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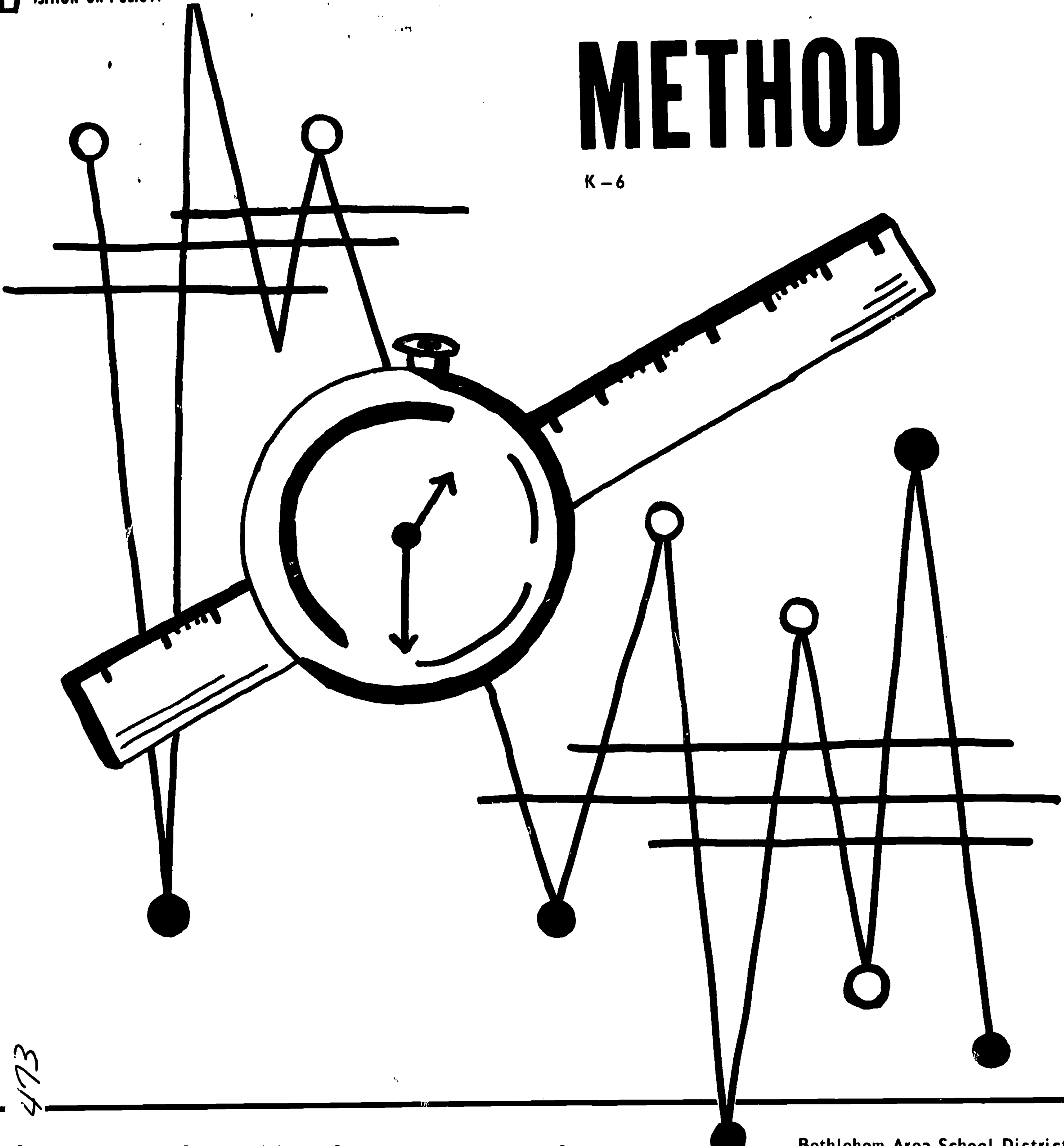
Contained in this unit are activities designed to develop science process skills for Grades K through 6. A chart shows how the activities for each grade relate to the operations of classifying, inferring, observing, predicting, interpreting data, estimating, measuring, using numbers, experimenting, and controlling variables. Each activity is introduced by a "leading question," followed by a list of materials and suggestions for the activity. The 115-page appendix contains resource information relevant to other activities as well as those in the unit. It includes notes on problem solving, demonstration and laboratory procedures, testing, use of microscopes and microprojectors, care of aquaria and vivaria, field studies, chick embryology, and graphing. Geological and biological identification charts and keys are given, also measurement tables, chemical data and astronomical data. (EB)

SCIENTIFIC METHOD

K – 6



Elementary Science Unit No. 3
1968

Bethlehem Area School District
Bethlehem, Pennsylvania

SCIENTIFIC METHOD

BETHLEHEM AREA ELEMENTARY SCHOOLS

BETHLEHEM AREA SCHOOL DISTRICT
Bethlehem, Pennsylvania

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1968

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FOREWORD

The Scientific Method Unit varies from the other curriculum guides produced by the elementary science committee in that it stresses process rather than content. It is an attempt to show the teacher various methods in presenting the process approach to students. It is hoped that these techniques be applied to the existing and future elementary science units produced in Bethlehem. The committee suggests that the lessons in the Scientific Method Unit be studied during the first few weeks of school. The lessons are short and can be completed in a few science class periods. It can serve a two-fold purpose - orient the pupil to the process of inquiry and provide the teacher with material during the "getting ready" period of the school year.

Process is often referred to as the "skills" of science, the "activities" of science, and the "key" operations of science. One cannot teach process or content alone. A good science program must offer both to the learner. The "skills" of science cannot be taught in isolation; when we teach content we must help children learn an organized structure of content.

Process refers to such operations as: classifying, inferring, observing, predicting, interpreting data, estimating, measuring, using numbers, experimenting, and controlling variables. The chart on the following page classifies activities to the one or more operations that are involved. It is not important to have children learn this terminology, but rather to be able to apply these learnings to new situations. Obviously, this method can be applied to all areas of our school curriculum.

	CLASSIFYING	INFERRING	OBSERVING	PREDICTING	INTERPRETING DATA
K	8, 9,10,11, 12		1, 3, 4,11	2	4, 5
1	5, 6,14		9,10,12,13, 16	1, 2,15	1, 2,11
2	4, 8,10		2, 3, 9	1,11,12	1,11
3	15,16,17	14,15	2, 3, 4, 5, 13,14,19,20, 21,23	4, 5,13,23, 24	19,20,22
4	6, 9,16	13,17,20	3, 4, 5, 7, 11	10,12,20	1,11,22
5	9,11,12	4, 8,18,22, 23,26	1, 4, 6,19, 20,21	6,10,13,14, 17,20,27	2, 7,14,16, 27
6	15,25	1, 3,22, 25	5, 6, 8, 9, 10,11,12,13, 17,18,19,20	2,10,11,16, 17,19,20	7, 8,12,16 21,23,24

ESTIMATING	MEASURING	USING NO'S.	EXPERIMENTING	CONTROLLING VARIABLES
			6, 7	
	4, 8, 11, 13		3, 7, 12, 14	
3	1, 6, 7	5	12	
	3, 9, 10, 11 18	1, 6, 8	7, 12, 13, 24	
	1, 3, 14, 18 22	1, 8	2, 7, 15, 21	13, 19, 23
13, 22, 25	3, 5, 7, 16 26	5, 15, 17, 25	2, 21, 23, 24, 26, 27, 28	3, 7, 19
1, 5, 7, 21 23	1, 6, 7, 8, 9, 16, 17, 18, 21, 23	1, 6, 7, 8, 12, 14, 18, 21, 23	2, 4, 5, 8, 9, 13, 17, 18, 19, 20, 22	3, 7, 8

SCIENTIFIC METHOD

KINDERGARTEN

SCIENTIFIC METHOD

ACTIVITIES

Kindergarten

1. Leading Question: Let's watch these jars.

Materials: Three jars, three cotton balls, one mashed banana, one chopped carrot, one chopped onion

Procedure: Place the banana, carrot, onion, and a cotton ball in each of the jars. Do not cover the jars. Include a cotton ball in each jar. Place the uncovered jar in a warm place. What do the children think will happen? What are the predictions of the children?

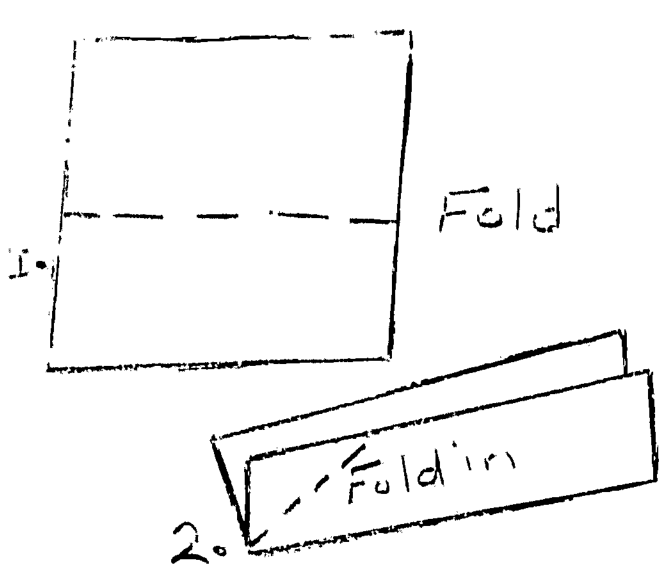
Allow approximately two days for observation. After conclusions are formed, discuss the results. Why does only the banana jar have flies? What kind of flies are they? Are fruit flies a good name for these insects? Why? Why does mother cover food? Why are garbage cans covered? What would banana peels do to our playground? Other fruit?

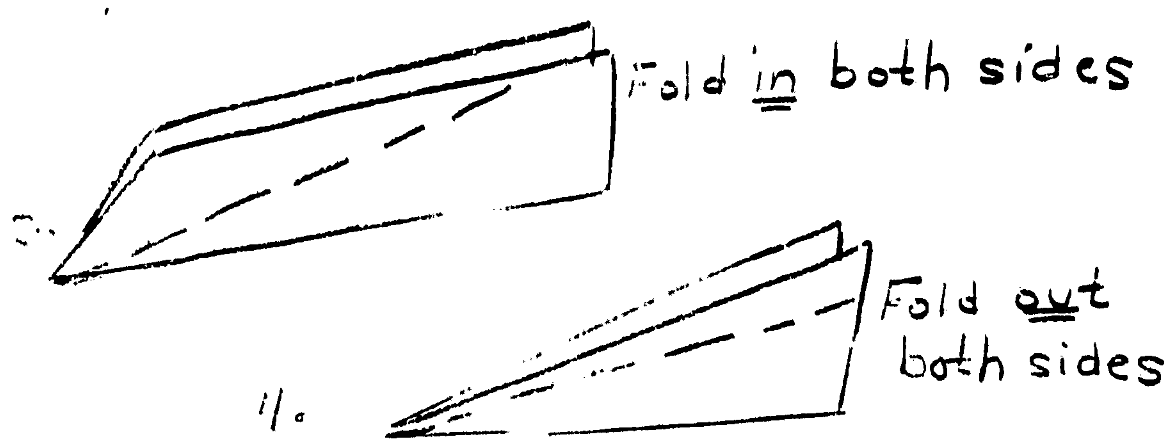
2. Leading Question: What holds it up?

