is able to survive drought more easily if it has roots, and that the root is a useful part of the plant's water carrying system. The experiment does not show that plants must always have roots.

The children are encouraged to suggest and set up other experiments, but the one described above should be included, because it is likely that some of the experiments suggested by the children may seem to indicate that plants don't need roots at all. (In trial teaching it was found that with some plants if the roots were removed and the plant was kept well watered it did not show ill effects for the length of the test period. This is because the children are usually working with extremely sturdy plants that are often selected as house plants because they are able to survive adverse conditions. Even when neglected or deprived of suitable growing conditions they will not die as easily as many common outdoor plants.)

This lesson may take several days and should be started on Monday or Tuesday.

OBJECTIVES

By the end of the lesson the students should:

- Identify roots as underground parts of the plant.
- See that a plant needs water and will wilt when deprived of it.
- Recognize that roots are a useful part of the plant's water carrying system.
- Understand the role of the control in their experiments.

MATERIALS

- three potted coleus plants, approximately the same size (at least 4")
- tray
- newspapers
- water in basin
- knife
- wide-mouthed jar

PROCEDURE

Activity A

Show the children the coleus plants and ask them what plants need in order to survive. List their ideas on the board. The list may include the following, based on their experiences in Unit 23:

- water
- light
- the right temperature

Ask the children to tell briefly what their evidence is that plants need each of the conditions they have mentioned. Have them talk about experiences that they have had with plants and describe what results they observed when plants were deprived of one of the conditions they needed.

After the children have had an opportunity to share their ideas, tell them that for the next few days they will be doing some experiments with plants and water.

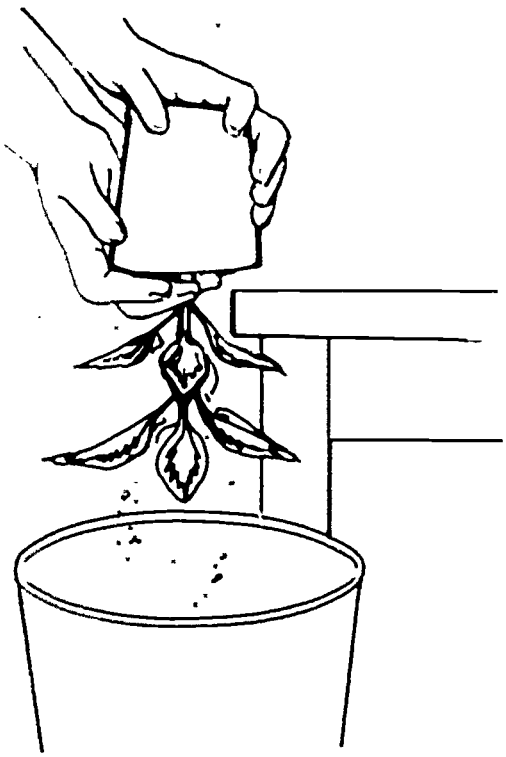
Hold up a coleus plant and ask the children how they think it gets water. They can be expected to say that we put water on the soil in the pot. Ask how they think the water gets into the plant, since we don't put the water directly into the plant but on the soil. The discussion might revolve around questions such as these:

HOW DO YOU THINK THE PLANT GETS WATER FROM THE SOIL?

ARE THERE ANY PARTS OF THE PLANT TOUCHING THE SOIL THROUGH WHICH THE WATER MIGHT GET INTO THE PLANT?

Ask how we could find out what part of the plant is under the soil. We could look.)

Spread newspaper on a desk or table and then take one of the coleus plants. Have a child gently take the plant out of the pot and remove the soil from around the roots.



The child can put his hand over the pot so that the stem passes between his fingers. Then he can invert the pot and rap it sharply on the edge of a desk so that the ball of soil drops into his hand. Have a wastebasket or newspaper underneath to catch spills.

The child may wish to swish the roots in a basin of water to wash off the remaining soil and loosen the roots enough for observation.

Have all the children look carefully at and touch the roots. (Either pass the plant around on a tray or have the children file past it on a table or counter.)

When the children return to their seats have them describe the roots. Encourage them to look at the roots again if they want to check on the accuracy of their descriptions. (When you have no further need for observing the roots, set the plant into a jar of water and save it for the next day.) As the children describe properties of the roots, list them on the board. For example:

- The roots are long.
- They're thin.
- There are lots of roots.
- They have branches.
- The branches are irregular. There is no symmetry to the way they grow.
- They have mud on them.

Ask the children if they think that all plants have or need roots. Then have them tell why. Their reasons for having roots might include to get water, to hold the plant up, to get food, and to hold the plant in one place. Reasons for not needing roots might refer to the fact that cut flowers can be kept in water.

Accept the ideas offered, and then ask the children what they think would happen to the coleus plant they see before them if it didn't have roots. List their predictions on the board so that you can refer to them later.

- The plant would die.
- It would grow new roots.
- Maybe it wouldn't be able to get water.
- [illegible] didn't need roots, and would get along fine.
- It might fall over.

Ask how the children could check their predictions of what would happen to the plant if it didn't have any roots. They might have suggestions for experiments. Try some of them. But among them be sure to include the experiment we describe in detail here.

One way to find out what would happen to a plant if it didn't have roots is to cut the roots off. Take one of the coleus plants; and tell a child to cut through the stem below the bottom leaves, and then insert the cut end of the stem into the soil in the same pot, a little distance from the original base of the plant. The stem should be inserted deeply enough to hold the plant steady. A pencil can be used to make a hole for the stem.

Take time an undisturbed plant for comparison.

Ask the children to observe the two plants side by side and tell you what is the same about them and what is different.

Their answers may include the following:

- They have the same kind of leaves.
- One of them doesn't have any roots.
- The leaves are about the same size, but one plant is shorter than the other.

If no one comments on their condition, ask whether they look equally healthy.

From now on, the two plants will be treated in the same way to see whether there are differences in the way they respond.

The plant with roots will be the control in the experiment. (The children used controls in Unit 23 to help them remember what something looked like before they began experimenting with it.)

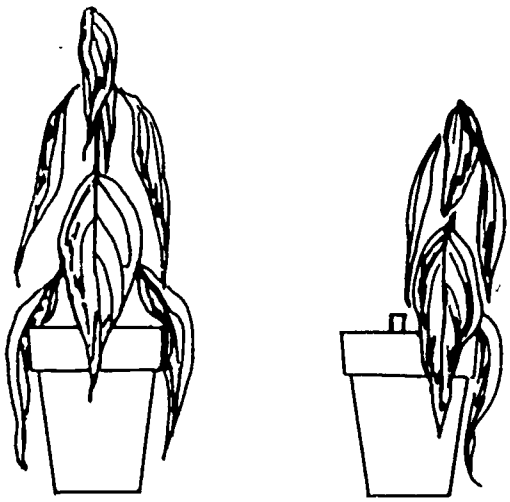
Ask the children how they will be able to tell if the plant is getting along all right without the roots. Ask what would be evidence that the plant doesn't need roots. What would be evidence that the plant does need roots?

Most children will say that they think the plant without the roots will die. Ask them what a dying plant looks like. How will they know if it is dying? They should be able to decide that if a plant is dying its leaves will be droopy and the plant will be limp.

Now place both plants in the sunlight. Do not water the plants until both are wilting. It may take from two hours to two days for them to begin wilting, depending on the sunlight, humidity, and temperature in your room, and depending on how damp the soil was when the experiment was started.

Have the children check the plants periodically. One will wilt before the other. As soon as both are wilting, continue the activity. (The timing is important here, because if there is too much delay both plants may die. A delay of an hour or two is no problem, but a delay of a day might be too much.)

When both plants are wilted, place them before the class and ask the children how they think the plants are getting along. Have them identify which plant has roots and which has none.



Ask if the one with roots or the one without seems to be getting along better. At this stage the children may have differences of opinion, since both plants should be in bad shape. Some children will say that the one with the roots looks better, because they think that is the answer expected. It may be hard for them to accept the evidence that the one with the root also looks bad.

Then ask the children what they think would happen if both plants were watered. After they have had a chance to predict, have a child water both plants well, until a little water comes out of the hole at the bottom of the pot. Then leave the plants where the children can watch them from time to time, while they go on with other work. In half an hour to an hour the plant with roots will have revived. The plant without roots will still look wilted.

Have the children discuss the differences between the two plants at this stage of the experiment, and then ask what conclusions they can come to. When a child draws a conclusion, ask what his evidence is.

Many children make dogmatic statements based on limited evidence because they "knew" what was going to happen beforehand. Try to help them put aside prior opinions and just look at the evidence of the experiment.

With the limited amount of experimenting the class has done, it is appropriate to draw only limited conclusions. When the children make generalizations for which they have little evidence, remind them that conclusions should be based on evidence rather than just on opinion.

In the case of this particular experiment, a reasonable conclusion is:

- The roots are useful for getting water into the plant.

The evidence for this conclusion is:

- When we watered both droopy plants the one with roots revived quickly but the one without roots did not.

Note the limitations of the experiment and the conclusion that can be drawn. The experiment has shown only that roots are part of the plant's water carrying system, and that they help get water into a plant quickly. The experiment does not show that roots are always necessary for plants.

Roots serve several functions. One of these is that they help plants survive extreme drought. Because of the large surface area of the roots, a whole plant is able to absorb water quickly. On the other hand, a plant without roots absorbs water much more slowly because water can only get in through the very small area of contact between the stem and the bit of soil it is touching. Some plants grow new roots when kept in moist sand or soil. If they do not, they will not survive very long.

Activity B

This last activity shows how some plants survive extremely adverse conditions.

You should now have two potted plants, one healthy coleus (with roots) and one droopy coleus (without roots). Put the plants aside in a well-lit place but not in hot sunlight. Water them regularly, as needed. (Plants should be watered thoroughly whenever the soil gets dry, and then should not be watered again until the soil gets dry again. Overwatering causes rotting of underground plant parts.)

Have the children keep watch over the two plants. In a week or two they will be able to make an observation. The plant that they thought was dying did not die after all. Some of the most droopy leaves on the cut coleus will have died, but new leaves will be growing. The children can dig up the originally rootless stem to find that new roots have grown.

Changes will also be apparent in the piece of stem attached to the original root, from which the upper part of the plant had been cut. The stump of stem will have sprouted new leaves.

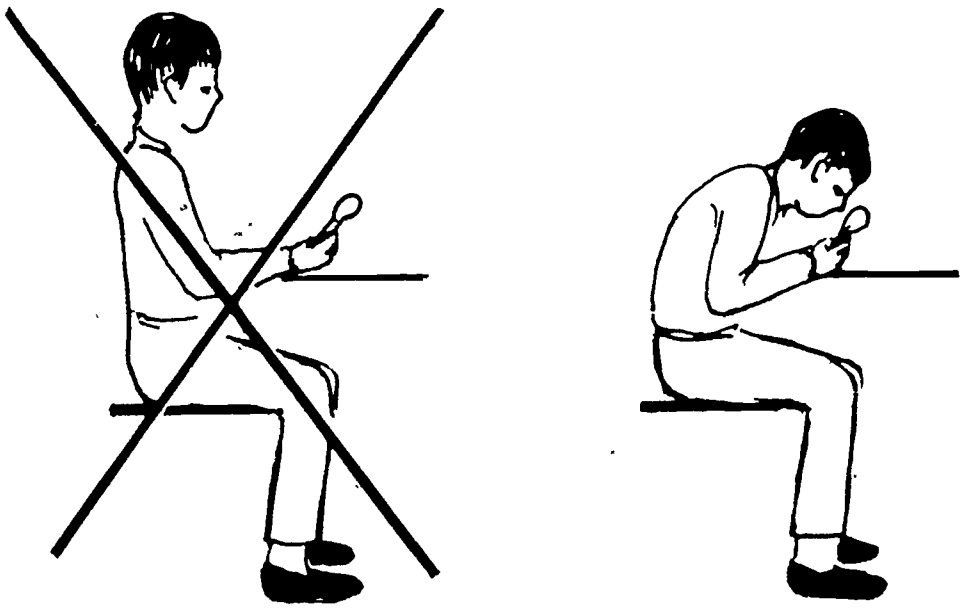
This demonstrates the coleus' ability to replace parts it has lost.

Tell the children that some plants will grow new roots and others will not. Ask them to tell about any other plants that they know that will do this. If they have no suggestions because of lack of experience, they may like to set up experiments with several kinds of plants to find out which ones will grow new roots.

USING A MAGNIFIER

You can get a wider field of vision through a magnifier if you hold it close to your eye. In order to adjust the focus, move your eye and the object closer together or further apart.

If you and the object remain stationery, you adjust your focus by moving the magnifier up and down until you get the clearest image. The magnification will be the same either way, but when the magnifier is further from the eye the field of vision is much smaller.



Lesson 10: THE STEM

The children investigate what happens to the water after it enters the roots of a plant. They first discuss where water might go from the roots, and then they go on to a detailed study of celery stems. They see that when a celery stem is set in a cup of colored water, the dye from the cup soon shows in the leaves. They break the celery stem and find that the dye has gone up through the strings.

OBJECTIVES

In the course of this lesson, the children should be able to:

- Interpret the presence of red color as evidence that the colored water in the cup traveled up through the celery stem and leaves.
- Interpret the red color of the strings and veins to mean that the water travels along those particular paths.
- Interpret lowering of water level in cup as evidence that water went up through celery stem.
- Describe roots, stems and leaves as parts of the plant's water carrying system.

MATERIALS

-- for the class --

- the unpotted coleus plant from Lesson I
- sharp knife or razor
- plastic cup
- masking tape
- plastic bag or plastic wrap
- 1 bottle red food coloring
- gallon container of water

-- for each child --

- a celery stalk with leaves
  (You will need two or three bunches. Keep celery in a plastic bag and refrigerated until needed. Wilted celery will not draw up water well enough.)
- magnifier
- 16-oz. plastic cup

PROCEDURE

Activity A

In the last lesson the children experimented and discovered that water went into the plant through the roots. Mention this, and then ask where the children think the water goes after it goes into the roots. List their ideas on the board so that the class can go back and look for evidence to support them. The children may suggest some of the following:

- Water goes into the plant, into the leaves.
- It stays in the roots.
- It goes back out of the roots into the soil.
- It goes up the stem.

Most children will think that water goes into the plant, because they found that after they watered the wilted plant in Lesson 9 the leaves became firm again.

IF WE THINK WATER GOES INTO THE LEAVES, HOW DOES IT GET THERE? (Through the stem.)

Bring out the coleus plant that you put in a jar of water in Lesson 9. Ask the children to tell what they think the stem is like inside.