Materials: 9" x 12" sheets of paper

Procedure: Demonstrate the construction of a simple fold airplane. Then allow time for children to construct airplanes. When construction is complete, go outdoors. Face the children into the wind. How does your airplane fly? Does it go far? Try again. Face the children away from the wind. What will happen? Will it go better? Why? Discuss results.

Note to teacher: If the children are put in a single line the results will be uniform. Use this prediction exercise on a relatively windy day.



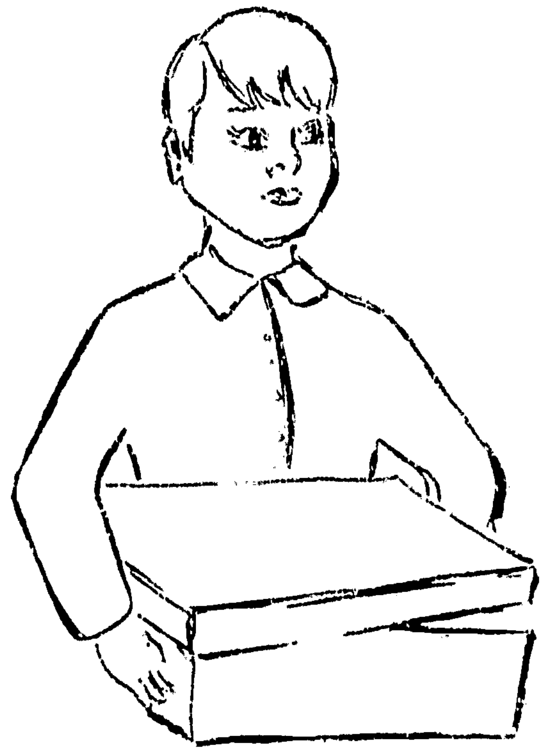


3. Leading Question: What can our hands tell us?

Materials: Crayons, pencils, nuts, rubber band, string, buttons, chalk, money, types of vegetables, covered shoe box with holes in sides

Procedure: Place one of the above objects in a closed box. Select a child to insert his hand into the box. (See illustration.) Can he name the object he is touching? Example: What would tell him it is a rubber band and not a piece of string?

Note to teacher: Do not let the children see the objects you intend to use.



4. Leading Question: How does the thermometer help us dress?

Materials: Giant thermometer, poster board, colored construction paper

Procedure: Assemble the children in a group so that the giant thermometer is easily visible. Use a piece of tape or other non-permanent marking to indicate room temperature. Take the class outdoors and note outdoor reading. Guide the children to discover rise and fall of the mercury. Do this daily for one week. By the end of the week many children should be able to predict rise or fall for the outside reading.

Discussion points:

How the thermometer helps us--
Relate types of clothing to the season
Discuss temperature and clothing

Place five (5) homemade thermometers on a bulletin board and label with the days of the week. Using the giant thermometer take the outdoor reading each day. (Teacher must do this, children are to note rise and/or fall.) Return to the classroom and use the colored construction paper strips to record the correct reading on the homemade thermometer. At the end of the week the children will have a record of their readings. Simple comparing questions may be posed such as:

Which day was hottest? Point to the thermometer.
Which day did the thermometer fall the most?

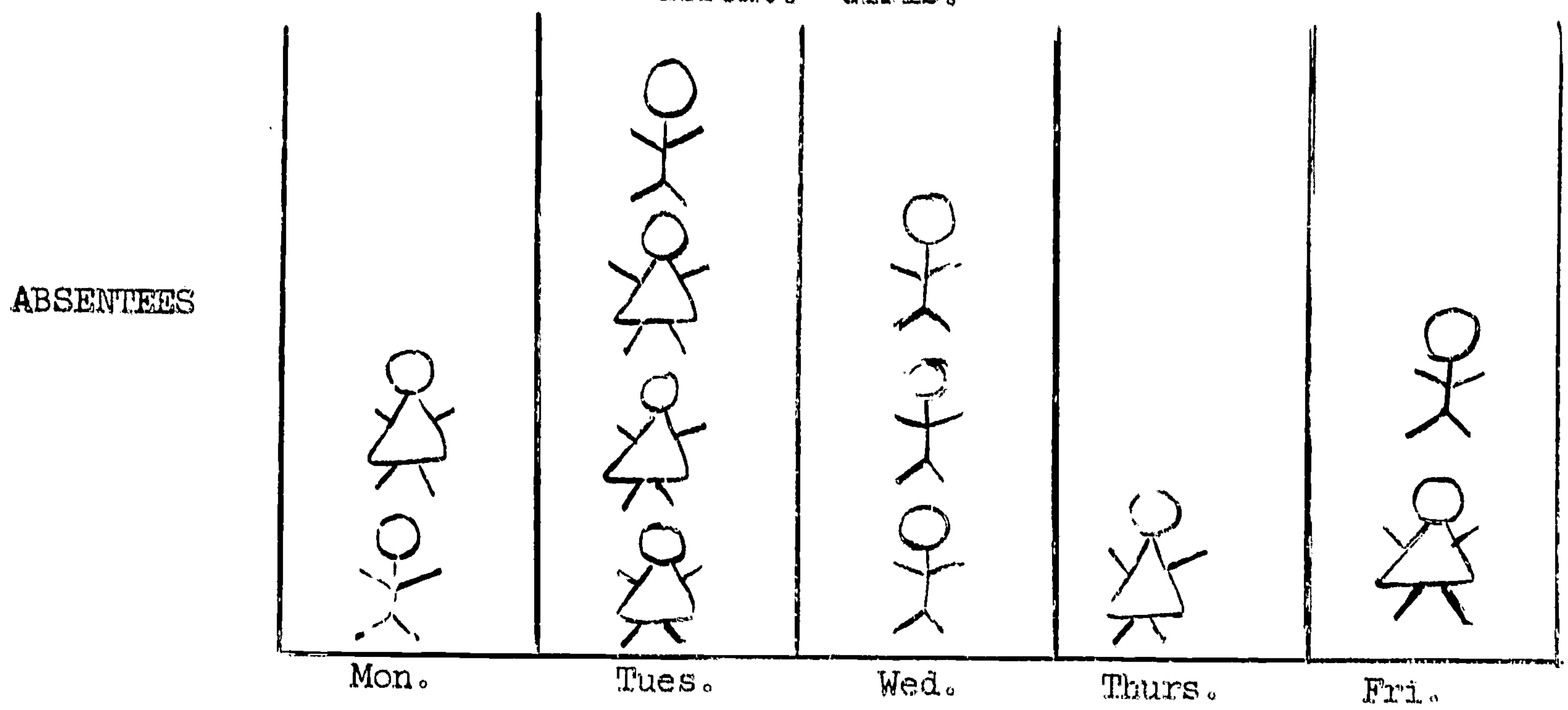
Extended Study: If bulletin board space permits, the teacher may wish to have pictures of various types of outdoor clothing available and discussion may result in a class choice of appropriate outdoors clothing for that day. The picture may be mounted along with the thermometer.

Note to teacher: It may be necessary to take the reading at different times each day to show a great temperature change. Initially, the teacher may use ice to cause a great rise or fall. (Blowing on the bulb of the thermometer will also show an increase in temperature.)

5. Leading Question: Are you here?

Materials: Cut-outs of boy figures and girl figures, a bulletin board for graph display

Procedure: Ask the children to observe how many classmates are absent. For each absentee place a figure on the graph. Use the graph daily for one week. What day were most of the boys and girls absent? What day shows most boys were absent? Girls?



6. Leading Question: Can we touch shadows?

Procedure: Group the children into pairs. Select a sunny spot on the playground and have the children shake hands. How do their shadows look? Are their shadows shaking hands? Try to shake hands with their shadows. Can they touch shadows? What happens when they try to touch shadows? Permit the children to experiment touching fingers, shoes, arms, etc. Later classroom discussion should involve the results they discovered while experimenting with their shadows.

Note to teacher: Use an X and have the children make their fingers' shadow touch the X. Using a stone ask them to encircle the stone with their hands' shadow.

7. Leading Question: <u>How can shadows play?</u>

Materials: Chalkboard, chalk, straws, paper, glue, 150 or 100 watt bulb or filmstrip projector

Procedure: Instruct the children into making "stick puppets". They may construct their stick puppet by drawing their own figure or cutting a picture from a magazine. Glue the "puppet" to a straw. The background for the puppet play will be the chalkboard, on which a house, tree, boats, and water may be drawn. Have the classroom dark and shine a light on the chalkboard. Place the light several feet from the board. Arrange the children and their puppets halfway between the light and the chalkboard. Let the children make their puppets perform as shadows.

Note to teacher: The children might want ways to experiment further with what shadows do.

8. Leading Question: <u>How can we group things?</u>

Materials: Pencils, balloons, and beads

Procedure: Arrange the children in a circle. Place in the middle of the circle the materials for this experiment. Ask the children how they might arrange these articles into groups. Have a child arrange one group. Ask for another way to group these articles.

Note to teacher: Suggested groupings: Color, size, similarity, weight, and use. Save these articles for follow-up activity.

9. Leading Question: <u>What things can you carry home?</u>

Materials: Use same materials as in activity 8 and include one chair, potato, carrot, orange, coffee can, a large ball

Procedure: Encourage the children to select three objects and to demonstrate how they would carry these three home. Place the objects they can carry in a designated place.

Note to teacher: Add these objects to the box and use again for the following activity.

10. Leading Question: What will fit into the box, but not fall through the hole?

Materials: A cardboard box, one foot square, open at the top with a one inch diameter hole at the bottom. Use the same materials for classifying as used in the preceding activities but now include several walnuts, wooden blocks, two erasers

Procedure: Allow the children to make their classification of the things that will fit into the box but will not fall through. After they have chosen an item, allow them to try their choice. Some may find by putting the pencil a certain way in the box, it will fit through the hole, another way it will not. Using the same objects, let the children suggest classifying ideas. Example: Can we eat it? Can we play with it?

11. Leading Question: How are objects on your tables alike?

Materials: Blocks, beads, marbles, buttons, boxes, balls (all objects of various sizes and colors)

Procedure: Have experimental materials in sufficient quantity so that each table of children can see and feel the objects.

Through questioning techniques, not telling, guide the children to classify the objects in the following ways: shape, color, size (large or small), hard, soft, rough, smooth.

Note to teacher: Children should realize that: objects of various shapes may be grouped together when they are grouping by color.

12. Leading Question: Which colors belong together?

Materials: Yellow, green, red pencils; yellow, green, red deflated balloons; yellow, green, red beads

Procedure: Have the children sit in a circle, with the above objects placed in the center. Encourage the children to select a set of yellow, green, or red objects and put them in a designated place. How do these look different? Would you put the balloons with the beads? Why?

Note to teacher: At the end of this activity place the objects in a cardboard box for follow-up into next activity.

SCIENTIFIC METHOD

GRADE 1

SCIENTIFIC METHOD

ACTIVITIES

Grade 1

1. Leading Question: What do you eat for breakfast?

   Materials: Different colored paper, experience chart paper, small squares of construction paper - 2 colors

   Procedure: Ask the children if they would like to find out what other children's favorite breakfast foods might be. Suggest they interview second grade children. Ask if they think their favorite foods would be the same as second graders. Discuss their opinions. Be sure to emphasize the need for more information in order to make predictions.