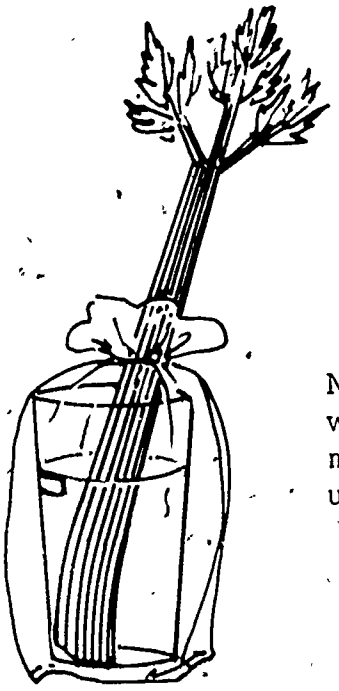
Cut the plant from the root and cut the stem into several sections. Pass the pieces around so the children can feel them and look at them. Ask them to describe some properties of the coleus stem. They may mention that it is green, square, slender, long, wet on the cut end, solid in the center, and has no visible tubes.

Then show the class a stalk of celery and tell them that it is a kind of stem that is easy to study because it is so large. Cut it into sections and pass them out so the children can compare the celery stem with the coleus stem. They will see light green dots that are not visible in the coleus. They will learn later that these are the cut ends of water carrying tubes, but do not tell them now what they are.

Remind the children that we have been talking about whether water goes up through stems into plants, and ask them to suggest experiments that might help them find out. As usual, accept all suggestions, and help the children set up experiments to test their ideas. Described here are two experiments that you should be sure to include. The first is a demonstration and the second is an experiment that all the children should do. Both are based on observing what happens when a stalk of celery is put into a cup of water.

Activity B

This is a demonstration that you should have some children set up. They should make a fresh cut across the bottom of a stalk of celery and put the stem into a cup of water. Have them mark the level of the water and then cover the cup with plastic to prevent evaporation. A drop in the level of the water will be evidence that the water went up the celery stem. Put the setup in a well lighted place, and then go on to the next activity.



Note: The change in water level will be more apparent if you use a narrow glass.

Activity C

After the demonstration in Activity B has been set up, but before any results have been observed, proceed with this experiment, which is the main activity of the lesson.

Ask the children how we would know if the water was going up into the stem. Has any one of them ever seen water going up into a plant? Ask why this would be difficult to see. (Because water is colorless and plants aren't transparent.) Ask if there is anything we could do to the water so that we might be able to see it in the plant. If no child suggests it, tell them that food coloring might make the water easier to see.

Then let several children predict what would happen if colored water went into the stem, and have them describe what they expect to see.

Each child will do this experiment. For a class of 30 you will need about a gallon of colored water. Prepare it in front of the class by adding enough red food coloring to a gallon of water to make it a deep red. Give each child a plastic tumbler and have him label it with his name on a piece of masking tape. Then pour four to six ounces of colored water into each tumbler.

Have a child get the celery from the refrigerator. Make a fresh cut across the bottom of each stalk of celery just before you give it to a child. He should place it in the colored water immediately, so that the cut end does not have a chance to dry up.

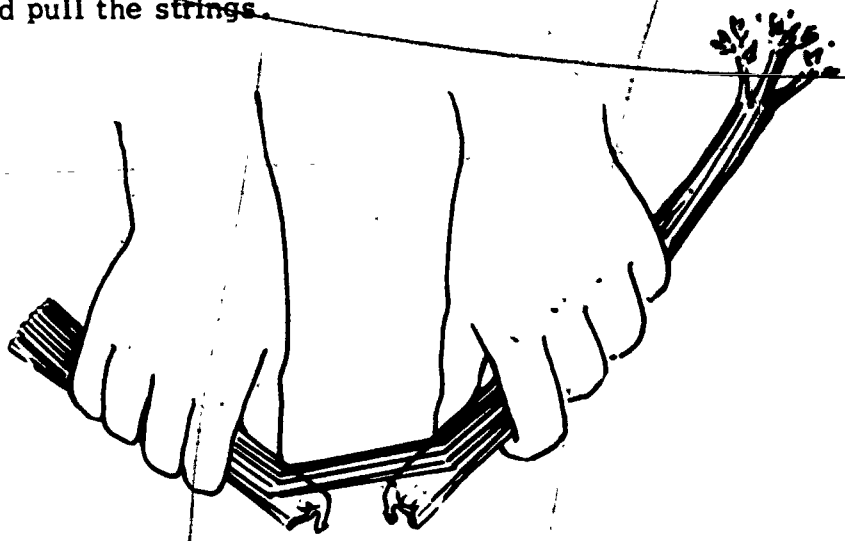
Prepare a similar setup for yourself, so that you can keep watch to see when to begin Activity D. The length of time required for the colored water to be drawn up the celery stem and into the leaves depends on the amount of light, heat and humidity in your room and the condition of the celery. It should take two to four hours.

Go on to some other work, and when the celery leaves show tinges of red, return to this experiment.

Activity D

Make a fresh cut a short distance from the end of each stalk of celery. Have the children look at the cut ends with magnifiers and describe or draw what they see. Have them count the red dots and notice that all the stems don't have the same number. The children may recall that in the celery cross-section they looked at earlier, the dots were green. Ask what they think the dots are. What made them red?

Then have the children break a piece off the ends of their stalks and pull the strings.



Tell the children that the strings are tubes. Ask where they think the water went from the tubes in the stem. They should notice the red tint in the leaves. Have them tear across a leaf and use their magnifiers to look at the torn edge. They should be able to see red dots in the center of the veins. From the surface of the leaf the veins look green because the walls of the veins are too thick to let the red show through. The tissue of the leaves is thinner, so the red can be seen more easily.

Ask the children what they have observed so far to be part of the plant's water-carrying system. They should be able to summarize:

- roots
- stems
- leaves

Tell them that you will study the leaves and what happens to the water in them the next day.

Activity E

Check the demonstration set up in Activity B. If the water level is considerably lower, have the children look at it. (If not, wait till the next day.) Mark the new water level. The children should be able to interpret the difference between the two water levels as an indication of how much water went up through the celery stem.

Lesson 11: THE LEAVES

In the previous two lessons the children found that water enters the plant through the roots and travels up the stem to the leaves. Here they investigate what happens next. Does the water stay in the leaves or does it travel further? The children list their ideas and set up experiments to find out which are correct. Among the experiments, you should include the one that is described here in detail. It demonstrates that water comes out of the leaves in the form of water vapor, which can be trapped in a plastic bag and will condense on the inside surface of the bag in water droplets.

This lesson will take two days.

OBJECTIVES

During this lesson the children should be able to:

- Decide on experiments to detect the presence of water.
- Interpret the results of their experiments to indicate that water comes out through a plant's leaves in the form of water vapor.
- Identify roots, stems and leaves as parts of the plant's water carrying system.

MATERIALS

- 2 coleus plants, preferably one with branches
- 2 large Baggies
- 6 small Baggies
- 2 wire twists
- 2 strips cobalt chloride paper
- gooseneck lamp (optional)
- Worksheet 21
- Adventures in Living Plants, by Edwin B. Kurtz, Jr. and Chris Allen, University of Arizona Press, Tucson, Arizona, 1965.

PROCEDURE

Activity A

Remind the children that yesterday they saw that water traveled up the stems of the celery and into the leaves. Ask them where they think the water goes next. Encourage the children to describe as many possibilities as they can. Their ideas should be listed on the board so that the class can go back to consider what kind of experiment could test each. A list of suggestions might include some of the following:

1. The water might stay in the leaves.
2. It might go back down into the soil.
3. It might come out of the leaves.

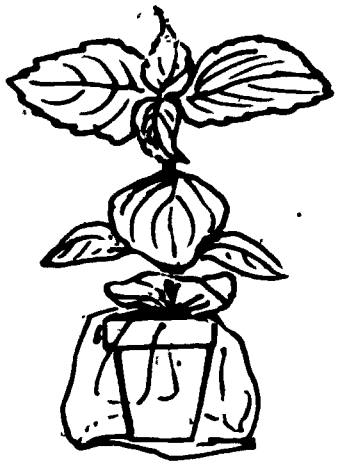
How could the children find out what really happens? Ask how they might test each idea, and help them find ways to make the tests. Possible tests for the three ideas listed above are described here. The class can work together to develop appropriate tests for the ideas they suggest. Basic to all the tests is this: If water is present in or coming out of a particular part of the plant, it should be possible to see evidence of its presence in one way or another.

Each class will decide upon and set up its own experiments. Set up as many as possible at the same time, depending on how many plants you have. The third experiment described below should be included with others the children suggest.

1) If water stayed in the leaves, the leaves should get fatter and fatter, since the plant keeps taking more and more water up from the soil. Observation will tell whether this happens. The children have seen an example of exactly this kind of thing happening, when the wilted plant was watered and the leaves "fattened" as their crispness was restored. The children will see, however, that there is a limit to how much water the leaves hold. They do not puff up beyond their normal thickness. Therefore, through observation they can conclude that the water does not stay in the leaves.

2) If the water went back down the stem into the soil, it could be used again by the plant, and the plant would not need to be watered over and over again. How can this be tested? If the idea that the water is reused is correct, the plant should thrive without further watering when the soil is covered with plastic to prevent evaporation. If the plant set up this way wilts and the soil under the plastic cover gets dry, it shows that the water is not going from the soil into the plant and then back into the soil. It must be going somewhere else after it goes from the soil into the plant.

Set up your experiment and put the plant aside in a well lit place.



It may take as much as a week for the plant to wilt, depending on the size of the plant, the amount of soil, and how recently it was watered. See that the children give the experiment plenty of time and don't try to draw premature conclusions.

3) If the water goes out through the leaves or the stem, there should be some way to verify it. The first step would be to examine the leaves to see if they are wet. (Some plants actually do form drops of water at their tips, but coleus doesn't.)

When the children feel that the leaves are dry, ask them whether this really means that water doesn't come out of the

leaves. Ask them if they know of any other form that water takes, where it doesn't feel wet. (The children have had some activities with water vapor in second grade, but may have forgotten it. Use as much of the following as you find necessary. If the children respond immediately showing familiarity with water vapor, skip the next two paragraphs.)

Wipe a wet sponge over the blackboard. Then ask if the board is wet or dry. As the board dries, ask where the water is going. (Into the air.) Another example they might talk about is what happens to the water in wet laundry when the laundry hangs on a line and dries.

The children are not expected to understand how or why water goes into air. This is merely a demonstration that it does. If they still have problems accepting the notion that water can go into the air in an invisible form, borrow Unit 20 from a second grade teacher, and review with the class the water vapor activities on pages 100-102.

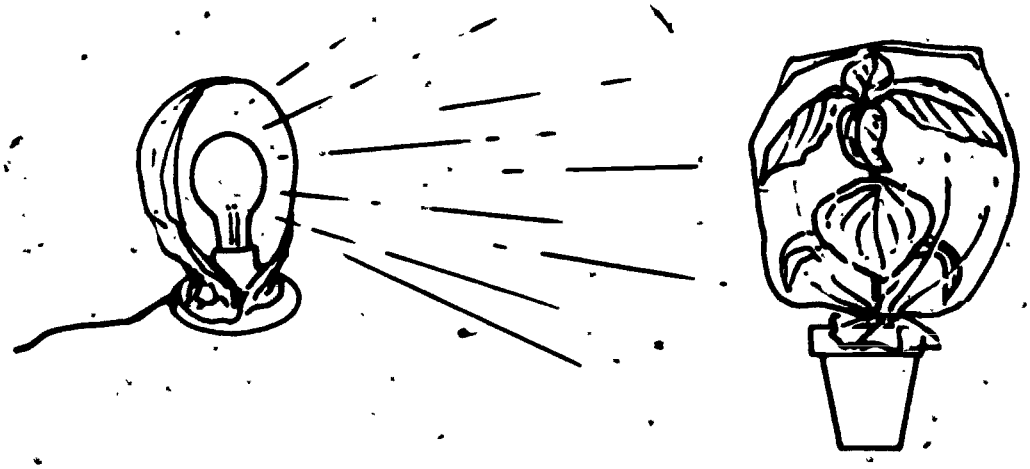
Resume the plant activity here:

Remind the children that our original question was to find out whether water came out through the leaves. We saw that the leaves were dry, and we asked whether the water might come out in any other form that didn't seem wet. Now we have found that there is another form in which water might be coming out, that is, water vapor.

Ask the children for suggestions as to how we could trap water to prove its presence if it were coming out of the leaves in the form of water vapor. If the children do not suggest using a plastic bag, show them one and ask if they think it might be useful.

Have a child check the bag for leaks by blowing air into it. Then the bag should be placed over the plant and fastened snugly around the main stem. Water the plant and set it aside where it can be looked at every hour or two until results are observed. If you wish to complete this activity on the next day, set the plant on a windowsill where it will be in daylight but not in direct sunlight. If you wish to complete

it on the same day, set the plant under its plastic bag about 18 inches from a 100W bulb in a gooseneck lamp. The bright light will speed up the experiment. (If you do not have a gooseneck lamp, you can improvise one by shaping a reflector of aluminum foil.)



In two to four hours under a lamp (or the next day in daylight) the plant will have given off enough moisture that fine droplets will have formed on the inside surface of the plastic bag. The longer the plant is in the bag, the more moisture will be collected. (If the plant is left too long under too bright a light, so much moisture will be given off that the plant will wilt permanently. The plastic bag makes for a high temperature, such as what you get in a closed car in sunlight, and the heat increases the rate of transpiration.)

Have the children tell what they observe when they check the experiment. They will see droplets of a clear fluid on the inside surface of the plastic bag. Have them describe the properties of the liquid and ask what they think it is. Many will think it is water. Some children have suggested it might be a plant waste product or sweat. Ask if the children remember how you can test for water. Show them a strip of cobalt chloride paper and ask if they know what will happen if you wet it. Put a drop of water on it and show them how it turns pink. Remind them that in second grade they had done experiments with cobalt chloride paper showing that other fluids did not turn it pink, so it can be used as a test for water.

Remove the plastic bag from over the plant, and give a child a fresh strip of cobalt chloride paper with which he can test and find that the droplets in the bag are water.

Recall that we wanted to find out where the water went after it got into the leaves of the plant, and ask the children what they have learned about that question from their experiments. Give them time to draw conclusions.

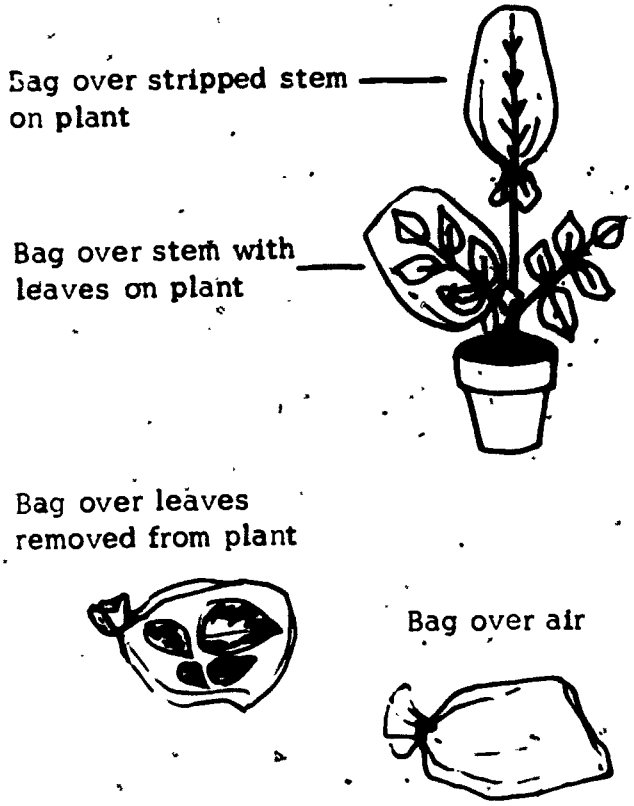
Then tell the class that we have experimented and have seen that the water went into the air. Are there any ways that we could test to find out if it really came out of the leaves? Where else could it have come from? List the children's ideas, and keep the list on the board to serve as a guide in setting up experiments to test the ideas. Tell the class to think over experiments they would like to set up the next day.