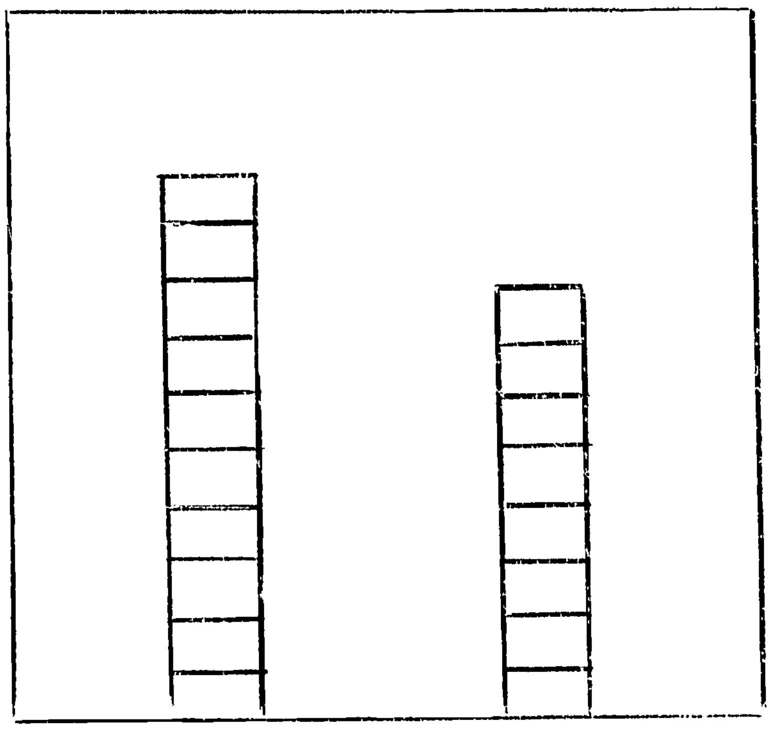
   Teacher-pupil planning will be necessary in order to set-up a committee to approach second grade for information needed. Inform and plan with the other teacher. In order to make comparisons the first graders must have the same number of second graders participating in the activity. Collect the data and graph it. Compare the results with the predictions. Perhaps the children might continue making predictions and interpreting data by collecting information from the other grades.

2. Leading Question: What are your two favorite breakfast foods?

   Materials: White paper, experience chart paper, chalkboard, small squares of construction paper - 2 colors

   Procedure: Without any discussion ask the children to write their two favorite breakfast foods. Collect the papers. Next, ask how many wrote eggs? How many wrote toast? Which food do you think was named most? Ask their reasons for their answers. Suggest checking the papers to find out which food was named most. Have the children interpret the data they have received. List the different types of foods on the chalkboard. Use tally marks to determine which two foods were mentioned most.

Have the children graph this information on experience chart paper, by pasting a small square of construction paper of the same color, every time the food is mentioned.



3. Leading Question: Does ice melt faster in water or air?

A. Materials: 30 paper medicine cups, ice, cold water, cups of different sizes, paper towels, ice chest, thermometer

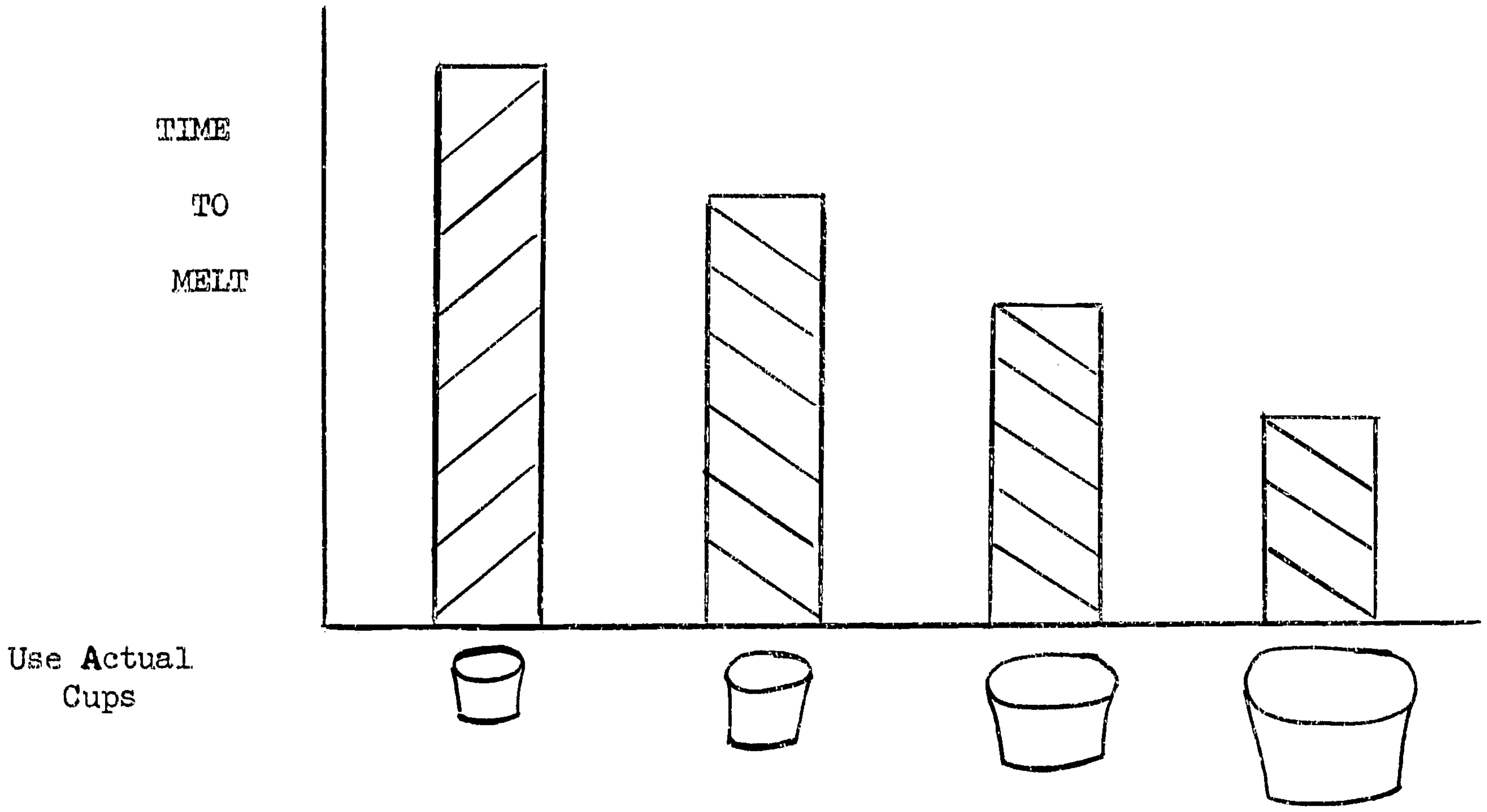
Procedure: Discuss the importance of using the same size ice cubes. Ask the children to pour cold water into the different sized cups. If two cubes are not available for each child, leave several in the air at different places around the room. Have the child place the other cube in his container. Then have the children compare the melting time. Distinguish the melting time results by recording the time on an experience chart.

Note to teacher: Some child may suggest that the water is warmer than the air. Use the thermometer and let him compare the temperature of the air and the water.

Extended Study: If interest is shown concerning amount of water used, the child may be interested in whether or not the amount of water makes a difference.

B. Materials: Paper medicine cups, ice, water, different size cups, paper towels

Procedure: The children might be divided into groups, each member using a different volume of water, but using ice of the same size. Using a bar graph on the chalkboard use time compared to the volume of the four different cups.



4. Leading Question: <u>What can we measure?</u>

Materials: Yardsticks, 12" rulers, popsicle sticks

Procedure: Display the various measuring instruments. Question the sizes of these instruments. What are they used for? Encourage the children to measure a long distance, such as the length of the room. Let the children measure the distance using the different measuring instruments. Did it take more or less popsicle sticks than rulers, yardsticks? Did it take more or less rulers than popsicle sticks, yardsticks? Why? Interpret the results in a variety of ways.

5. Leading Question: Is an orange and a banana the same?

Materials: Oranges, apples, grapes, bananas, grapefruits, limes, pears, lemons

Procedure: Divide the class into groups. Distribute several pieces of fruit to each group. Ask them to group the fruit. Have each group explain how they classified the fruit and why. Encourage the children to regroup their fruits to discover other ways of classifying.

Note to teacher: Suggested ways to classify:

a. size
b. color
c. taste
d. shape

6. Leading Question: What's different?

Materials: Books, library

Procedure: Have several children arrange the books on the library shelf. Discuss their arrangement. What can be discovered about some of the books? If a child sees a few books that are of the same color, guide him to classify accordingly. Conclude that although all the objects are books, we can vary classification.

Extended Study: Inquire if the children have any pets. If not, ask them what kind of pet they would want. Have the children find pictures of their pets to display on a bulletin board. Have the children group all pets as land, air, or water animals.

Have each child draw the type of home in which his pet lives. Classify accordingly.

Note to teacher: Possible classifications:

a. fish bowl
b. aquarium
c. doghouse
d. dog bed
e. box

Have the children bring in the type of food their pet eats. Examine each food. Note the differences, similarities. Classify the foods.

Note to teacher: Possibly classify according to:

a. color
b. texture
c. smell
d. wet (canned food)
e. dry (in a bag, box)

7. Leading Question: What will cling to a magnet? (Will you stick to a magnet?)

Materials: Magnets, chalk, paper clips, paper, thumb tacks

Procedure: Start by using one item, perhaps the paper clips. Allow the children to feel the pull of the magnet. Will the chalk cling to the magnet? Will the thumb tacks? Will the paper? Encourage the children to try other items in the room and at home.

Note to teacher: Have the children practice recording the results of this experiment. See suggested procedure.

8. Leading Question: Can we measure this room with our body?

Materials: Construction paper, pencils, scissors

Procedure: Encourage the children to express their ideas. Introduce the idea of the hands and feet if the children do not suggest them. Have the children outline one of their hands and feet on construction paper and cut them out. The teacher should also participate. Measure the room using hands, then feet. Each time compare the results. Emphasize the differences and similarities, pointing out the need for a standard unit of measurement.

Note to teacher: Stress the need for a standard unit of measurement because of the various sizes of hands and feet.

9. Leading Question: Why does butter change its shape?

Materials: Butter, ice, hot plate, two buckets, two pie plates

Procedure: Put a small pat of butter that is at room temperature on a warm pie plate. Do the same thing with a pat of butter that was in the refrigerator. Have the children touch each one, and express what they feel. Ask them to predict what will happen and which one will melt first. State their reasons. As they are melting have the children describe what changes are taking place. After they have both melted, place the pie plates in buckets filled with ice. Encourage the children to predict what will happen. What did occur? Why?

10. Leading Question: <u>Do turtles receive oxygen from the air or from the water? (How do turtles breathe?)</u>

Materials: Turtle, glass jar, (2-liter), water

Procedure: Place the turtle at the bottom of the glass jar which is 3/4 full of water. Observe its movements. Count the number of times the turtle appears at the top of the water within a one minute period.

Extended Study: The class may wish to observe the turtle's response to stimuli such as: sound, feeding, temperature change, light, touch.

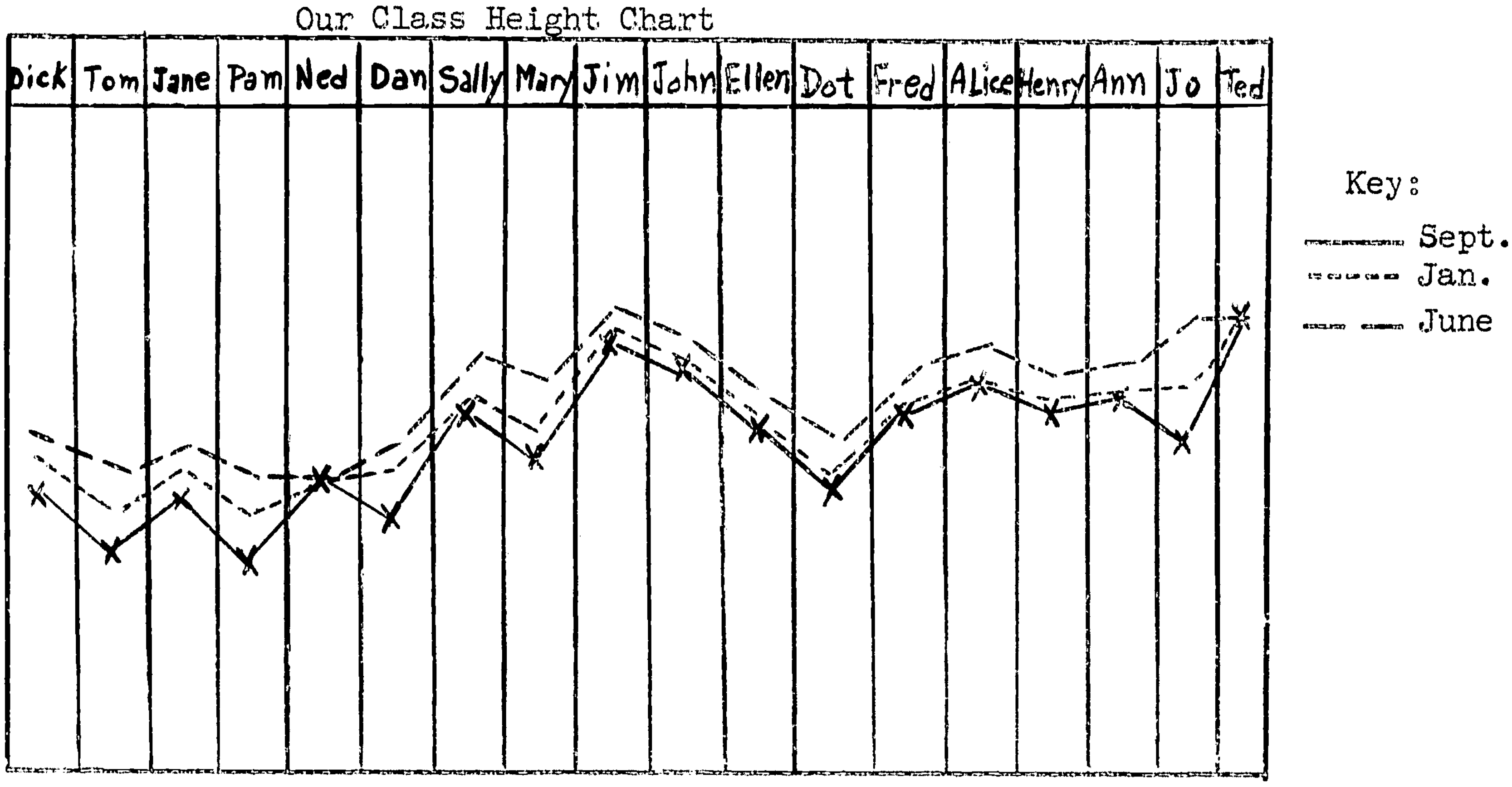
The class may be encouraged to observe pets or other animals. Prior discussion of possible stimuli should be conducted to avoid injury to the animal.

11. Leading Question: <u>How tall are you?</u>

Materials: Brown wrapping paper or frieze paper, felt marking pens (several colors)

Procedure: Prepare the following chart:

Our Class Height Chart



Measure each child and record with a dot on the chart. Connect the dots to form a line graph. (Repeat Sept., Jan., June.) Compare heights of the children. (Have several children stand in front of the chart——move away and compare the children to the line graph.)

Note to teacher: Since chart represents actual size and represents a year's growth, the chart can be cut in vertical strips and sent home.

12. Leading Question: <u>Can an object sink and float?</u>

Materials: Jar, water, tub or large bowl, paper cup with tiny hole, Ivory soap, other non-floating soap

Procedure: Permit individuals to try their suggestions. Eventually, place the jar in a position so that the mouth is not near the water (it floats). Allow some water to enter the jar (it fills with water and sinks).

Place the paper cup in the water (will slowly sink).

Observe each bar of soap. What happens to one and not the other?

Note to teacher: Guide children to realize we must be careful in science and not make rash judgments.

13. Leading Question: <u>Are you always the same height?</u>

Materials: Colored chalk, frieze paper

Procedure: Select a child to be measured. Have him lie down on the paper and trace his shape. Cut out the shape. Compare this to the child and his measurements on the measurement chart.

Take the children outdoors on a sunny day. Have the same child face the sun and mark his shadow length. Compare to paper shape. Note difference in size. Repeat several times during the day. Record the various markings with different colored chalk.

Extended Study: Each child may mark his shadow on several occasions during a given day. Begin study of cardinal direction using the sun and shadows. Observe other shadows: building, posts, trees, cars.

14. Leading Question: What can we discover by using these objects?

Materials: Water, large tub or bowl, cork, soap, ball, ruler, pencil, fork, spool, nail, key, scissors, pencil

Procedure: Fill the tub with water. Children will probably suggest dropping them into the water. The two categories (things that float, things that do not float) should be evident to the children. If not, repeat the experiment, do not tell the children. Allow the children to test any other objects that are not damageable by water. Tell the children that scientists share their information with others by writing it down. Suggest that they think of some way to tell others what they have discovered.

Note to teacher: Some suitable way should be devised to show the classification.

Extended Study: Vary the amount of water in the tub to determine any change in the classification of an object.

Suggest to children that further investigation can be made at home and findings reported to the class. Individual mimeographed charts will serve to record findings. Data may be shown by having the children draw pictures.

15. Leading Question: What will happen if a weight is put on a scale?

Materials: Large spring balance scale, chalk, chalkboard

Procedure: Ask the children to predict what will happen if a weight is put on a scale. Have a child place a weight on the scale. Compare the results with the predictions. Mark the results on the chalkboard. Repeat using a different weight. This time have the children predict if it will weigh more or less than the other one. Record this observation. Continue using various weights. What conclusions can be drawn?

Note to teacher: In order to record the results on the chalkboard hold or mount the scale in front of the chalkboard. An excellent demonstration spring balance scale can be borrowed from the Central Science Materials Library.

Extended Study: Permit the children to weigh various objects in the room. Guide the children to the generalization that the size of the object does not indicate its weight.

16. Leading Question: <u>What happens to a candle when it burns?</u>

Materials: Candle, candle holder, match, plate

Procedure: Light the candle and have the children observe the candle as it burns. Does it melt fast or slow? Does it stay the same size? Predict the amount of time it would take to melt a half an inch. Is there any change in the color of the candle as it is melting? Does the candle change its shape? What happens when the drippings cool? To enforce what has taken place tilt the candle so that the wax drips onto a plate.

SCIENTIFIC METHOD

GRADE 2

SCIENTIFIC METHOD

ACTIVITIES

Grade 2

1. Leading Question: Where does water go?

Materials: Two jars, one with a cover, each containing exactly four inches of water, ruler

Procedure: Fill both jars with an even amount of water. Tightly cover only one of the jars and place both jars in a sunny, warm place. For the next several days observe and measure the amount of water in the jars. With a colored crayon mark the water level on each jar. What has happened to the water in the covered jar? In the uncovered jar? Plot the results of the evaporation on a simple bar graph.

2. Leading Question: Is time long?

Procedure: Instruct the children to observe how often they use time over a 24 hour period of time. Through observation they will determine that time is lasting. How do they know when to eat dinner? What tells them when to watch a favorite TV program? How do they know when to go to school? How do the children know when to take their medicine? How does Father know when to stop working? How does Mother know when to take a roast out of the oven?

Note to teacher: Although the children cannot read a clock at this stage, they can still be made very aware of time.

3. Leading Question: How ripe is it?

Materials: Two wide-mouthed jars with screw-on tops, a partly-green banana, two unripe tomatoes (green or slightly pink).

Procedure: Place in one jar the partly-green, unpeeled, banana and one small, hard tomato. In another jar place only one small, hard tomato. Screw the tops on each of the jars very tightly. Place both containers in a dark, cool place (60°F.). Several days later check to see what has happened to the tomatoes. Which one is redder? When one of the tomatoes is bright red, cut both tomatoes into small pieces. Taste them. Which one tastes better?

Note to teacher: The tomato with the banana will ripen first. This occurs because the green part of the banana emits a gas called ethylene. Ethylene is used to ripen other fruits, such as melons, pears, peaches, and almost every vegetable.

Extended Study: Scientists think ethylene gas may be given off by flowers, leaves, stems, and possibly the tubers from a potato. How could the children find out?

4. **Leading Question:** How are we different, yet all the same?

Procedure: Have the children suggest ways to group their class then group according to the children's suggestions. Lead children to realize that large categories are needed, so that all children are included. Suggested groupings:

a. hair - blond, brunettes, red-heads
b. color of shoes
c. boys, girls
d. shoes, sneakers
e. height
f. color of eyes

5. **Leading Question:** How large is our classroom family?

Materials: Number line

Procedure: Have each child tell how many people are in his family (including himself). Have one child indicate with his finger on the number line the total members in his family. Have the child remain at the number line. Let another child indicate how many members are in his family beginning where the first child is pointing. How many members are in the two families? Continue the activity having a third child begin where the second child is pointing. Allow the first child to sit down. How many members are in the three families? Continue until each child in the classroom has indicated the number of members in his family.

6. **Leading Question:** Who will make the discovery?

Materials: Trundle wheel (available in Central Science Materials Library), yardstick, chalk

Procedure: Have the children measure a distance from four to eight yards across the front of the room. Let them mark only the starting and ending points. After they have the experience of measuring, ask them to do it again. They should not tell you the distance they measured.

Take the trundle wheel, and being sure to start after the first click, measure the distance and identify.

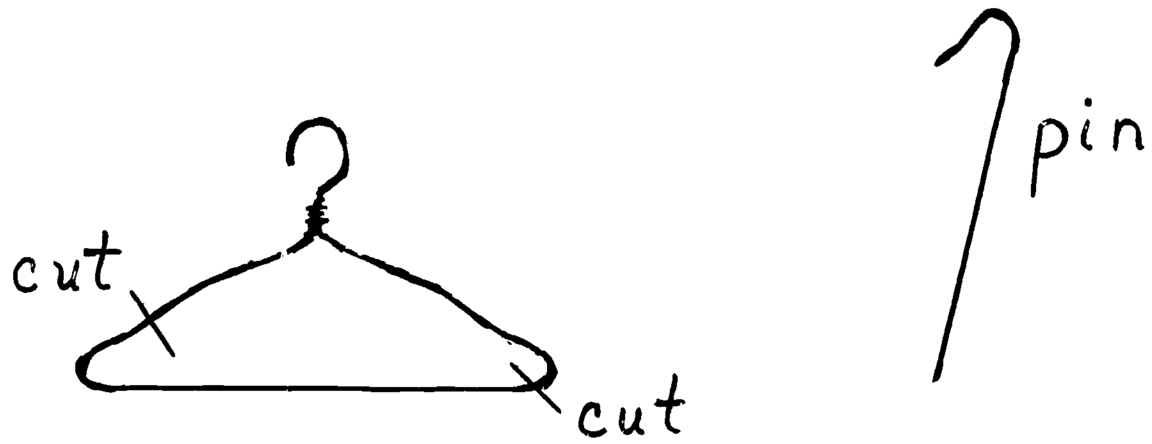
"How was I able to tell the distance?" After the children have started their observations, do it again. Let them try it.