Activity B

Start this lesson in the morning and set aside some time in the afternoon to complete it. (The afternoon session will be brief.)

Refer to the list made at the end of the last activity. The children may want to add other ideas about where the water in the plastic bag might have come from. The list may include the air, the bag material, the stems, the leaves, the buds, the whole plant. Ask how the different ideas could be tested, and help the children set up experiments. Be sure that they think through their experiments enough to be able to tell what they are testing for and how the results will give answers to their questions. For example, a plastic bag over a stem stripped of its leaves should test whether water comes out of the stem. If there is water in a bag over a stem with leaves, but no water in a bag over a stripped stem, they should be able to conclude that the water came from the leaves.

This diagram combines several possible tests:



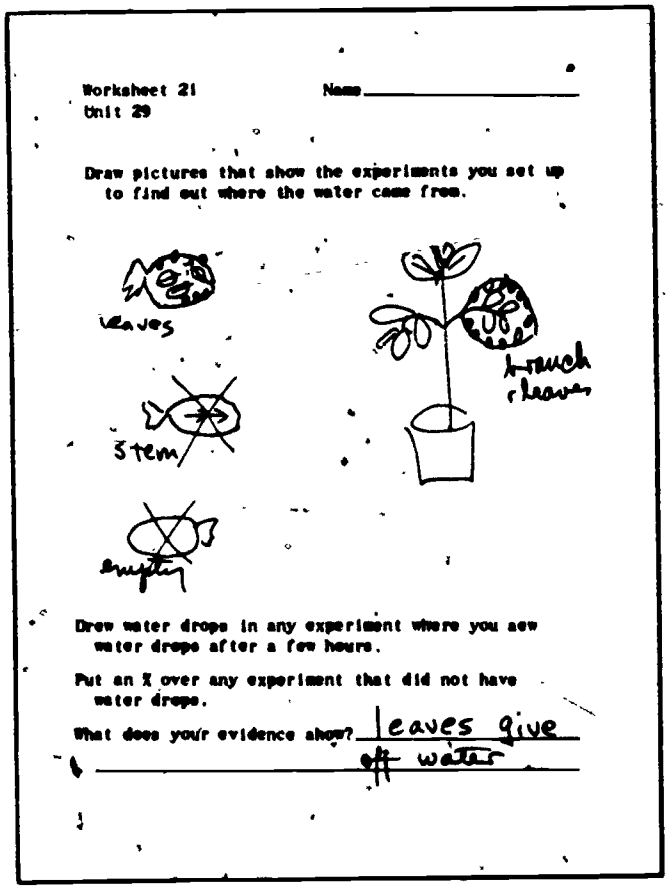
When the experiments are all set up, they should be placed under a lamp as in Activity A. Observations can be made and conclusions can be drawn the same afternoon. If you put the experimental setups in a window (without sunlight) you will have to wait till the next day. (A sunny window will produce quick results, as does a gooseneck lamp, but you have to be careful not to overheat the setups.)

Have the children turn to Worksheet 21 and draw pictures of the experiments that were set up. Then they can go on to other work.

Activity C

When at least one of the bags shows a good collection of water droplets, have the children observe the results of their experiments. They should look closely at the bags to decide which have moisture in them and which do not. They should be able to come to the conclusion that in the previous experiment (in which the bag covered all plant parts above the soil) the water probably came out of the leaves, because in this series of experiments there isn't much moisture in the bags that don't have leaves in them, and there is visible moisture in the bags that contain leaves.

Have the children fill in experimental results and conclusions as directed at the bottom of Worksheet 21.



Worksheet 21 Name _____
Unit 29

Draw pictures that show the experiments you set up to find out where the water came from.

leaves

stem

much leaves

Drew water drops in any experiment where you saw water drops after a few hours.

Put an X over any experiment that did not have water drops.

What does your evidence show? leaves give off water

Activity D

Read Chapter 6 of Adventures in Living Plants by Kurtz and Allen, and retell it to the children in third grade language. It is an exciting story of a trip through a plant's "plumbing system" made by children who have taken a reducing pill. They have to wear diving suits and fight the rapid current. Read only from the beginning of the chapter until the children get up to the leaves and look out through the stomates. (Stomates are microscopic holes in the leaves through which the water passes into the air.)

Lesson 12: WHAT ARE THE PARTS OF THE SYSTEM?

In the first activity the children draw diagrams of a plant's water carrying system. Since each makes his own decision on what parts are necessary, the diagrams may not look alike. Some children will include only roots, stems and leaves. Others may want to include tubes, soil, water and even the air. The children should be able to tell the class their reasons for their choices of what they include and what they leave out of the plant's water carrying system.

There is no "correct" interpretation of what should be included in the system. This lesson is an excellent way to help the children understand that a system is really man's analysis or way of looking at natural things. One can make his own decision as to what the system is to include for his experimental purposes. He can limit his system or make it broad, depending upon what he is trying to learn about it and what experiments he is setting up.

In the second activity the children compare the water carrying systems of different plants. The systems of all leafy plants are basically the same, in that they include roots, stems, and leaves in some form. However, there are very different-looking roots, stems, and leaves that are adapted to particular environments. The children look at pictures of different plants and identify and compare the structures. In these pictures roots are the easiest to identify and stems the most difficult. Roots are usually underground and branch irregularly. Stems can be identified because they always bear buds and leaves arranged in a definite pattern. (In the case of a runner, as in the strawberry, new plants grow from the bud. The potato is an underground stem, and the eyes are tiny buds.)

Finally, the children consider how different plants might be suited to different environments.

OBJECTIVES

Each child should be able to:

- Draw and explain a simple diagram of a plant's water carrying system.

- Compare the water carrying systems (roots, stems, and leaves) of different plants.
- Discuss ways in which different kinds of roots, stems, and leaves might be more useful in particular kinds of environments.

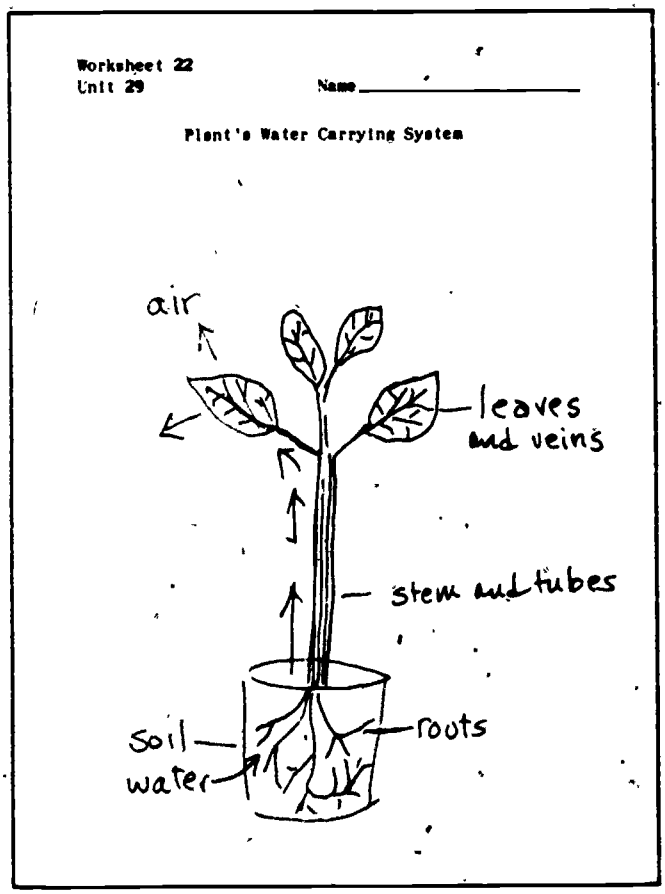
MATERIALS

- Worksheets 22 and 23
- green onions (optional)

PROCEDURE

Activity A

Have the children turn to Worksheet 22, on which they are to draw and label a picture of a plant's water carrying system. The children may work individually or in pairs.

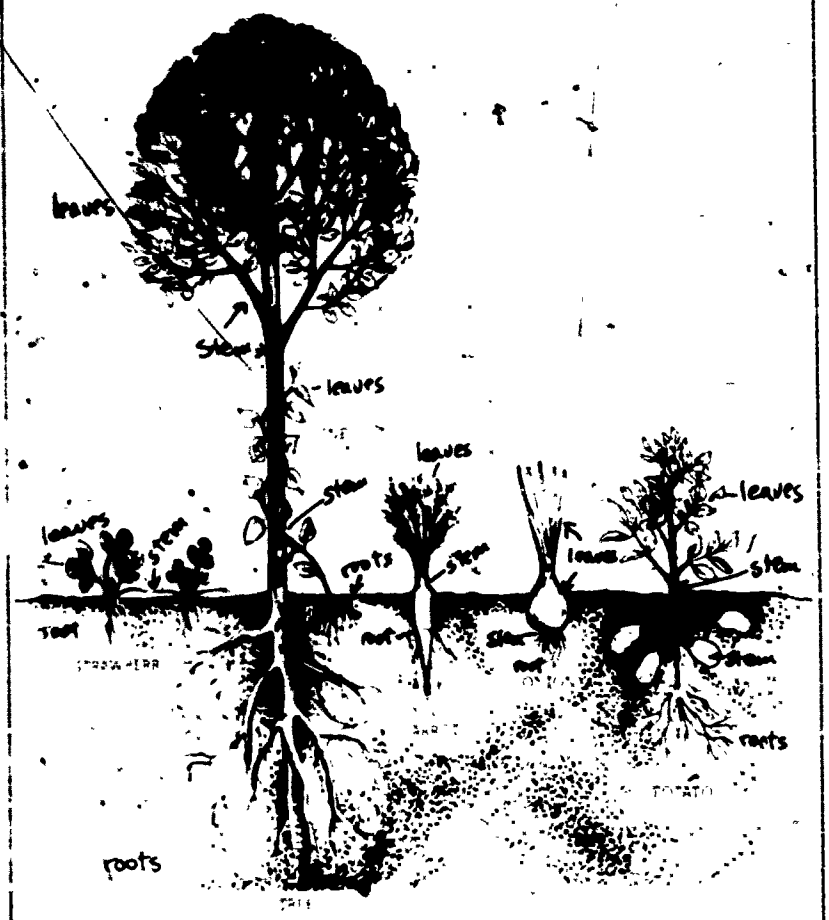


Each child should consider the plant's water carrying system, what he thinks is part of the system, and why. After the children think it through for themselves and have made their drawings, they should have an opportunity to discuss and share what they have done with the class.

By the end of the activity, each child should have recorded his ideas of what the parts of the system are, and he should be able to explain why each part is included. His diagram should be labeled with the names of the plant parts and with arrows showing the direction of water movement.

Worksheet 23 Name _____
Unit 29

Label the roots, stems and leaves of each plant.



This worksheet illustrates variations in plant structure.

STRAWBERRY: The runner is a stem that goes along the ground and sends up new plants at intervals.

TREE: The tree trunk is its stem.

VINE: This stem is pliable, long and twining, unlike the tree.

CARROT: The stem is the short, chunky greenish section between the large root and the feathery leaves.

ONION: The rings of the bulb are actually part of the leaf structure. The stem is the small area from which the bulb scales (rings) rise and the roots descend.

WHITE POTATO: This plant has two kinds of stems. Above-ground stems have leaves. Underground storage stems are the potatoes, and the buds on them are the eyes.

Activity B

Ask the children if they think all plants have the same kind of roots, stems and leaves. Have them turn to Worksheet 23 and see if they can tell which are the roots, stems and leaves on each of the plants. Give them time to label as many plant parts as they can.

In a class discussion ask children to tell how they labeled the parts of the tree. It is unlikely that there will be much disagreement on this, though some children may find it hard to conceive of the tree trunk as a stem. Go on to the vine, on which the children should also be in agreement. Then ask how they labeled the parts of the other plants. Now there is bound to be disagreement, since the plants were chosen to illustrate great variety in plant structure.

After the children have had a chance to express themselves, tell them that some of the plants show special kinds of roots, stems and leaves. Tell them the correct identification, using as much of the information on the facing page as you think appropriate. The purpose of this worksheet and discussion is simply to help the children understand how much variety there is in plant structure, and to show that though other plants may seem very different they do in fact have a basic similarity to the coleus and the celery the children investigated in detail in the earlier lessons.

(It would be interesting to bring a few green onions into the classroom and let the children take them apart to see how the white layers of the bulb are each continuous with a long green hollow leaf. They can see how this structure is different from the coleus and the lettuce leaves. They can also see the unusual stem – the compact stubby section at the base of the bulb from which the roots and leaves grow.)

Then have the class discuss ways in which different kinds of roots, stems or leaves might be more appropriate or useful in different environments. Ask questions such as these:

WHAT KINDS OF ROOTS MIGHT BE USEFUL IN DRY PLACES? IN WINDY PLACES?

HOW COULD A LONG STEM BE USEFUL?

HOW WOULD A LARGE, LEAFY TREE GET ALONG IN THE DESERT? WOULD THAT BE A GOOD ENVIRONMENT FOR IT?

Let the children share their ideas. This discussion should help the children become aware that some plants' water carrying systems are better adapted to one environment than to another. If the children are interested in going into further detail, tell them that dandelions grow almost everywhere, and ask if anyone knows what kind of roots they have. Ask if they can think of some reasons why it would make a difference if a plant had one kind of root or another. Suggest that some children dig up some dandelion plants to bring in. They should try to get all the roots. While they dig they should notice the moisture in the soil. Is it more moist near the surface or deeper down? If the children are interested, they can investigate plants that grow in wet places, dry places, open fields and heavy forests, and compare the parts of their water carrying systems.

Lesson 13: HOW MUCH WATER GOES THROUGH THE SYSTEM?

The children have seen that water enters the plant through the roots, travels through the stem to the leaves, and then out from the leaves into the air. An interesting extension of these activities is to find out how much water passes through assorted leafy stems.

The children place the stems of coleus and other plants in colored water and observe the change in water level in the container as the water goes through the plant and into the air. They find that each stem takes up a different amount of water. The rate of transpiration (water loss) is dependent upon numerous factors including size and type of plant, amount of leaf area, humidity, breezes, and temperature.

Start this lesson in the morning. It can be completed in the afternoon or the next day, depending on conditions.