When they discover the clicks and the yards are interchangeable, lay the yardstick down and use the trundle wheel to demonstrate each click will equal one yard.

Use the wheel in the hall. How many yards long is our hall? Why is the trundle wheel a good measuring instrument?

7. Leading Question: How far can the trundle wheel go?

Materials: Trundle wheel, two poles placed ten yards apart joined with cord, hangers (to use as surveyor pins)



Procedure: Using the trundle wheel, let the children try to measure the playground. They most likely will lose count of the clicks.

Using the poles (similar to football) and the surveyor pins (hangers), measure the area. The pins should be placed by every pole. If we have six pins and each marks the distance of ten yards, how long is our playground? Why are these pins helpful?

Note to teacher: The survey pin may be used indoors by laying them on the floor.

8. Leading Question: How does our nose help us see?

Materials: Onions (chopped), banana, peanut butter, oranges, limburger cheese, peppermint candy, gum, perfume, sour milk, cake, garlic powder, cinnamon, pepper, cloves, nutmeg, apple (sliced), egg, dry cereal (odorless), bread, potato, bags for each article

Procedure: The child may use no other sense than his nose. At a designated place, list the three classifications....unpleasant, pleasant, no odor.

Note to teacher: Some children will have different ideas of classification (example: perfume won't be pleasant to all).

Note other ways of classification that may be needed to find out the identification of the potato, egg (sense of touch).

When activity is finished let the child test inference by naming articles.

9. Leading Question: Can we stop nature from moving soil?

Materials: Two cardboard boxes, soil for each, aluminum foil, rocks

Procedure: After a heavy rain, explore around the building. Note the places where soil has been washed over the sidewalk, and places from which the soil has been removed. Why did the soil wash away here? Why not in this spot?

Use the cardboard boxes lined with aluminum foil. Put soil in both, and in one box place rocks. Run a measured amount of water over each surface. What are the rocks helping to do? What's happening in the other box? Let's go outside and find places where soil is not washed away. What holds soil in these places?

Note to teacher: The children might want to note down other things they observe in the prevention of erosion.

Extended Study: Use child's suggested ideas as to erosion prevention (using trees, making a wall, planting grass, growing flowers) and let child experiment usefulness of each. The results can be recorded as to which erosion prevention worked best.

10. Leading Question: How are neighborhood helpers alike but different?

Materials: Pictures

Procedure: Encourage discussion and request pictures of neighborhood helpers. For those helpers that pictures are not available the children may draw the examples. These then may be used for bulletin board classification.

Classification may be led first into the concept of work. Do they work for our city? Our government? Our industry? Are they independent workers as doctors and dentists?

Does the teacher wear a uniform? The policeman?

What helpers come to our home? Which ones must we go to?

After the classification the teacher may illustrate the examples on the bulletin board.

11. Leading Question: What objects will float?

Materials: Three bowls, water, cooking oil, alcohol, paper, corks, leaves, sticks, nails, rocks, cardboard, pieces of glass

Procedure: Have the children drop various objects into a bowl of water. Observe which objects sink and which objects float. What happens to the paper after it soaks in the water for several minutes? Interpret this data on the chalkboard.

Repeat the same procedure using cooking oil in a bowl. Record the data on the chalkboard or chart. Do any objects float in the cooking oil that did not float in the water?

Using a bowl with alcohol, repeat the first procedure. Again, record the data on the chalkboard. Do any objects float in the alcohol that did not float in the water or the cooking oil?

12. Leading Question: Will aluminum foil float?

Materials: Three bowls, water, cooking oil, alcohol, two pieces of aluminum foil

Procedure: Discuss with the children the idea of aluminum foil floating or sinking. Record on the chalkboard the number that think it will float and the number who think it will sink. Take a piece of aluminum foil and roll it into a solid little ball. Drop the ball into the water. What happens? What if the aluminum ball were hollow? Question the children if they think the hollow ball of aluminum foil will float or sink. Take the other piece of aluminum foil and fashion it into the shape of a boat. Place it on the water. What happens?

Repeat the above procedure using a bowl filled with cooking oil. Is there any notable difference?

Repeat the first procedure using a bowl filled with alcohol. Is there any difference between the oil and the alcohol? The water and the alcohol?

SCIENTIFIC METHOD

GRADE 3

SCIENTIFIC METHOD

ACTIVITIES

Grade 3

1. Leading Question: What is net weight?

Materials: Package of pudding, 2 aerosol cans (1 empty and 1 full), trip balance scale

Procedure: Examine the package of pudding and the full aerosol can to note the manufacturer's stated net weight. Provide discussion time for discovering how to determine net weight. Allow suggestions to be tried. If necessary, suggest the use of the scale. Steps:

a. Weigh the full package and make a note of the weight.
b. Remove the contents, weigh and note.
c. Subtract the weight of the empty liner from the weight of the liner filled with pudding, the remainder is the net weight.
d. Compare printed net weight to calculated net weight.
e. Discuss the reasons the manufacturers state the net weight.
f. Repeat procedure using the two (2) aerosol cans.

Extended Study: Calculate the net weight of other packaged or ' nned goods.

2. Leading Question: Is new falling snow clean?

Materials: Snow, 2 quart containers, filter paper

Procedure: Collect a quart of freshly fallen snow in a quart container. Allow it to melt. Pour the melted snow (water) into the other quart container through a filter. Observe. Was there dirt on the filter paper? Why?

3. Leading Question: "Hey, Buddy, have you seen my snowman?"

Materials: Snow

Procedure: The class can build a snowman in the school area. Through observation and recording of the data, the children can become aware of how weather effects snow. Record the following information on a chalkboard or poster board immediately after the snowman has been constructed:

a. Height
b. Width
c. On what kind of a day does it melt?
d. Does it melt the same amount (inches) every day?
e. What is the temperature when it melts?
f. Does it melt more on one side than the other? Why?
g. Does it melt more at the top or the bottom?

4. Leading Question: <u>Seen any bugs lately? (A winter activity)</u>

Materials: Wide-mouthed quart jar, funnel, lamp, (rubbing alcohol and glycerine optional).

Procedure: Collect leaves, grass, bark from decayed logs, and other plant life which may be found under the snow, wooded areas, and school grounds. Place all collected material in the funnel which is placed in the mouth of the jar. (If the insects are to be preserved, add a solution of half alcohol and glycerine to the jar.) Next, place a lighted lamp in such a way that the heat from the bulb will fall on top of the material. This arrangement will dry the material from the top down. Ask the children to speculate as to what will now happen.

Note to teacher: As the material warms and dries out the insects revive and move down to a moister (?) area, eventually falling down through the stem of the funnel into the container.

5. Leading Question: <u>Mary, Mary, Quite Contrary, Why Does Your Garden Grow?</u>

Materials: One $\frac{1}{2}$ gallon plastic bleach bottle, sandwich size plastic bag, cellophane tape, rectangle of 3/16 inch plywood or similar material, paper towels

Procedure: Cut out plastic bottle as shown in illustration number 1. Cut the bottom from the plastic bag, forming a tube. Fold the paper towel to fit snugly inside the plastic and insert toweling into the plastic bag, extending out several inches on the other end.

Use the cellophane tape and attach the bag and towel to the plywood. Place one strip of tape along the center line (see illustration number 2). This forms the germination chamber.

Place the seeds along the center line of the germination chamber. The tape along the center line must be tight enough to keep the seeds from dropping through but at the same time allowing room for the roots to decend. Next, lightly tape the top of the chamber in place.

Fill the plastic bottle with water. Place the germination bottle in the chamber with the exposed end to the towel in the water. The toweling will serve as a wick supplying the moisture to the seed. Observe what happens.

Note to teacher: Following suggestions can be used for observing and determining the data:

a. A bar graph showing the daily rate of growth. (Can be of particular importance if more than one type of seed is used.)
b. A graph showing the days involved in the germination for each seed.
c. Do two of these germination periods at the same time -- exposing one to sunlight, the other only to darkness. Again, collect, chart, and record data collected.