OBJECTIVES

During this lesson the children should be able to:

- Interpret change in water level as an indication of how much water a plant stem has taken up.
- Record information in tabular and diagrammatic form.
- Identify the role of a control.
- Interpret the results of their experiments as showing that all plant samples cannot be expected to have the same transpiration rate.

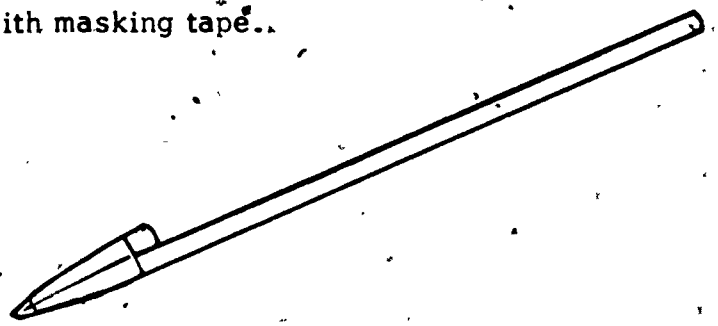
MATERIALS

- assorted plant stems
  (See description below, under "Preparation.")
- large transparent plastic straws (one for each stem)
- green food coloring
- 5 medicine droppers
- masking tape
- water
- Worksheets 24 and 25

PREPARATION

Select an assortment of stems with leaves that are long and slender enough to fit well down into a large plastic drinking straw. (You can strip a few lower leaves off a shorter stem.) Place them in a container of water until you are ready to use them. Choose some with large leafy areas, because they will transpire more quickly and the change in water level will be more marked. Try to get stems from many types of plants – shrubs, trees, tall grass, vines, house plants.

Prepare the straws by making a sharp bend an inch from one end and fastening it with masking tape.



Add food coloring to one quart of water.

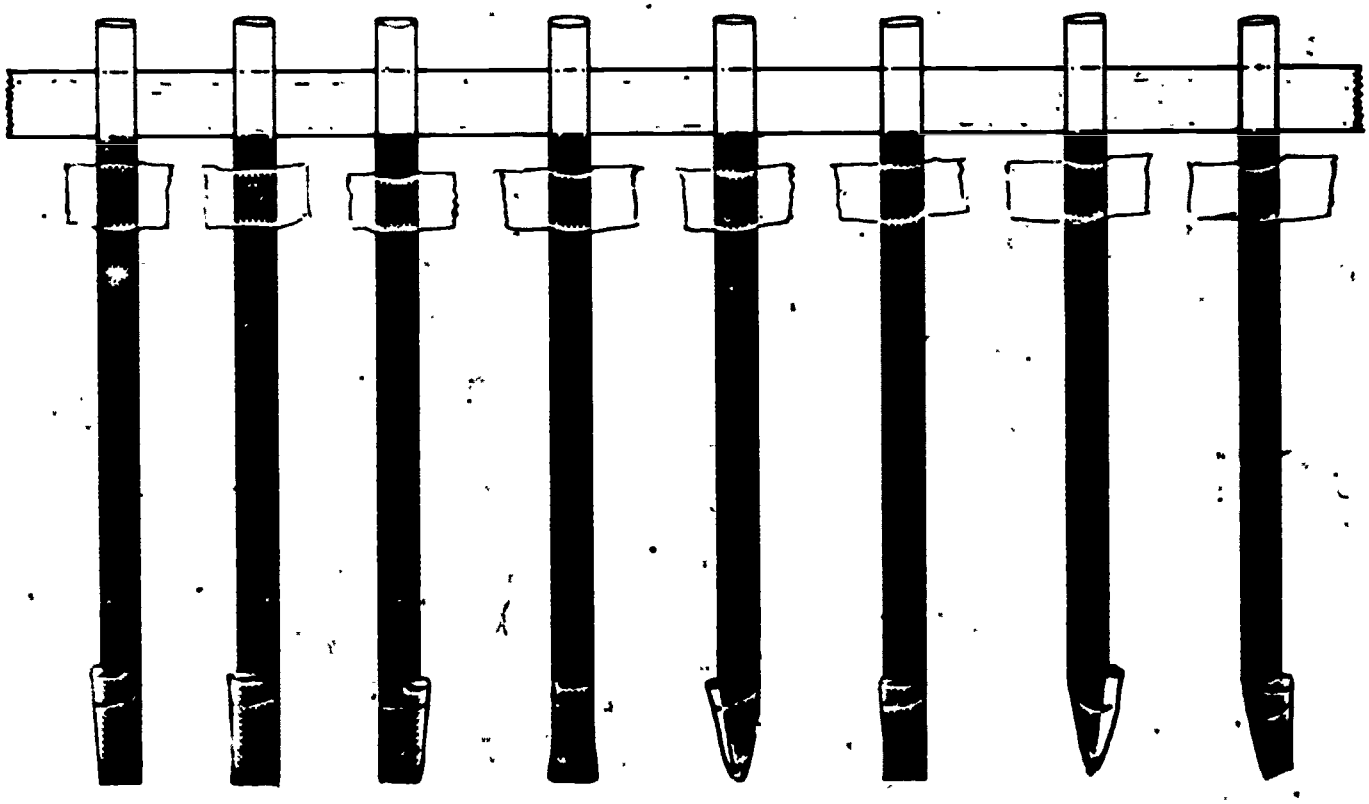
PROCEDURE

Mention to the children that they have identified the different parts of a plant's water carrying system by doing many experiments, but one thing that they haven't explored is how much water goes through the plant's water carrying system in a given period of time. Ask if the children think that all plants take up about the same amount of water or if some take up more water than others. They should discuss some of their experiences which make them think that plants do or do not need similar amounts of water.

Ask the children what kinds of experiments they might set up to investigate the question. The children may wish to set up other experiments as well as the one suggested below and should be given opportunities to do so.

Bring out the assortment of stems that you have collected and show them to the children. Mention that these are just parts of plants and we might get different results with whole plants, but we can still find out something about how much water is taken up by these stems. Tell them that to find out how much water these stems take up we could put the stems in water and measure the change in water level. Show the children the taped straws and the colored water that you have prepared.

Let different children use medicine droppers to fill each of the taped straws to about one inch from the top. Place a piece of masking tape horizontally across a window. The straws should then be attached to the window pane with transparent tape so that the water levels are lined up with the bottom edge of the masking tape. Let the children see that the edge of the masking tape serves as a marker for the water level in each straw.

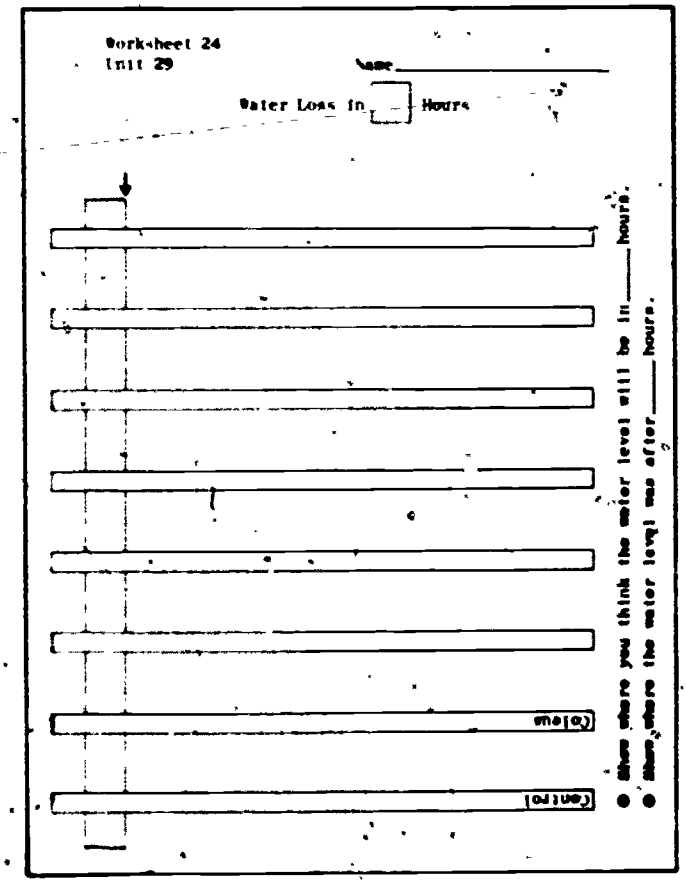


Then have children put a stem into each straw. The water will now rise to different levels, but the children should understand from their displacement activities in earlier units that this does not mean that the amount of water in the straws has been changed. (If any water rises high enough to spill, you should remove the stem and make a mark to show the starting water level for that straw, and then replace the stem.)

Tell the children that they will check later in the day to see how much water the stems took up. Ask the children what the evidence will be if the plant has taken up some of the water. They should expect the level of the water in the straw to be lower than it is now.

Ask the children to suggest a control that could be set up to show if the missing water really was taken up by the plants, or if the level would have gone down even if there were no stems in the straws. Have one of them fill a straw with colored water and tape it to the window, but put no plant into it.

Have the children turn to Worksheet 24 and write the names of the plants that they are using for the experiment, one at the base of each column. Have them draw pencil lines where they think the water level will be on each straw in the afternoon. They might discuss whether they think all of the plants will take up about the same amount or whether some plants will take up more than others. They should tell why they think as they do.



Worksheet 24
Unit 29

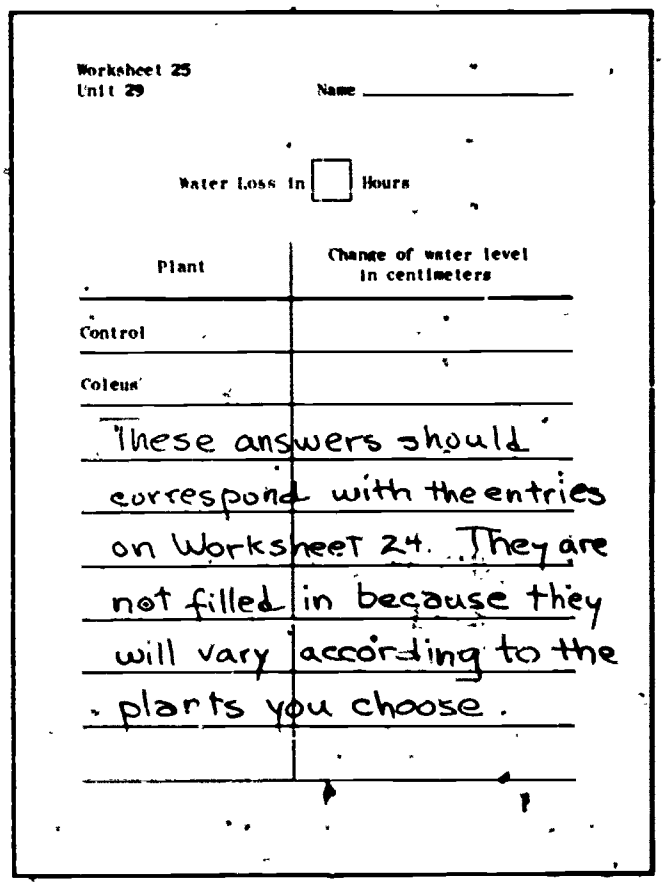
Name _____

Water Loss in ___ Hours

● Show where you think the water level will be in ___ hours.
● Show where the water level was after ___ hours.

Coleus

Control



Worksheet 25
Unit 29

Name _____

Water Loss in ☐ Hours

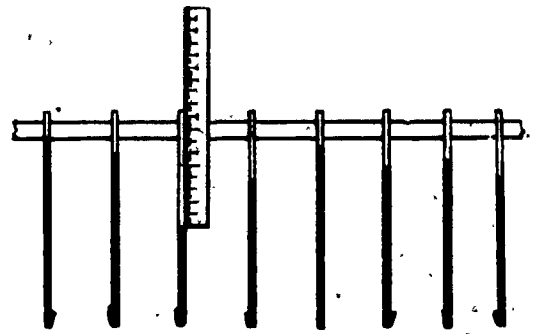
Plant	Change of water level in centimeters
Control	
Coleus	

These answers should correspond with the entries on Worksheet 24. They are not filled in because they will vary according to the plants you choose.

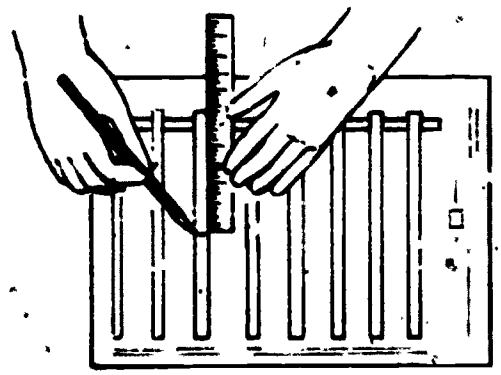
In the afternoon have the children look at the straws to see how much water was taken up by the stems. (If there has been very little change, delay the rest of this lesson until the next day.)

Ask how they can compare the water levels now with what they were at the beginning of the experiment. They should remember that the bottom edge of the masking tape was the marker for the water level at the start. To find the present water level they will have to remove each stem. (It may be necessary to review what they observed yesterday about how the water rose to different levels because thicker stems displaced more water than thin ones did.)

Now the children can measure the distance between the two water levels to find out how much the level dropped. A few children should make these measurements and report them to the class so that all can fill in the table on Worksheet 25.



Then the children can work alone or in pairs to transfer the information from the table on Worksheet 25 to Worksheet 24. Here they are to measure the distance from the lower edge of the masking tape, draw a line to represent the water level on the straws, and color the portion of the straw below that line to represent the remaining water.



Have the children discuss how much water was taken up by the plants. The discussion should be based on their direct observations and the experimental data. During the discussion they might consider the following questions:

DID ALL THE PLANTS TAKE UP THE SAME AMOUNT OF WATER?

WHICH PLANT APPEARS TO HAVE TAKEN UP THE LEAST WATER? THE MOST?

WHAT HAPPENED TO THE CONTROL? WHAT DOES THAT TELL US?

Ask the children if they have any ideas about why the plants took up different amounts of water. They have little basis for any conclusions, but they should be encouraged to speculate. Be sure that they recall their activities showing that water comes out through plant leaves. They should be able to relate this to their discussion about how much water was taken up by the plants. If necessary, call their attention to the differences in number of leaves on each stem, and the differences of leaf area and leaf thickness.

Lesson 14: WATER IN LEAVES

Our attention has been focused on how water enters a plant and goes through it. This lesson demonstrates that water does not just pass through the leaves but also remains in the leaf tissue. (Water is needed for all the physical and chemical changes that take place in the plant.)

The children find out how much of the plant tissue itself is composed of water. They weigh a lettuce leaf, let it dry out, and then weigh it again to see how much water the leaf has lost.

They also compare the rate of water loss of lettuce and cabbage leaves, and consider how rate of loss relates to the kinds of conditions under which different plants can thrive.

The lesson concludes with a summary telling that water is used by the plant to make food.

This lesson will take two days.

OBJECTIVES

In this lesson the children:

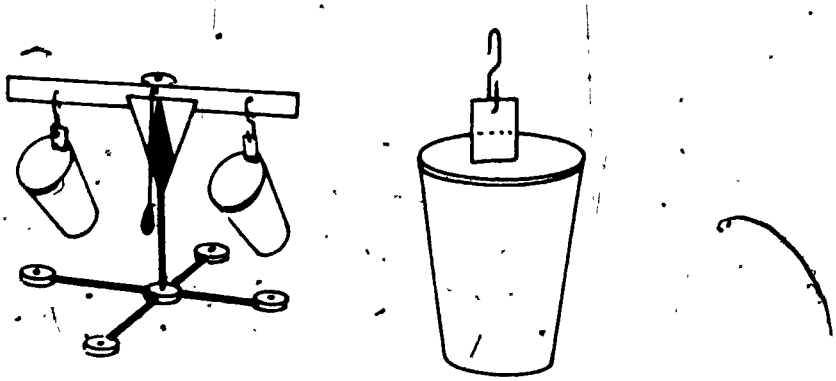
- See that there is water in leaf tissue.
- See that leaves dry out faster in some kinds of plants than in others.
- Are told that plants use water for making food.

MATERIALS

- beam balance
- two 12-oz. tall clear plastic cups
- lettuce leaves (several)
- cabbage leaves (several)
- a few leaves of succulents (fleshy-leaved plants such as jade plant, aloe, hen-and-chickens)

PREPARATION

Use masking tape to attach plastic cups to the beam balance.



PROCEDURE

Activity A

Remind the children that they have seen how water is taken up by a plant and comes out of the plant through the leaves. Ask if they think the water just passes through the plant or has stopping-off places.

Then show the children the assortment of different types of leaves.

DO YOU THINK THERE IS WATER IN THESE LEAVES? HOW MUCH? HOW CAN WE FIND OUT?

The children will suggest various ways, such as cutting a leaf and looking inside, squeezing one over a cylinder, etc.

Have volunteers try the different methods suggested. The children may be surprised at how watery and gelatinous the interior of the leaves of succulents is, but they may not be able to measure the amount of water present.

If the children do not suggest it, proceed as follows:

WHAT WOULD HAPPEN TO THE WEIGHT OF A LEAF IF THE LEAF DRIED OUT? (It would get lighter.)

DOES THIS SUGGEST A WAY WE COULD FIND OUT HOW MUCH WATER A LEAF CONTAINS? (Weigh it before and after it dries out.)

Bring out the beam balance and put a lettuce leaf in one plastic cup. Balance the leaf with sand, paper clips or some other convenient substance. Set the balance aside to permit the leaf to dry out, and go on to other work. Have children look at the balance occasionally during the day and see that the arm with the lettuce leaf is rising gradually as the leaf wilts.

The next day ask the children to suggest ways of finding how much water has evaporated from the leaf. Someone may suggest adding water to the cup containing the lettuce leaf until the balance is restored. Do this. When you add the water, try to do it so that it runs down the side of the cup and collects at the bottom. The volume will be more dramatically visible if you add the water so that none gets caught in folds of the leaf.

Now show the children a lettuce leaf and a thick piece of a cabbage leaf, and ask which they think will dry out faster. Then balance the two by tearing off bits of the heavier one or by adding more pieces of the lighter one, and set the balanced leaf system aside for later observation. If you have the appropriate plants, you can also balance a succulent (jade, aloe, etc.) against coleus or geranium leaves.

When the results have been observed, ask the children what they think about the conditions under which each of the plants thrive. Can one stand hot sunshine better than another?

Activity B

The children have studied the water carrying system of plants and traced water on its path from the soil, through the roots, stems and leaves, and into the air. They might think that the plant is just a passageway for the water. Remind them that they have also seen that the plant will die if it doesn't get enough water. They have seen that there is a great deal of water in the leaves. Tell them that the plant uses the water to make its own food. Plants are not like animals, which have to take in food from outside their own bodies. Green plants use water, sunshine, chemicals from the air, and chemicals within the plants themselves, to make their own food. (The "plant food" that comes in bottles is not really food at all, but contains chemicals that the plant uses to make its own food.)

Animals depend on the ability of plants to make food. They are unable to make their food in their own bodies, and therefore eat the plants. Children who are interested in studying this relationship further can look in the library and encyclopedias for books and articles about food chains and ecology.

NOTE

In Lesson 9 you cut a coleus plant off from its roots and put the stem into the soil. The plant wilted, but you were asked to put it aside, together with the control plant, water it regularly and watch to see what happens. If you have not already done Activity B of Lesson 9, on pages 52 and 53, do it now.

9

EROSION

COMMENTARY

In order to investigate a natural phenomenon it is often helpful to set up a model in which some elements (variables) can be controlled. In this section the children experiment with a set of materials to investigate what factors affect erosion. They compare the results of their preliminary activities with pictures that show evidence of erosion in natural settings. These activities provide a background of direct experiences. Then the children decide what elements should be part of a model of an erosion system. They tentatively identify incline, soil and water as among the necessary parts of the erosion system. Then they investigate how each of these can be varied and how the changes affect the total system.

On a field trip the children can look at the effects of erosion in a natural setting. Then they set up a miniature landscape in which they can predict that erosion will occur in some areas and not in others.

OBJECTIVES

After the students finish this section they should be able to:

- Tell that erosion is the wearing away of soil. (All the examples they study will be wearing by water.)
- See a stream table as a model of a natural erosion system.
- Relate formations that they see in experimental models to landscapes and pictures of landscapes.
- Identify some parts of the erosion system as incline, soil, amount and flow of water, and ground cover.
- List parts of the system whose change might influence erosion in their model system and in nature. (These are the variables with which they will experiment.)
- Set up and work with model erosion systems in which all but one variable is held constant, after the class has agreed on procedures.
- Describe and compare the erosion patterns when parts of the system (incline, soil, water flow) are changed.

PREPARATION

For Lesson 19 you will need one cup each of an assortment of different kinds of soil — garden soil (preferably from several different gardens), soil from a construction area, from a riverbank, etc. Have the children bring them in well ahead of time, or collect them yourself, whichever is more convenient. For Lesson 22 you will also need additional soil. Read the lessons now to decide how you will plan to teach them and how much soil you will need.

Lesson 15: RUNNING WATER OVER SAND

The children explore the kinds of things that happen when water flows over sand on a stream table. They are to experiment freely with the materials. This free approach should provide a wide variety of experiences.

After the children experiment they discuss their observations. The lesson should take 45-60 minutes.

OBJECTIVES

At the end of this lesson the student should be able to describe the experiments he did and tell what his observations were.

MATERIALS

- 15 plastic shoe boxes
- 15 small styrofoam trays
- 15 large styrofoam trays
- 30 paper cups
- 15 cups of sand
- 30 magnifiers
- 30 medicine droppers
- centrally located water supply (bucket or sink)
- Worksheets 26 and 27

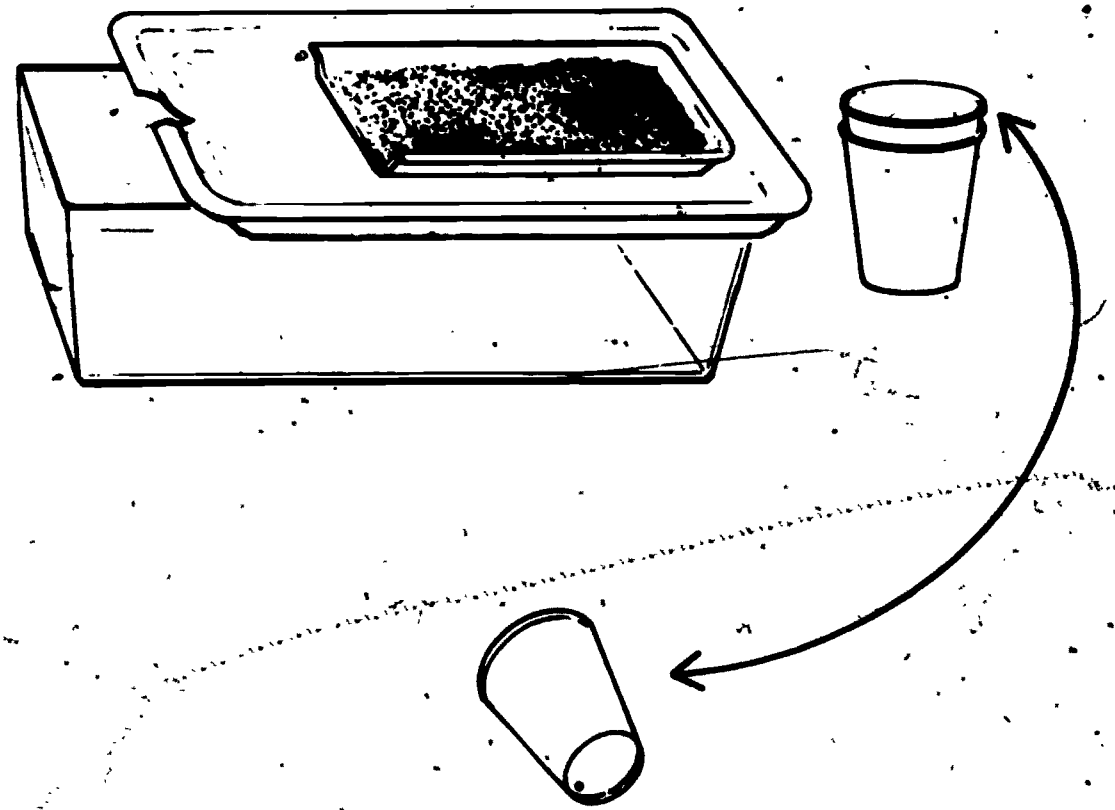
PREPARATION

The children will be working in pairs. Assemble and prepare the materials for a stream table for each two children:

- 1 plastic shoe box
- 2 styrofoam trays, one large and one small
  (Cut out a large notch at the center of one end of the larger tray, as shown in the diagram on the next page. Cut off one end of the smaller tray as shown.)

- 2 paper cups
  (Use a sharpened pencil to poke a small hole in one cup as shown in the diagram. Place this cup inside the second one. Put water into the cup with the hole.)
- 1 cup of sand
  (Pour the sand on the small tray, opposite the end that was cut off.)
- 2 magnifiers
- 2 medicine droppers

Before you teach this lesson, assemble a stream table according to the diagram below. Take the cup with water in it out of the other cup and let the water run through the hole and onto the sand. Spend some time working with it to see the variety of effects you get when you change the rate of flow of water, the angle of the tray holding the sand, etc.



Worksheet 26
Unit 29 Name _____

Get these materials from your teacher.

One set of materials for enough for you and your partner.

plastic shoe box	
small tray with one cup of sand on it	
large tray with notch cut	
2 paper cups, one with hole	
1 medicine dropper	
1 magnifier	
water	

Level the sand

Use your equipment to investigate these two questions:

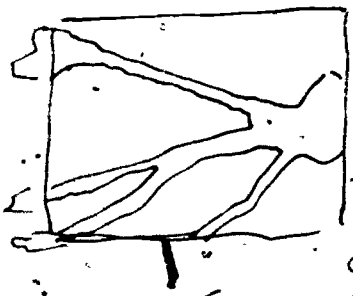
1. What happens when water is poured or "rained" on sand?
2. What things affect the movement of sand by water?

Use the next page to draw pictures or write about what you did and what you saw.

Worksheet 27
Unit 29 Name _____

Stream Table Results

This is how the tray looked when it was flat



When I tipped the tray the water ran down this way ←

PROCEDURE

Show the children an assembled stream table. Tell them that they are going to work in pairs, and each pair will be using its stream table for several days; so they will want to keep it in good condition. Do not go into any detail about how they are to use the stream tables. Simply make the general statement that they will be using them to observe the effects of flowing water on sand.

Tell the children to look at the questions at the bottom of Worksheet 26 in their student manuals. Then ask for suggestions about what they might do with the equipment to find some answers to these questions. After they have offered several suggestions, have them pick up their equipment and work in pairs to learn what they can about the interaction of sand and water.

Have the children use magnifiers so that they will be able to see small-scale effects and observe the movement of grains of sand by water.

Tell the children that if the sand gets soaked it is difficult to do the experiments. Therefore they are to begin with one cup

of water, which they may use as they wish — pouring it, dropping it with the medicine dropper, or letting the water run out of the little hole in the cup onto the sand. After they have used one cup of water the children may get a second cup from your centrally located water supply. If they use more than two cups of water, the sand is likely to slide off the tray. (You may want to have several pitchers of water located at various places in the room.)

Prepare the children to expect continually changing patterns.

After the children have had 10 to 20 minutes for experimenting and recording their results, have them set their trays together on a table or side counter. Then have them walk past all the trays to observe the results of their classmates' experiments and make comparisons. The most interesting things will have happened while each pair was experimenting, but the different ways in which the materials were handled will provide a variety of formations on the different stream tables.

When the children have returned to their desks, open the discussion by asking them to tell you what they observed in their experiments. List their observations on the board in a place where you can keep it for the next day. The beginning of a list from a class might look like this:

- The water made the sand move.
- When I dumped a lot of water in one spot it made a big hole.
- When I tipped the little tray the water ran downhill faster.
- When the tray was flat the water stayed in puddles.
- When I put a whole lot of water on at once all the sand slid off.
- The water ran in streams and made rivers.

Let the class add to the list until they think that just about everything they observed has been noted.

Leave the list on the board for the next day's lesson. The stream tables should be left undisturbed for further observation the next day.

Lesson 16: NATURAL EROSION

This lesson is developed in three stages:

1) The children relate what they have observed in the stream table activities to what they see in pictures showing the effects of flowing water on landscapes.

2) They discuss what factors may have caused variety in erosion patterns in nature, drawing inferences from their experiences with their stream tables.

3) They consider what they can use as a model to investigate some of the factors they think may have affected the erosion patterns. (The stream table will serve as their model.)

There are many different ways to give children the experiences listed above. The lesson describes one way to do this. You should adjust the suggested procedure to suit the needs of your class, but keep in mind that as much as possible should be left to the children's imagination and initiative.

The term "erosion" should be introduced. Erosion is the wearing away of the land. In these activities we concentrate on the movement of soil by water. It is not necessary for the children to use the term, but you should introduce and use it.