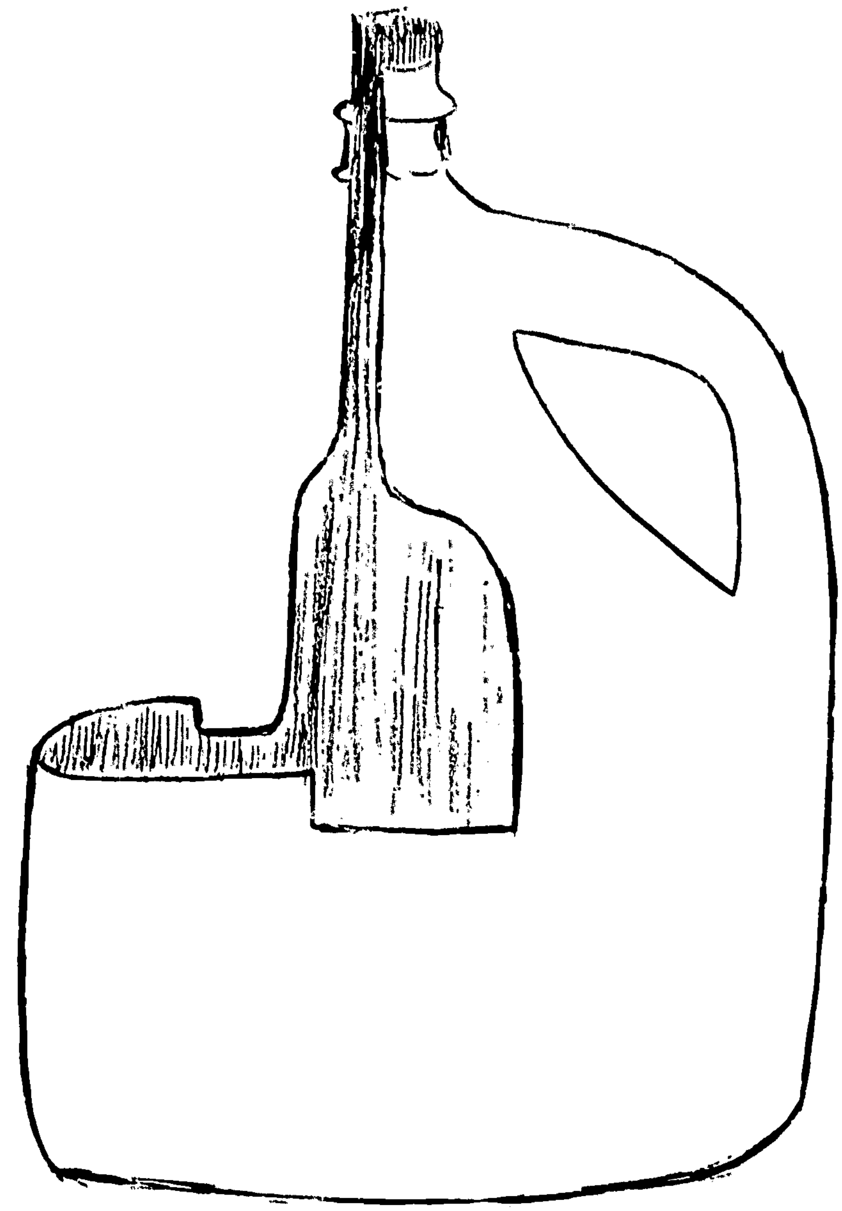


Illustration # I

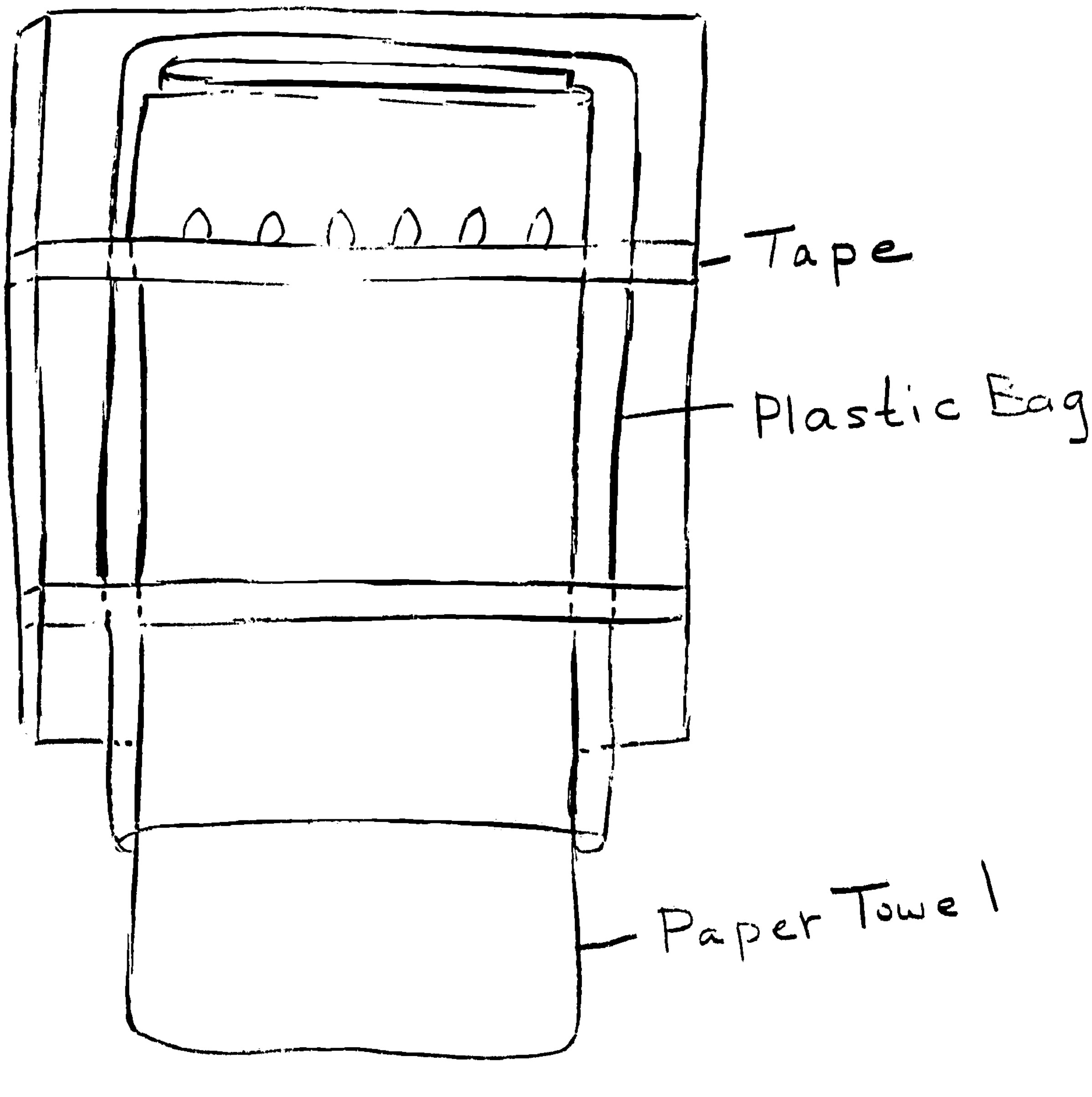


Illustration #2

6. Leading Question: How can we use the number line to tell time?

Materials: Learning Laboratory K 105 Number Line, giant clock

Procedure: Refer to manual which accompanies the Learning Laboratory for number line activities. Compare number line to the clock. Guide children into discovering that the clock is a circular number line.

Extended Study: Ways of telling time long ago. Teach the telling of time according to present days methods.
Investigate ways of telling time today.

7. Leading Question: What's in a glass of water?

Materials: Glass of water for each child, small cardboard tubes

Procedure: Have each child work individually and encourage experimentation. Some suggested activities are listed below:

1. Try looking through the glass. Are objects the same size? (Objects in the distance appear thinner.) Move to the right. How does the image move? Move the eye closer to the glass. What happens to the image?

2. Tilt the glass and not the new position of the water relative to the glass. Watch the oval shape where the water surface meets the glass. Insert an open tube and note the height to which the water rises. Why? Remove the tube. What happens?

Note to teacher: This activity can be varied by including extended experiments involving floating and dissolving.

8. Leading Question: Can weight be changed?

Materials: Two bathroom scales, preferably with a large dial and not covered by a strong magnifying glass

Procedure: Place the scales at some convenient location in the classroom and allow the children to perform some of the following activities:

a. Weighing selves over a period of time. Simple bar graphs could be drawn to illustrate weight changes.
b. Try changing weight by changing positions on the scale. What happens?
c. Suggest weighing selves by standing on two scales. Does it make a difference?
d. Have two children stand on the scale. Does their weight total the same as standing individually?
e. Weigh other objects separately and in combination. (Metal coffee cans and sand can be used.) Does the sand weigh the same on both scales? Why or why not?

9. Leading Question: Are heads the same?

Materials: Giant outside calipers, yard stick

Procedure: With the calipers, compare and measure the outside dimensions of a person's head. Record your measurements on a sheet of paper.

With the yardstick compare and measure the outside dimensions of a person's shoe. Record your measurements.

With the yardstick compare and measure the outside dimensions of a person's shoulders. Record your measurements.

Note to teacher: Practice scientific writing by having the children properly record their findings.

10. Leading Question: How thick is thick?

Materials: Giant thickness gauge, yardstick, meterstick

Procedure: Measure and compare the widths and thickness of tables, chairs, door frames, etc. Record the information using the proper procedure for scientific writing. Repeat this activity using the metric system.

11. Leading Question: Is it bigger than a breadbox?

Materials: Giant inside calipers, 1 yardstick

Procedure: After measuring the inside measurements of boxes, closets, shelf units, the inside of their desks, etc., have the children compare and record their findings.

12. Leading Question: <u>Where does it go?</u>

Materials: A variety of mixtures found in the kitchen such as sugar, salt, baking soda, plaster of Paris, wheat paste and sand, iron filings, baby food jars, vinegar, water, cooking oil, acetone (available from the Central Science Material Library), spoon

Procedure: Place one teaspoon of each of these mixtures in the baby food jars. Mix these materials with some water. Observe what happens. Do they dissolve, get sticky, or stay as they are? Record the observations.

Repeat the same procedure using cooking oil. What materials dissolved in cooking oil that did not dissolve in water? Record their findings.

Repeat the same procedure using vinegar. What happens to the baking soda? Did anything dissolve in vinegar that did not dissolve in cooking oil or water? Record the observations.

The same procedure should be repeated using acetone. What happens? Did anything dissolve in acetone that did not dissolve in the other three liquids. Record your findings.

Compare all findings and discuss the results.

13. Leading Question: <u>Why do we close windows during a fire drill?</u>

Materials: Four candles, three jars of different size, matches

Procedure: Light one candle and cover with the smallest jar. What happens? What does it tell about air and fire? Light three candles and cover them with three jars. Which one do the children think will burn the longest?

Note to teacher: Be sure to ask the questions before the candles are covered by the jar. Light four candles. Cover three of them with the jars and keep the one candle uncovered. Which one will burn the longest? The shortest? Why?

Extended Study: Use four candles of different thicknesses (i.e. birthday, votive, etc.). Light and cover all four with jars. Will they burn out at the same time? Why not?

14. Leading Question: <u>How can you tell what is in this box?</u>

Materials: An assortment of small, well-known items such as chalkboard erasers, chalk, pencils, paper clips, bean bags, crayons, thumbtacks, rocks, a brick, spoons, cups, balls, soap, piece of chocolate, a carrot, several shoe boxes or cigar boxes painted the same color

Procedure: Prominently display a group of well-known, small objects. Take two of these objects and place them in two painted shoe boxes. After several of the children have ventured a guess as to what is in the box, ask why they made that guess. Upon what is their observation based? What inferences were made?

Note to teacher: It may be difficult to separate observations from the inferences. Some of the observations leading to inferences may be as follows:

Recall - The children may recall something that they saw before on the table.

Shape - This may be deceiving because the shape of the box will camouflage the shape of the object.

Size - The children can tell the general size of the article by the size of the box. (The article has to be small enough to fit into the box.)

Touch - The children can lift the box to determine the approximate weight. By gently shaking the box, the children may guess by the sound the object makes as it strikes the side of the box.

Smell - If an object has an odor, the child may be able to associate that odor with the particular object.

Divide the class into smaller groups. Furnish each group with a painted shoe box containing an unknown article. Let the children handle the boxes and record their guesses. Encourage free but quiet discussion at each table as every child ventures his guess. After a ten minute interval, discuss with each group their guesses (inferences) and observations. Open the boxes. Review the observations and inferences that were made. Which were correct? Which were misleading?

15. Leading Question: <u>Do we taste what we smell?</u>

Materials: Pieces of sweet and bitter chocolate, vinegar, sugar, sour candy, peanut butter, apples, jelly, fruit, dandelion plants, lemons, limes, etc.

Procedure: Cut the foods into tiny pieces and place them on paper plates. Cut a small piece for each member of the class. Divide the class into small groups and distribute the food to the children.

Instruct the class to smell the same piece of food (e.g. the lemon piece). How does it smell? Now smell something sweet. Does it smell the same as the lemon? How does it differ? Have the children note their inferences on a mimeographed chart. Tell the children to taste the sample. Does it taste like it smells? Note the findings on the chart.

Note to teacher: In addition to sweet, sour, and bitter, how many other ways can the children discover to classify taste? What will happen if the children hold their noses and swallow? Can the food be tasted?

FOODS

CLASSIFICATION OF TASTES						

16. Leading Question: <u>How are animals similar?</u>

Materials: Live insect specimens, bio-plastics (available from the Central Science Materials Library). stuffed mounts (if possible), pictures, drawings, cutouts

Procedure: How are these animals the same? How are they different? Lead a discussion as to how the children could classify these animals. The children might suggest classifying them by those that fly, walk or crawl, have legs, live in water, lay eggs, etc. List the classifications on the chalkboard. Permit the children to examine the specimens to see how they walk, those that have antlers, etc. What other ways can these animals be grouped or classified?

17. Leading Question: <u>Is lunch time work?</u>

Procedure: Have the children name all the activities they did during the day. List these things on the chalkboard. How can these activities be classified according to things that are similar? (Following discussion). What things are for comfort? What things are for pleasure? What things are to help us work?