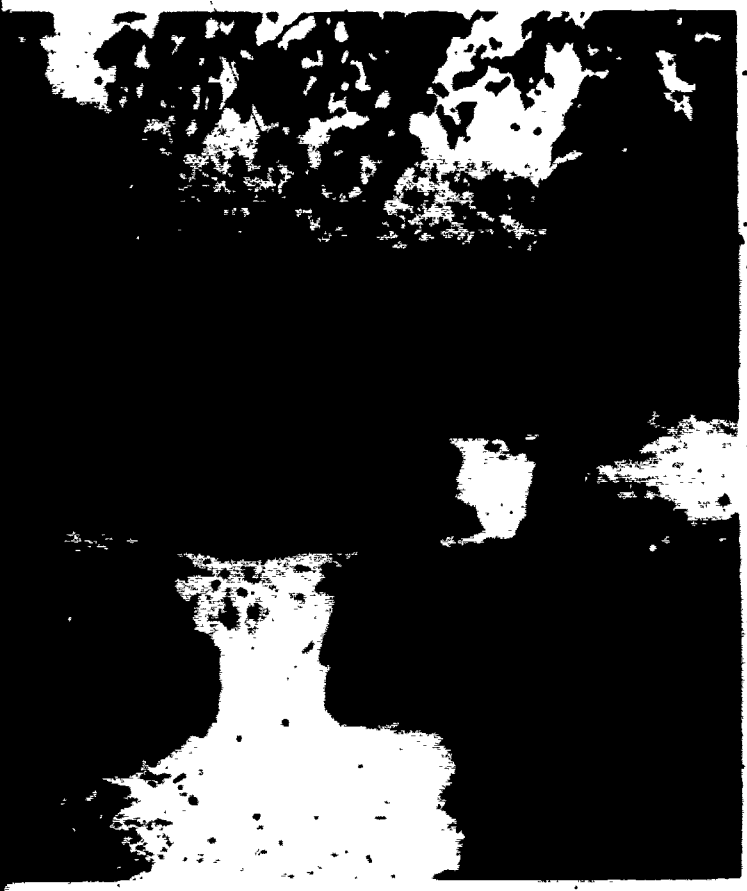
OBJECTIVES

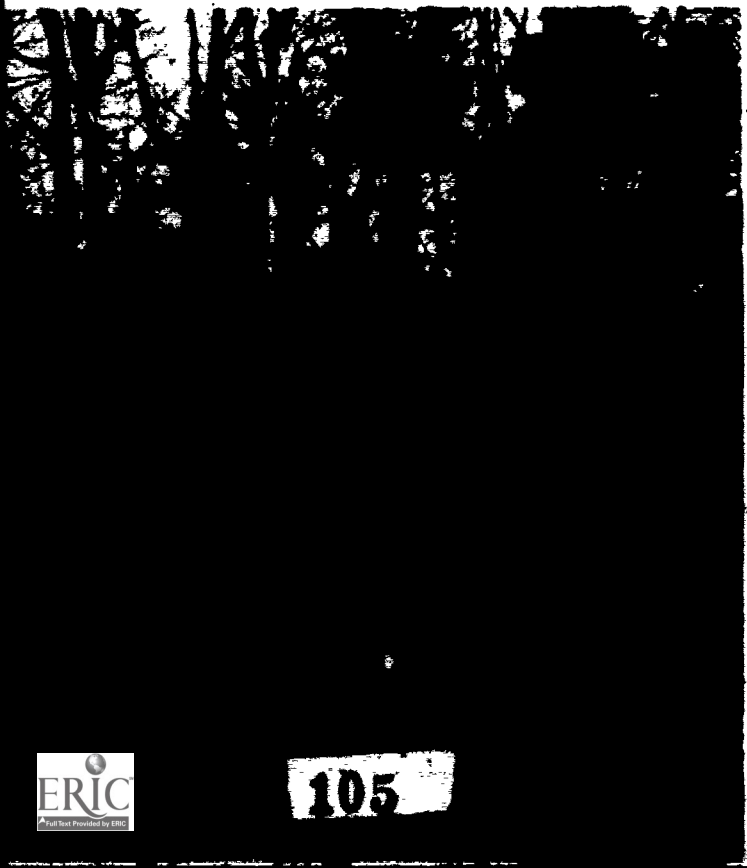
At the end of this lesson the students should be able to:

- Relate the kinds of patterns that they see on their stream tables to pictures that show similar patterns and effects in natural landscapes.
- Identify some parts of an erosion system as soil, incline and water flow.
- Work with the class to plan a suitable model of an erosion system that can be used to investigate factors affecting erosion.
- Develop standards with the class for care of equipment and then take the responsibility for maintaining their equipment.

Worksheet 28
Unit 29

Examples of Erosion





MATERIALS

- 3 or 4 stream tables kept undisturbed from the day before
- Worksheet 28

PREPARATION

Look at the stream tables kept from the day before. Select three or four that show different erosion patterns. (If none are satisfactory, flow water from a cup over several to create new effects that the children can use for observation and reference.)

Set the stream tables where it will be convenient for the children to look at them.

PROCEDURE

Stage 1

The day before, the children compiled a list of the observations they made while working on the stream tables. Have the list read out loud now. Then have the children turn to Worksheet 28 and look at the pictures. Ask if they see things in the pictures that look similar to the effects they observed on their stream tables yesterday. Then ask them to describe what differences, if any, they observe between the erosion patterns in the trays and the pictures.

Next ask the children if they can describe the different erosion effects. They might note that some gullies are shallow and others have steep sides, or that some are more winding and others are straighter. List the erosion effects as they are described. (This list should be preserved. You may want to copy it onto a piece of tagboard, leaving space after each item for additional information to be added later.)

Stage 2

Now ask the children to speculate about what they think could have caused the different erosion patterns in the pictures. In order to help them consider cause and effect, encourage them to describe the things that they did with their stream tables

and the results they got. Some of the different natural patterns in the pictures will have direct relationships to the things that they observed on the stream tables. For example, some children may have left the tray flat and others may have sloped it; they may notice that some of the land in the pictures appears to be steeper, too. The water flow may have been different — faster or slower, more or less — on the different stream tables; they may see different natural effects that might also be due to different water flow.

List on the board the kinds of things the children think might have caused the differences in erosion effects. (Encourage the children to make general statements here about variable factors, rather than detailed speculations about specific pictures.) The list might include:

- Water flow (faster or slower, more or less).
- Incline of ground (steep, moderate or flat).
- Kind of soil (sandy, rocky, etc.).
- Presence or absence of ground cover (grass, trees, shrubs).

(You will note that in compiling this list the children are tentatively identifying parts of an erosion system, although they have not been asked specifically to do so.)

Stage 3

There may be other things on the list, some relevant and some irrelevant. Ask the children what they can do to find out which are really factors in erosion and which are not.

The children may suggest studying effects of erosion outdoors. This activity should be part of a thorough exploration. It is presented later in this section as a field trip. However, at this point help the children also to think of some of the problems involved in an outdoor investigation. They might not be able to investigate some of the factors listed on the board. For example, they wouldn't be able to decide when it is to rain or how hard. They might be able to find only a moderate grassy slope when they want to check on a steep sandy one.

Ask if they can think of anything they might do in the classroom to help them investigate the factors affecting erosion. This should lead them to look for a classroom model in which they can control the different factors. They should not have difficulty in seeing that the stream table, which they used for free activity the day before, is suitable for controlled experiments and can be used as a model of the natural system.

Have them discuss ways in which they could experiment on following days to test the list of things that might influence erosion patterns. Save the list for future reference.

Clean-up

The children will have to prepare their stream tables each day to be ready for the next day's experiments. Have them help make a list of clean-up procedures. The stream tables will be usable if they are still damp the next day, but not if they are soaking wet. Therefore, the following should be included on the list:

1) Drain off water still on the small tray.
2) Empty water from shoe box.
3) Spread sand evenly over tray to dry.
4) Keep all equipment for each stream table together.

Lesson 17: EXPERIMENTING WITH INCLINE

The next four lessons will give the children opportunities to work with erosion systems. In each lesson they change one factor while keeping the others the same, to find out how each affects the total system.

At the beginning of each day's activity the class will decide together how they will do the experiments. For instance, in this lesson they will decide that the factors to keep the same are the kind and amount of soil, and the water flow. Then they will decide how they wish to change the incline for experimental purposes. Once they have established the experimental procedures, they will get their own equipment and each pair will work independently. When they have finished the experiment for the day, they record the results pictorially or in writing, and then prepare their equipment for the next day's activities.

Although the children decide to follow the same procedures, there will be some variety in their actual methods of experimentation, giving variety in the results. Point out that these differences do not represent failure, but show how hard it is to control all factors in an experiment completely.

The next three lessons have been designed to experiment with three parts of an erosion system — incline, water flow and soil. In Lesson 20 your class will have the chance to test other factors that they included in their list of things that might have caused differences in erosion effects.

OBJECTIVES

At the end of this lesson the student should be able to:

- State and demonstrate that incline affects erosion.
- Describe changes in erosion when the incline is varied.

MATERIALS

-- for each two children --

- stream table equipment (shoe box, 1 large tray with notch, 1 small tray containing 1 cup of smoothed sand, 1 cup with hole, 1 cup without hole, 1 cup of water)
- one 1-oz. plastic container

- magnifiers
- Worksheets 29-34

PROCEDURE

In Units 23 and 26 the children set up controlled experiments in which all factors were held constant except one. They will need to proceed similarly in these activities.

Review yesterday's lesson, in which the children established that the stream table could be used as a model to investigate erosion. They listed parts of the erosion system that might have caused differences in erosion effects, and discussed how to test the factors they listed. In the list they should have included incline, water flow and soil.

Tell the children that the first thing they will investigate is how incline affects the erosion system. Ask them what things they would have to change and what things they would have to keep the same in order to investigate this question. List them on the board as the children tell them to you. The list may be organized this way:

Things to change

- incline

(Leave space here.)

Keep the same

- sand
  (Everyone should use the same kind and about the same amount of sand. Each sand tray has about a cup of sand on it.)
- water
  (Everyone should use about the same amount, no more than two cups. The water should be applied in the same way: Let it flow from a hole in a cup and hold the cup two inches above the sand.)
- stream table equipment

After deciding which factors they will keep the same and determining how this can be done, the children should discuss ways to vary the incline. They should use at least three settings, flat, medium and steep, and should decide how each would be set up so that the angle of one medium incline has the same mag as all the other medium inclines.

Return to the first part of the list on the board, and under "Things to Change" insert the experimental conditions as the children decide what they should be.

The list might read:

Things to change

- incline

  A. flat
  (Have the small tray lying flat on top of the large one.)

  B. medium
  (Set the end of the small tray to rest on the edge of the large one.)

  C. high
  (Put one end of the small tray on an inverted 1-oz. plastic container.)

When the children have decided how the incline is to be controlled they should draw pictures or write a description of each incline setting in the appropriate blanks on Worksheet 29.

Then the class should be divided into thirds. Each third is to investigate one of the three inclines.

Have the children write what incline they will be working with in the box at the top of Worksheet 30.

Briefly read through Worksheet 30 with the children so that they will understand what they are to do independently.

First they are to read and follow the directions on Worksheet 30.

Worksheet 29 Name _____
Unit 29

Setting up an experiment to find out how incline affects the erosion system.

Things to change	Keep the Same
Incline	type of soil amount of water how the water goes on the trays

Tell how each incline is set:

Incline A The tray doesn't tip it is flat.

Incline B The end of the tray is on the edge of the big tray

Incline C The end of the tray is up on a little cup.

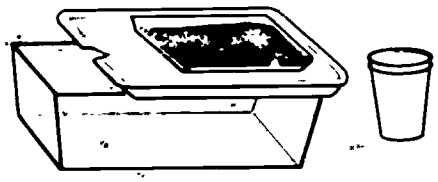
Worksheet 30 Name _____
Unit 29

Incline [B]

Get your stream table set up.
Check to see that you have everything:

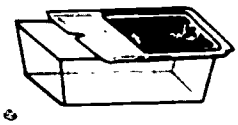
a. shoe box
b. 1 large tray with notch
c. 1 small tray with smoothed sand
d. 1 cup with hole
   1 cup without hole
e. 1 cup water
f. 1 1-ounce plastic container

1. Set up your stream table like this:



2. Adjust the incline of the small sand tray.

3. Let one cup of water flow from the hole. The X shows where it should fall.



After the children have done their own experiments they should turn to Worksheets 31 through 33. Each is to draw a picture of his experiment and write about it on the appropriate worksheet.

Then the children should go to look at experiments done at the two other incline settings and record what they observe. Each student should make his own observations and record of the other experiments. The class will have a chance to discuss what each has seen after everyone has completed the assignment.

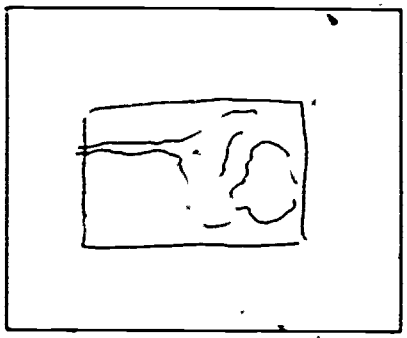
When the children have finished observing and comparing the experiments, they should turn to Worksheet 34 and answer the questions, using pictures or words to tell what they think about the effect of incline on erosion. They should base their conclusions on their direct observations. Worksheet 34 should be done by the pairs of children working together.

Worksheet 31
Unit 29

Name _____

Record your observations:

Incline A



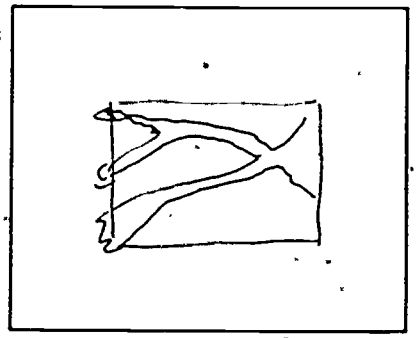
The water mostly stayed in puddles and some of it ran off the end of the tray

Worksheet 32
Unit 29

Name _____

Record your observations:

Incline B



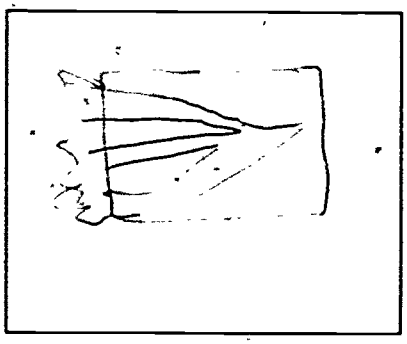
The water made gullies. Some sand washed off into the big tray

Worksheet 33
Unit 29

Name _____

Record your observations:

Incline C



The gullies are deeper than in the other trays. More sand washed off onto the other tray

Worksheet 34
Unit 29

Name _____

Answer in pictures or words:

1. Which incline showed the most erosion?

Incline C

2. Which incline showed the least erosion?

Incline A

How did incline affect the erosion system?

The higher the incline the more erosion there was.

Have the stream tables set somewhere at the side of the room, so they will not be a hindrance to the children's participating in a discussion. Give the children opportunities to share what they saw and tell how they think incline affects erosion.

A general observation that the children will probably agree upon is that when there is a greater incline, there is more erosion — that is, more sand is moved from one place to another.

After numerous children have had opportunities to share their ideas, have the class follow the clean-up procedures that they established the day before. The same equipment will be used in tomorrow's activities.

Lesson 18: EXPERIMENTING WITH WATER FLOW

In this lesson the children will keep the incline and soil type constant, and will see what happens when the water flow is varied.

OBJECTIVES

At the end of this lesson the children should be able to:

- State and demonstrate that water flow affects erosion.
- Describe changes in erosion when water flow is varied.