Note to teacher: This classification activity may be done combining the activities the child had during the day and the objects used, or with just the objects used or the activities performed.

18. Leading Question: Is a pint a pound?

Materials: Trip balance scale, two (2) pint jars, sand, water, cotton, shavings from the pencil sharpener, lead filings, dried vegetables

Procedure: Fill one pint jar with water and the other with sand. Place them both on the scale. What happens? Remove some of the sand from the one jar until it is equal in weight to the other jar. How much more water does it take to balance out the weight of the sand? Plot your results on a simple bar graph.

Note to teacher: It is important for the children to discover that the size of the container does not determine its weight.

Repeat the above procedure using the other materials. Allow the children to suggest and try various other materials. (i.e. flour, sugar.)

19. Leading Question: Will the movements of the fish change if the water temperature changes?

Materials: Goldfish (1), large jar for fish, large bowl or ice bucket, ice

Procedure: Place fish in large jar. Water should be room temperature. Record thermometer reading. Observe movements of the fish and record. Place jar into ice bucket. Allow five (5) minutes and again record water temperature. If water temperature has not changed wait an additional five (5) minutes. Observe and note the movements of the fish.

20. Leading Question: <u>Do animals respond to stimuli?</u>

Materials: Goldfish or guppies (no other tropical fish), paper clips, marbles or small pebbles, glass container for fish, flashlights, fish food

Procedure: Have a bowl with one (1) fish placed in a readily observable position. Allow children to suggest various stimuli which are non-injurious and allow them to observe and record responses. The following suggestions may be used in addition to those suggested by the children:

Drop a marble or small pebble into the water.
Shine a flashlight into the water.
Sprinkle food in the water.
Tap gently on the bowl.
Lower paper clip on a string.

The stimuli response should be repeated to determine whether response is constant.

21. Leading Question: <u>Would other fish respond in the same way?</u>

Materials: Goldfish, paper clips, marbles or other small pebbles, glass containers for fish, flashlights, fish food, mimeographed chart for each child

Procedure: Divide the class into small groups. Provide the above materials for each group. In addition, have each child record his observations on the chart. The previous procedure should be followed by each group.

My Goldfish

Stimulus	Response

Group findings should be reported to the class and conclusion drawn. Discussion should bring out the reason for multiple observations. Encourage individuals to study and observe other animals.

22. Leading Question: How can objects of likenesses be compared?

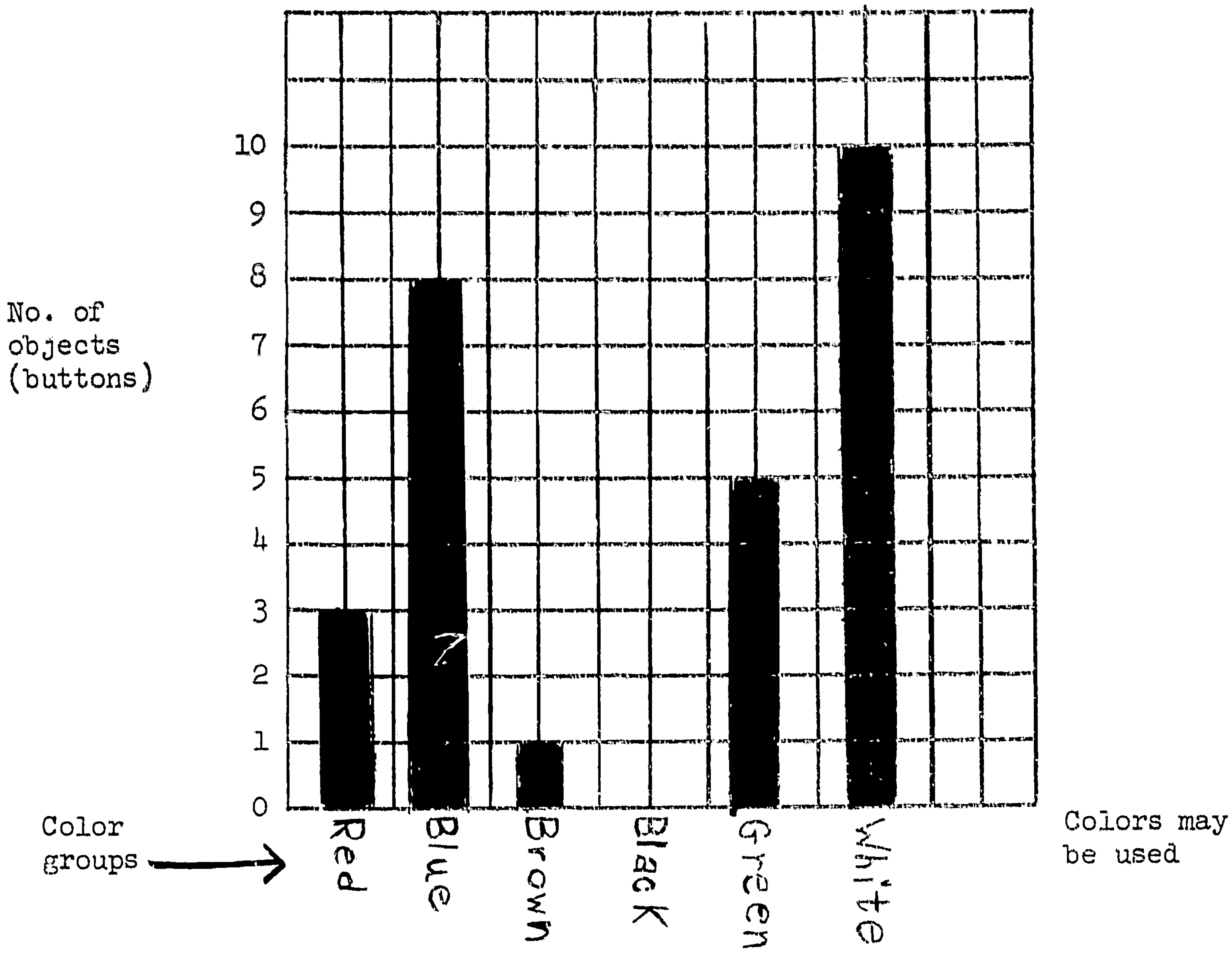
Materials: Graph paper or teacher-made grid forms duplicated, pencils or crayons, various colored objects

Procedure: Numerals may be used in the vertical axis to represent the number of objects (balls, blocks, pencils, buttons) while colored objects representing groups will be placed on the horizontal axis. Procedure may be reversed.

Note to teacher: Encourage children to read number line instead of block counting. For neater work, have students skip every other vertical line and color one half of the square on both sides of vertical axis used. Information can be set up in table form on board before attacking graph.

No. of buttons	Colors
0	Black
1	Brown
2	--
3	Red
4	--
5	Green
6	--
7	--
8	Blue
9	--
10	White

Which color has the greatest number of buttons? (White) How many? (10) How many blue buttons are there? (8) Are there any colors with less than three buttons? (Brown and black) Is there any color with no buttons at all? (Black)



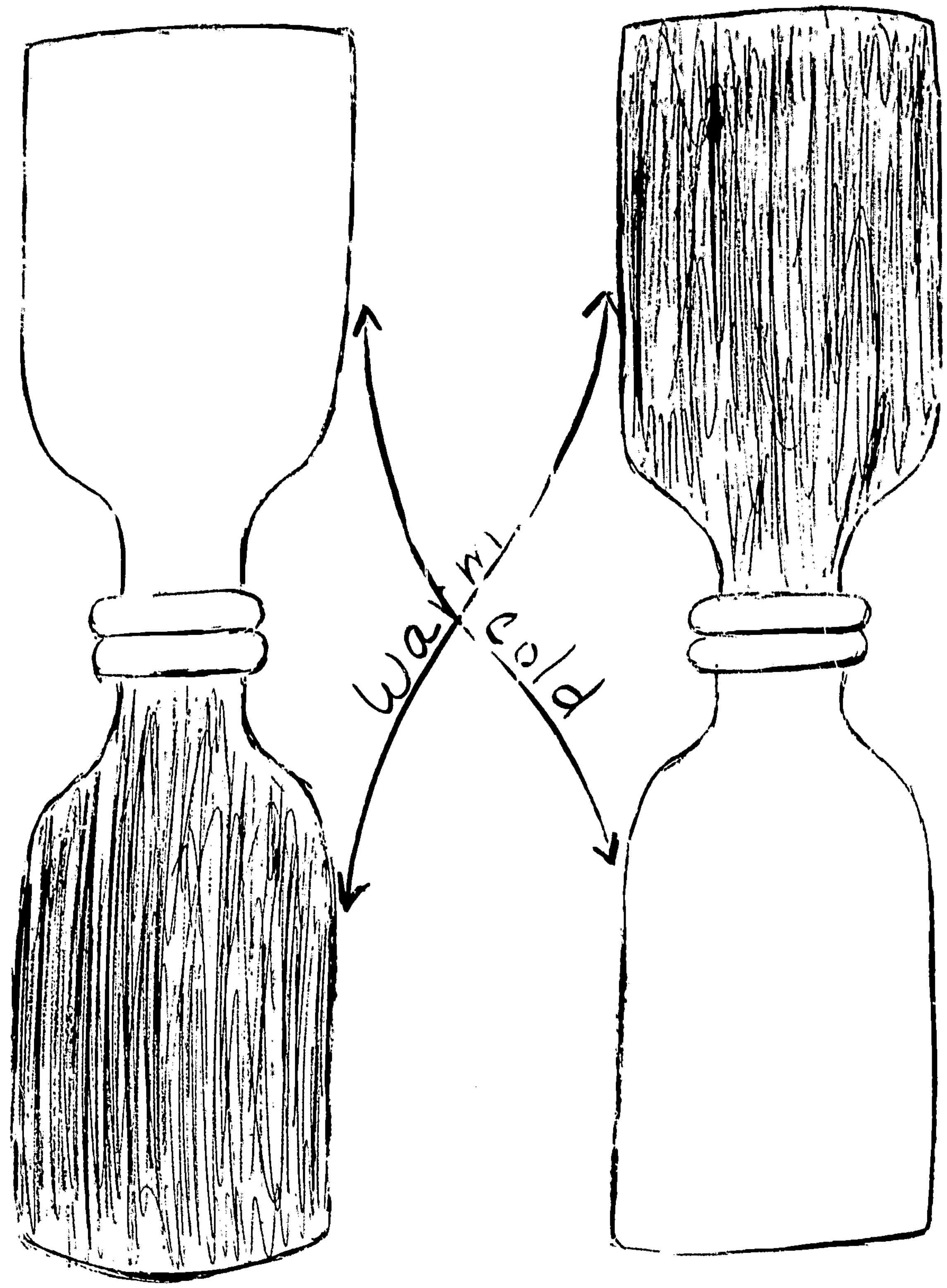
Ask if there is anything else in the classroom that can be recorded in table or graph form. Encourage groups to plot their own suggestions.

23. Leading Question: <u>What makes a current?</u>

Materials: Two (2) milk bottles, food coloring, warm water, cold water, a 3 x 5 card

Procedure: Fill the two milk bottles with water -- one cold, the other warm. Add and mix thoroughly, a little food coloring to the bottle of warm water. Put the 3 x 5 card on the top of the milk bottle containing the cold water: turn the bottle upside down and place on top of the other bottle. (Illustration) Remove the card. What happens? Why? Reverse the position of the bottles and observe the action.