MATERIALS

- cafeteria tray

-- for each two children --

- stream table equipment
- magnifiers
- medicine droppers (optional)
- Worksheets 35 through 37

PROCEDURE

The question to be investigated is, "How does water flow affect erosion?"

Ask the children what they will need to keep the same and what they will need to change in order to test the effects of the amount and flow of water. As in the previous lesson, list on the board the things to be changed and the things to be kept the same as the children identify them.

Since water flow is the part of the erosion system being tested, it will be the only thing that will change.

Then have the children decide which things should be kept the same. The amount of sand is one of these things. (They should each have approximately one cup of sand.)

Incline is another thing they will need to keep the same. (Have the class decide which incline would give them the most interesting erosion patterns. They should think back to the results of the activities they did in Lesson 17. They will probably decide upon the medium or high slope.)

They should also comment on the necessity for everyone to use similar equipment.

Then have the children suggest ways to vary the water flow. They may suggest things similar to the following:

- Change the speed with which the water flows by making more than one hole in the cup or by making holes of different sizes.
- Use a medicine dropper instead of the cup.
- Vary the place where they put the water — in one spot, or moving around.
- Vary the force with which the water falls by holding the cup higher up or lower down.

Make sure that everything on the list is tried by at least one pair of children. Each pair should select two ways to experiment with water and write these ways in the blanks on the bottom of Worksheet 35.

After they have established what things are to be kept the same and how they will vary the water flow, have the class write their experimental plans on Worksheet 35. Then the children should get the materials and do their experiments following the instructions on Worksheet 36. Results should be recorded on Worksheet 37.

When they have finished, have the children place their equipment at the side of the room before involving them in a class discussion. Then list the children's comments on the board and give them a chance to discuss and compare their results with each other. A general conclusion that most of the children will probably agree to is that when the water is flowed fast and there is a lot of it, there is more erosion — more sand is moved. But this is a good time for open-ended discussion. Don't try to tie the lesson into a neat package.

Worksheet 35 Name_____
Unit 29

Experimenting to find out how water flow affects erosion:

Things to Change	Keep the Same
Water flow	Incline type of sand equipment amount of sand

The ways you will change water flow:

1. punch lots of holes in the cup.
2. Hold the cup up high

Worksheet 36 Name_____
Unit 29

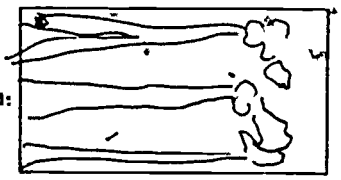
1. Get your stream table equipment.
   (shoe box, large tray, small tray with sand, 1 cup with hole, 1 cup without hole, water, 1-ounce container, medicine dropper)
2. Set up your stream table.
3. Adjust the slope of your small tray.
4. Level your sand.
5. Run water over the sand.
   Use your first method on Worksheet 35.
   Record your results on Worksheet 37.
6. Level your sand and drain off water.
7. Run water over the sand again.
   Use your second choice on Worksheet 35.
   Record your results on Worksheet 37

Worksheet 37 Name_____
Unit 29

Record Sheet

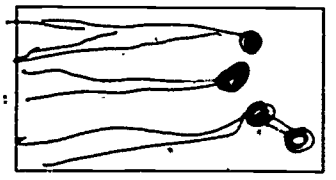
Method 1 for varying water flow.

What we observed:



Method 2 for varying water flow.

What we observed:



How did water flow affect erosion?

Lots of holes in the cup made more holes in the sand, when the cup was higher up the holes were deeper.

There should be room for disagreement. Encourage the children to refer to experimental data and to use materials to illustrate points.

It is quite possible to get different results from similar experiments when so many variables are affecting it. This is an important part of what the children are learning. They will be defining experimental procedures and refining their techniques as they move through the lessons.

After the discussion have them follow the usual clean-up procedures, but instead of spreading their sand in their own trays, have them dump the sand into one large tray where it can be spread out to dry. They should rinse off their small trays. (For tomorrow's activities they will be using sand, soil and clay rather than only sand.)

Lesson 19: EXPERIMENTING WITH DIFFERENT SOILS

The children will experiment with different kinds of soil to see what erosion patterns they get from each. Then they will combine more than one kind of soil in one tray and see what happens. This lesson will take two days.

OBJECTIVE

At the end of this lesson the children should be able to state and demonstrate that type of soil affects erosion patterns.

MATERIALS

- stream tables
  (You will need as many stream tables as you have kinds of soil from the list below.)
- soil (garden soil, sand, gravel, potting soil, natural clay)
- modeling clay
- Worksheets 38 and 39

PROCEDURE

Activity A

Tell the children that the question they will investigate today is, "How does type of soil affect erosion?" So far all their experiments have been with one kind of soil — sand. Ask them what other kinds of ground surface they have seen. List the kinds as the children tell them to you.

- different types of soil (i.e., black soil, red soil)
- clay
- stones or gravel
- rock
- grass
- asphalt
- concrete

Remind the children that they have observed some erosion patterns in sand. Ask how they think water flowing over these other kinds of ground would affect them. Do they think some would be eroded? Do they think some would not be eroded? Ask how they could find out. (They could do experiments where the kind of soil is changed but everything else is kept the same.)

Ask the children what conditions they will need to keep the same, and list them on the board as they tell them to you.

Keep the same

- slope
  (Use medium or high slope.)
- water
  (Use any single method of application that produced some erosion before.)
- method
  (All are to use the same procedure.)

Have the children tell you what to vary in the experiment. List them on the board.

Things to change

- kind of soil

Ask the children to tell you how they could set up a demonstration which would compare the erosion patterns in different soils. (They could put one kind of soil on each tray and flow water over them.)

Sand and modeling clay are provided in the kit. The modeling clay is to be used as a substitute for rock or cement in making landscape models on the stream table. Try to obtain or have children bring in garden soil, potting soil, gravel and sod. (Potting soil is generally much lighter weight than garden soil and may float off the tray when water is flowed over it. This makes an interesting comparison for the children.) See if you can get a sample of clay from a river bank. Be sure that the children do not confuse this kind of soil with the modeling clay, which is not a soil at all.

Choose some children to set up one stream table for each type of soil or substance you will be testing. Then select other children to flow the water over each stream table. Do this in a location where it is convenient for the class to gather around. (When these trays are prepared, you should keep in mind that it is easier to handle soil when it is moist.)

Have the children watch the experiments and then describe and compare the erosion patterns in the different types of soil or substances. They should record their observations on Worksheet 38.

When the children get back to their seats, have them discuss their observations. The following are some things they may notice:

- None of the clay washes away or is moved by the water.
- There are more and deeper gullies in the sand than in the soil.
- Depending upon the fineness of the gravel, it may or may not be washed away.

Have the children follow the established clean-up procedures and remove the soil from the small trays.

Worksheet 38
Unit 29 Name_____

How does type of soil affect erosion?

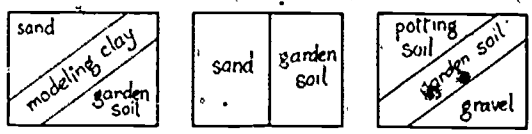
Things to Change	Keep the Same
type of soil	water flow incline materials

What was in each stream table?
What were the results?

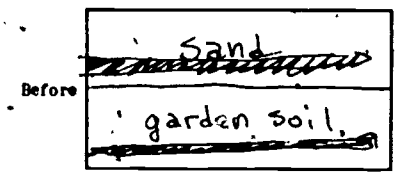
① sand Made gullies	② soil from a flower pot A lot floated away off the tray
③ soil from the empty lot Made gullies, not as much as the sand	④ gravel Made just a tiny bit of a gully
⑤ a piece of sod No gullies. A tiny bit of mud washed on to the tray	⑥ just a big flat sheet of modeling clay (supposed to be like cement) Nothing washed away. No erosion

Worksheet 39
Unit 29 Name_____

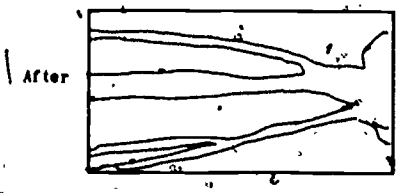
Some possible combinations of soil types:



Draw your own combination:
Use a different color to show the erosion pattern you expect.



Now flow water over the tray.
Show the erosion pattern you did get.



A big gully where the sand and soil came together

Activity B

Call attention to the fact that each tray has had just one kind of soil on it. Ask the children how they think it might affect the erosion patterns if there were more than one kind of soil on one tray. Give them an opportunity to share their ideas. Have them look at Worksheet 39. Talk about what they think would happen if they flowed water over trays that were like the drawings.

After they have given their ideas, ask them if they think there are any conditions in nature which might be similar to these mixed trays rather than the trays that contain just one kind of soil. Ask them to tell about any places that they have observed where there are more than one kind of soil or ground cover, with one kind touching another kind.

They might mention:

- The playground, where part is soil and part grass and part blacktop. Ask how this would affect erosion patterns.
- Sandy beaches, with woods behind them where the ground is soil.
- A concrete path going through a grassy area.

Ask what the children might use on their stream tables instead of cement or blacktop. (Modeling clay.) Then tell the children that they are going to be able to experiment with different kinds of materials on one tray. Ask them what things they will keep the same and list them on the board.

Keep the same

- slope
  (Medium or high.)
- water
  (Method of application should be the one they found most effective in Lesson 18 when they experimented with effects of different water flow.)

Have them look at some possible combinations of soil types on Worksheet 39, and then design their own with their partners.

When they decide what they will do they should draw a picture of it on Worksheet 39, gather the materials they need, and set up a stream table. Then they should predict what the erosion patterns will be. Have them use pencil or crayon in another color to draw on Worksheet 39 what they think the tray will look like after they have flowed water over it. Ask them to think about the following questions:

WHERE WILL THE DEEPEST GULLIES BE?

WHAT DO YOU THINK WILL HAPPEN WHERE TWO KINDS OF SOIL TOUCH EACH OTHER?

After preparing their setups and making the drawings of their predictions, give the children an opportunity to look at everyone else's setups by walking quietly around the room to see what the other trays look like.

Then have them return to their own setups and flow the water over the trays, using the method they have agreed upon. They should record the results on Worksheet 39 by drawing an "after" picture.

Have the children place the stream tables in a place where the class can walk past them and observe what happened to each.

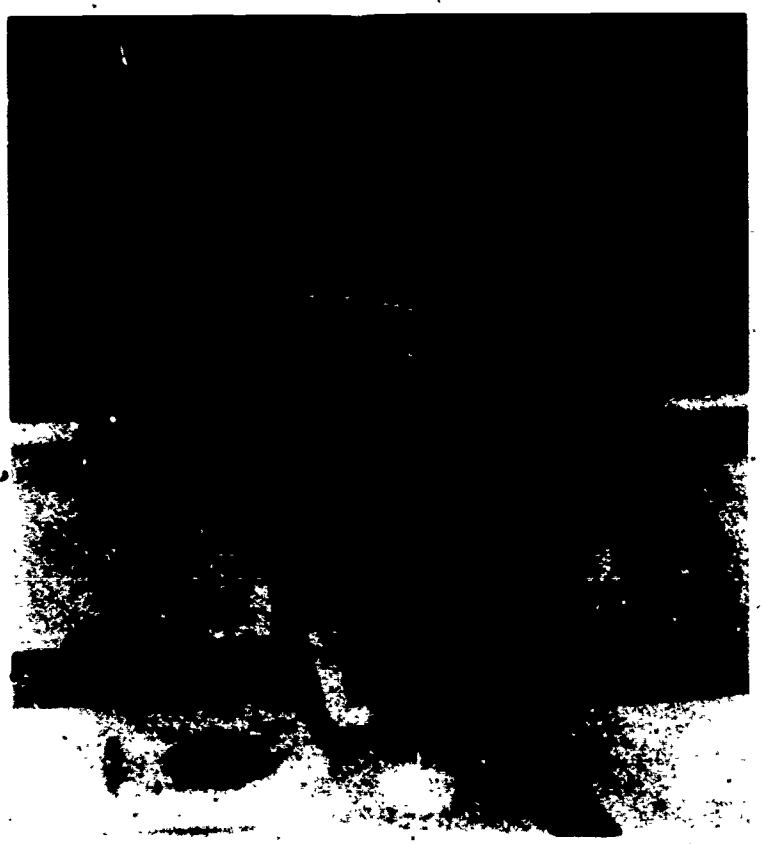
Then have them discuss their observations. List them on the board.

They might mention some of the following things:

- None of the clay washed away.
- There is a big gully between the clay and the sand.
- There are more gullies in the sand than there are in the soil.
- The sand washed away more easily and the clay stayed in one place.

Have them talk about their predictions and what the outcomes of the experiments were. Ask them what predictions they would make for another time if they were to repeat the experiments.

After this discussion have the children follow the established clean-up procedures and return each kind of soil to its appropriate place.



Lesson 20: (Optional) TESTING OTHER FACTORS

When the children first stated what factors they thought affected erosion, they may have included other parts in their system that they have not had an opportunity to test. This lesson offers an opportunity for the children to set up any other kinds of experiments that they would like, in order to find c ' if other things should be considered part of the erosion system.

If only a few children are interested in pursuing these activities, an opportunity should be made for them to do so.

MATERIALS

- stream table equipment
- Worksheets 40 and 41

PROCEDURE

The procedure here follows the pattern of previous lessons. The children will need to write down on Worksheet 40 what they will keep the same and what they will vary, and how these conditions will be controlled.

Then they may proceed with their experiments and record the results pictorially or in writing on Worksheet 41.

Some children may want to experiment with things they have observed in the natural erosion system that haven't been a part of their model. These might include:

- trees
- grass covering part of the land
- other kinds of soil that were not available at school and that they would like to bring in
- temperature
- amount of sunlight

Worksheet 40 Name _____
Unit 29

Experiment to test the effect of temperature on erosion.

Things to Change	Keep the Same
temperature of the water	type of soil incline water flow

Materials you will need: 2 stream tables
hot water
cold water

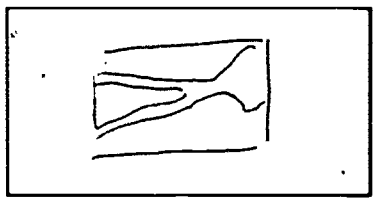
Describe what you will do: First I will fix two stream tables the same way. Then I will run hot water on one and cold water on the other

Worksheet 41 Name _____
Unit 29

Record Sheet

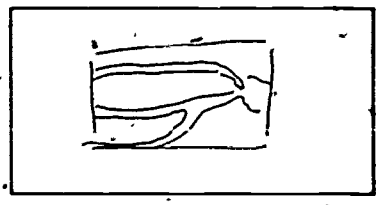
Draw a picture of what your setup looks like.

Hot ~~before~~



Flow water over your setup and record the results.

Cold ~~after~~



What did you learn from your experiment?

The gullies had different shapes but they were about the same deepness I don't think it makes a difference if the water is hot or cold.

Lesson 21: FIELD TRIP

This lesson relates what the children have observed on their stream table models to erosion phenomena in a natural setting. The field trip should be taken quite soon after a rain.

The children identify the factors that have influenced erosion on their stream tables and then discuss where similar conditions might be present near their school. Then they go outside to find results of erosion and observe and discuss them. It is hoped that this lesson will help the child to relate his in-school experiences to the world around him, and that there will be a transfer of his thinking and understanding from the classroom to this larger context.

OBJECTIVES

At the end of this lesson, the children should be able:

- To identify some effects of erosion outside.
- To identify that slope, soil type and water flow affect erosion patterns in a natural setting as well as on their stream tables.
- To discuss the implications of erosion for the ways that man interacts with the land.

MATERIALS

- popsicle sticks and bright yarn (to mark places where there is evidence of erosion)

PREPARATION

Before you take your class on the field trip it is necessary for you to scout the area carefully. This will enable you to help the children set realistic expectations about what they might possibly find when they go out. You may want to mark places along a trail ahead of time, and then take the children along that trail to make observations of each of the erosion features you have marked. Or you may want to have the children fan out in pairs to mark their own discoveries of erosion features.

It is often appropriate to combine these two approaches, so that there are some things ready for children who have difficulty finding what they came out to see.

Your immediate community is bound to provide many examples of erosion. (See Living Things in Field and Classroom, p. 112, for a number of examples of erosion in an urban environment. Other examples were shown in this unit on Worksheet 28.) Look for eroded banks on freeways, excavation sites or poorly-kept lawns. Check under a downspout for effects of heavy water flow. Look along edges of broken sidewalk to see if soil under it has washed away. In a sandy area, look for puddles and splash patterns after a rain. Note the absence of erosion in grassy areas and on asphalt or concrete.

PROCEDURE

Tell the children that in the beginning of this section when we talked about ways to observe erosion, and when we set up a model of an erosion system that we could control, we had talked about going outdoors to study erosion. But we decided that it would be difficult to control some of the factors that we wanted to study, so we experimented with a model first. Now that we have had opportunities to work with some of these factors, what kinds of things could we look for if we did go outside?

- Puddles.
- Gullies.
- Piles of soil or sand that have been carried from one place to another by water.
- Places where there is no erosion. (What are the conditions where there isn't any apparent erosion? What is protecting the soil from being washed away?)

Many of the effects to be found after a rain will be on a very small scale. Erosion is a gradual wearing-away process. The children should notice that it doesn't happen all at once, and they should be told that it may take many years to produce dramatic results.

Before going out, ask the children, "When we worked with the model erosion system, what did we decide affected erosion?" They should recall:

- Incline. (There should be more erosion where it's steeper.)
- Kind of soil. (Some eroded much more easily than others.)
- Flow of water. (A faster flow washes away more soil.)

The children's discussion should bring out that other things besides incline, soil and water flow might influence erosion.

- Ground cover is one of these other factors. (Grass, trees, bushes all help to hold the soil.)
- Other forces besides water may move soil. (The children may see evidence of erosion by wind.)

Ask the children to describe some of the places near the school where they would have at least one of the conditions named above.

As the children suggest places that they would like to look at in the school yard and neighborhood, list them on the board.

Each child should know exactly what he is going to look for when he goes outside. Children need to understand the expectations. They can work in pairs as they have done throughout the unit. Give each pair of children some markers that they can use to show where they have found evidence of erosion. (These could be popsicle sticks with pieces of bright yarn on them to stick into the ground near what they think is an effect of erosion.) If the conditions permit, the children could spread out, find what they are looking for and leave markers. Then when you blow a whistle they should gather in one spot from which the whole class will walk from place to place to see what the others have found.

If you have marked places along a trail ahead of time, take the children along the same trail to make observations about each of the erosion features that you have marked.

After making observations outdoors, it is probably best to return to the classroom where the whole class will be able to hear and participate in a brief discussion. The purpose of this discussion is to allow the children to share their observations and think about erosion in general and man's role in it. You might open the discussion by asking the children to:

- Tell the class about what erosion effects they observed.
- Relate what they saw to what they have observed on their stream tables.
- Tell where they saw the most erosion and the least erosion. (For each, ask what their evidence was.)
- Tell where they saw specifically how incline, soil type, or water flow affected erosion.

The following questions should be useful in extending the discussion and helping the children make generalizations:

- DO YOU THINK THAT EROSION IS USEFUL OR HARMFUL TO MAN?
- ARE THERE WAYS THAT MAN CAUSES THE LAND TO ERODE A GREAT DEAL?
- WHAT DO YOU SUPPOSE THE FARMER HAS TO WATCH OUT FOR?
- ARE THERE ANY WAYS THAT EROSION CAN BE PREVENTED?
- WHAT HAPPENS TO SOIL THAT IS WASHED AWAY IN EROSION?
- WHAT QUESTIONS WOULD YOU LIKE TO ASK ABOUT EROSION?

Some children may want to investigate questions similar to the above by looking in books and magazines or by making special reports. They may wish to investigate man's effects upon land and how this relates to erosion. This provides an opportunity to integrate science and social studies. The next lesson outlines some experiments that follow up on the sociological questions raised.

Tell the children that they will have another chance later to experiment in the classroom with some of the ideas they have discussed.

Lesson 22: MAN AND EROSION

In this lesson the children discuss factors that foster erosion and factors that prevent erosion. They look at pictures showing techniques that have been used to control erosion.

Then they build a model landscape in which they try to make areas where erosion will occur and areas where erosion will not occur. They predict what the erosion patterns will be by drawing a picture of the model landscape showing the paths that they think flowing water will take and where soil will be washed away. Then they flow water over it to test their predictions.

You may organize the activities in different ways. The entire class may plan one model landscape together or you may have three or four groups in the class each make a model landscape, or each pair of children may make one.

The interest of the class, the availability of materials and the ways in which your children work most effectively will influence your decision.

OBJECTIVES

During the lesson the children should:

- Demonstrate that they understand enough about erosion to consider the factors which affect it.
- Set up a model controlling those factors, so that erosion will be present in part of the landscape and not present in part of it.
- Discuss which factors in natural erosion can be controlled, and how man might effectively deal with incline, direction of water flow, kind of soil, and presence of ground cover.
- Discuss examples of erosion in their own community.

MATERIALS

Some of these can be brought by the children:

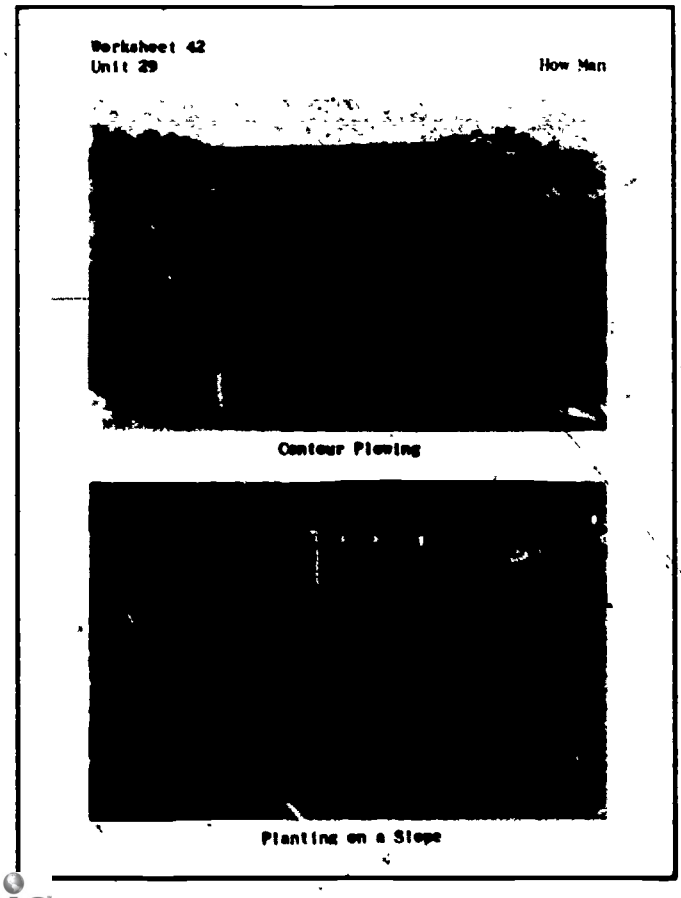
- sand
- garden soil

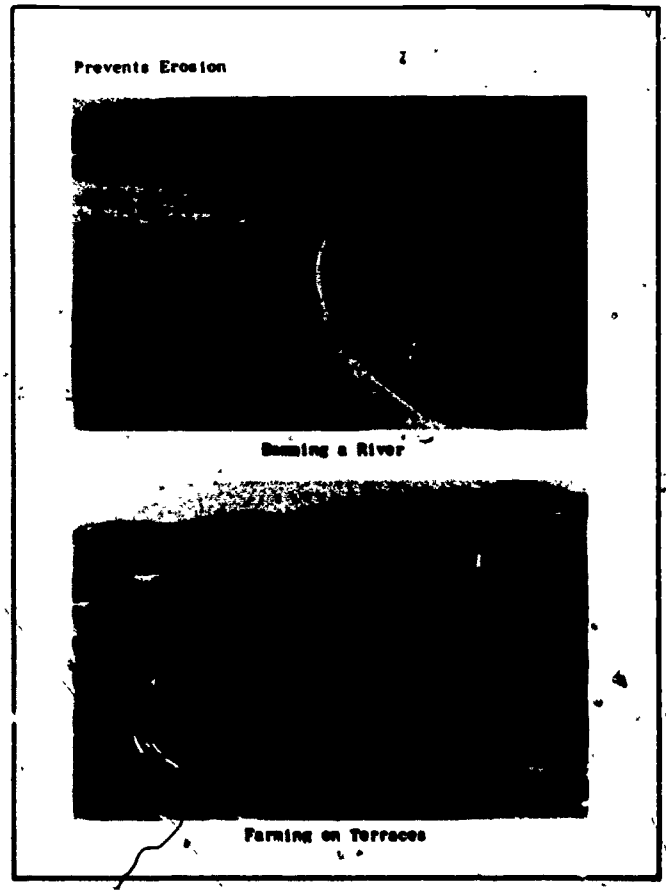
- clay
- sod
- seed (radish, grass)
- small twigs
- gravel
- rocks
- stream table equipment
- cafeteria trays or large cake pans
- Worksheets 42 and 43

PROCEDURE

Activity A

Have the children look at the pictures on Worksheet 42 that show techniques that have been used to control erosion (contour plowing to control water flow; terracing to control incline; damming to control water flow; planting to hold the soil.) Ask if any of these techniques could have been useful to prevent the erosion that they saw on their field trip.





Tell the children that now they are going to apply the many different kinds of experiences they had as they learned about erosion. They are going to build some model landscapes in which they will make areas that they want to erode and areas that they don't want to erode. They know many things about erosion which will influence the decisions they make about how each of these areas should be set up.

In areas where the children do not want erosion to occur they can control it in many ways and should discuss what some of these ways are before they proceed.

Their list may include:

- selection of soil
- incline
- planting ground cover
- sod

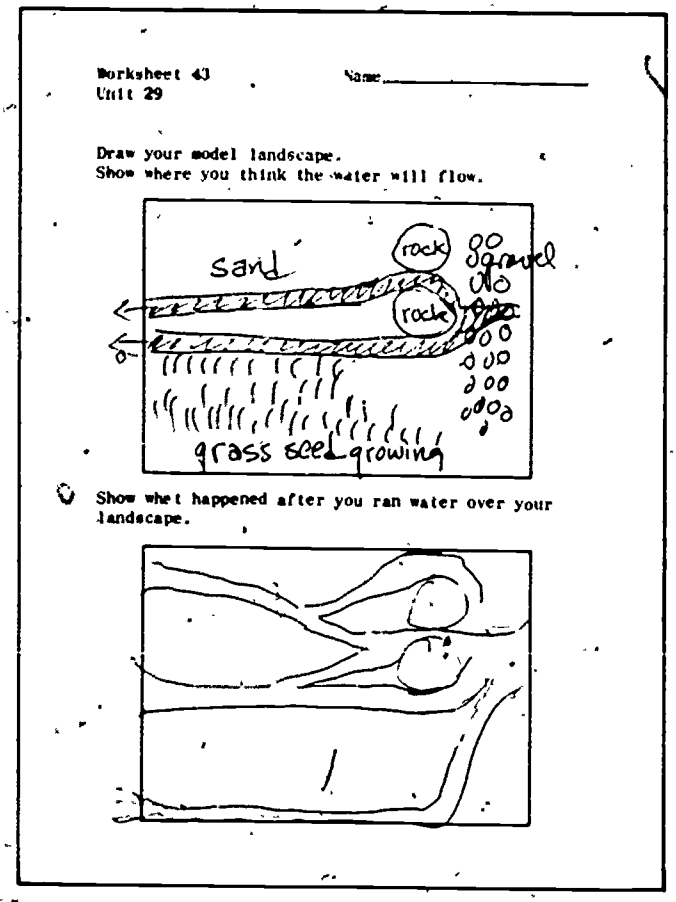
The children will think of many ingenious ways to set up their landscapes and use materials in interesting and appropriate ways.

Once the activity has been introduced to the children you can ask them to bring materials from home that they would like to use. Some children may volunteer to bring a supply of materials that will be sufficient for the number of landscapes that the class has decided to make.

If the children decide that they want growing things on their landscapes they will need to wait to test the landscapes for erosion patterns until the seeds have sprouted. Radish seeds germinate in about three days; grass seeds germinate in seven to ten days.) Then they can test their predictions by flowing water over the landscape.

Have them plan and set up their landscapes. They will find it much easier if they work with moistened sand and water, and plant seeds at the same time. Otherwise "watering" the dry sand, soil, etc. will cause some destruction of their setup right away.

The landscape planted with seeds must be kept moist and covered lightly with plastic until the seeds have germinated well.



Activity B

Before the children flow water over their landscapes, they should draw pictures of them on Worksheet 43 and show where they think the water will run and form gullies. They may write predictions under the pictures. Then they should flow water over the landscape and draw an "after" picture to show what happened. (If they have planted seeds for ground cover, they must wait until the seeds sprout.)

After the children have completed the activity, they should look at all the landscapes, make observations and discuss them.

You may want to use some of these questions to guide the discussion:

- WHAT KINDS OF THINGS WORKED BEST IN CONTROLLING EROSION IN YOUR LANDSCAPE?
- WHICH THINGS WORKED DIFFERENTLY FROM HOW YOU THOUGHT THEY WOULD OR MADE DIFFERENT PATTERNS THAN YOU EXPECTED?
- WERE THERE PLACES WHERE THERE WASN'T ANY EROSION EVEN THOUGH YOU HAD PLANNED FOR SOME? WHY DO YOU THINK THAT IT DIDN'T ERODE AS YOU HAD EXPECTED?
- TELL WHAT YOU DID AND WHAT THE RESULTS WERE.

Return to the subject introduced at the end of the last lesson and continue the discussion of how man interacts with nature. Encourage the children to continue independent reading and observation on erosion control. The children could look for effects of erosion in the community and discuss what the community is doing about them.