Extended Study: Repeat this experiment using salt water and fresh water.



24. Leading Question: <u>Can we swallow up?</u>

Materials: Paper cups, straws, water, seedless grapes (or other soft fruit), pillow

Procedure: Select several boys and girls for this experiment. Use the pillow as a base and direct the children, one at a time, to stand on his head. Once the child is in this position, proceed to feed him bits of the fruit. Repeat this experiment with the straws and the paper cups of water. What are the results? Can the children swallow up? Why?

Note to teacher: Girls should wear shorts or leotards for this experiment.

SCIENTIFIC METHOD

GRADE 4

SCIENTIFIC METHOD

ACTIVITIES

Grade 4

1. **Leading Question:** How can we present our information?

   Materials: Poster board, felt marking pens (several colors) or crayons, thermometer (outdoor)

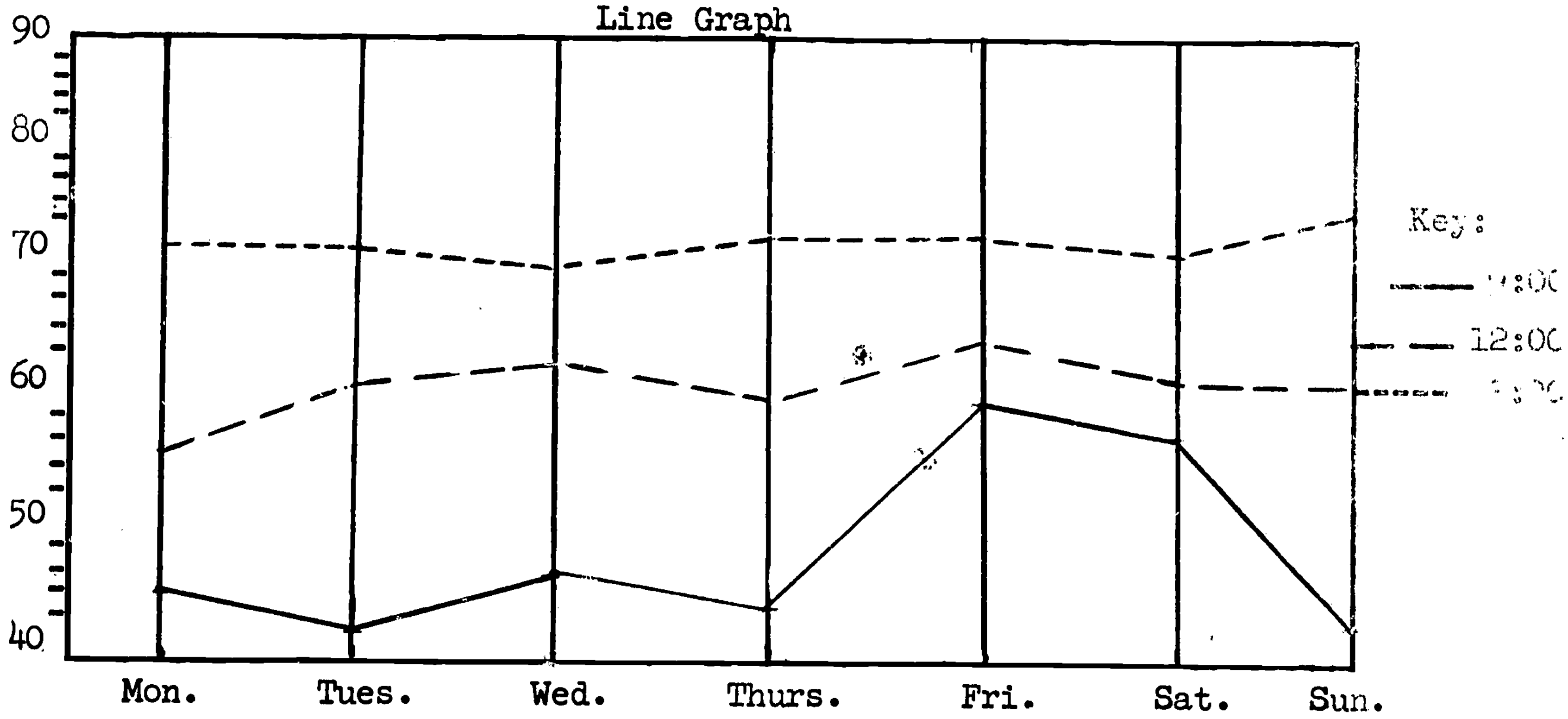
   Procedure: Prepare the following chart to record temperature readings.

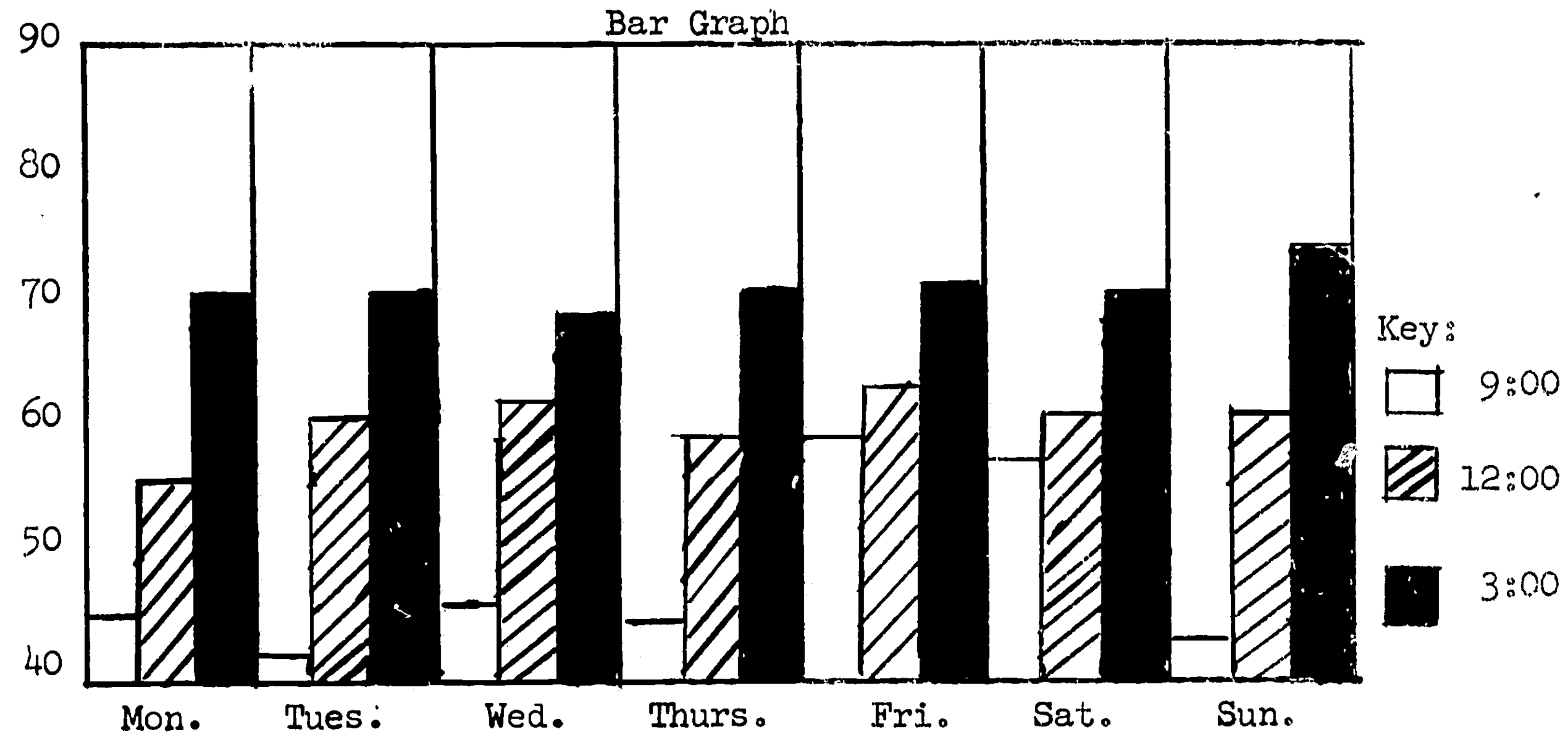
Weather Chart

	9:00	12:00	3:00
Monday	44	55	70
Tuesday	41	60	70
Wednesday	45	61	69
Thursday	43	59	71
Friday	59	63	71
Saturday	57	60	70
Sunday	42	60	73

If the children do not suggest other ways, the teacher may introduce line and bar graphs.

Line Graph





Discussion points:

Variety of ways to show data.
Compare uses of charts and graphs.
Develop math problems comparing degrees and temperature changes.
Discuss possible uses of graphic materials.
Investigate materials that use this method of data presentation.

Note to teacher: To follow lesson on thermometer reading, see Scott, Foresman Arithmetic.

Extended Study: Children may wish to gather and present other data in this form. Some individual projects should follow.

2. Leading Question: Why doesn't this compass work?

Materials: Several compasses, some in working order and some not working

Procedure: After the children have learned to use and read a compass, and have had an opportunity to handle a working compass, the teacher could distribute broken compasses. Have the children study the broken compasses and make a hypothesis as to reasons why the compasses do not work.

Example: The compass does not work because it is close to metal. The child could move to different parts of the room, away from metal. He may also place the needle near iron filings to check magnetism.

3. Leading Question: <u>How far does sound travel?</u>

Materials: One or two alarm clocks, yardsticks, cardboard box, triangle, drum, etc., chalk

Procedure: Use a loud-ticking alarm clock. Have a child stand about 3 feet from the clock and walk back slowly, until he can no longer hear the ticking of the clock. Mark this spot on the floor with chalk. After several children have performed this procedure have them make a paper cone out of construction paper. Holding the cone to their ears and listening for the tick of the clock, repeat the above activity and again mark the distance where it can no longer be heard. Measure both distances and record the results. Can the children hear further with or without the cone?

Placing the clock at different distances, the children could walk around at various angles until they no longer can hear the ticking. Mark these spots with a crayon or piece of chalk. Instruct the children to cup their hands behind their ears and listen again. Can they hear the ticking of the clock at the marks they had made?

Extended Study: The children may try this activity with various sounds such as the clapping of hands, the snap of a finger, the ring of the triangle, the beating of the drum, etc.

What would happen if the clock were put in a box? Try this activity with the clock tightly sealed in a box. Mark the distances again. Poke some holes in the box. Does it help the sound to escape any better? Cut some holes in the box. Do the sound waves sound louder? Why?

4. Leading Question: <u>Do you like what you see?</u>

Materials: Photographs and pictures of appetizing foods, war pictures, baseball scenes, toys and dolls, sharks, animals, accidents (Some pleasant, some slightly unpleasant.)

Procedure:

Group the children into sets of three or four and instruct them to watch the pupils in each other's eyes. Have half of the group close their eyes and turn their heads toward the lights. At a given signal, each child opens his eyes and looks at the lights. Have the other children observe and tell what happened.

Distribute one picture to every other child face down. Again, at the signal the child should pick up the picture and observe it for a few seconds. What happens to the pupils in their eyes. If it is a pleasant scene, do the pupils get larger or smaller? If they are hungry and look at a picture of food, what happens to their pupils?

Extended Study: The children can do these experiments on their own using a hand mirror and watching their reactions.

Note to teacher:

The second activity may not show immediate change in the pupils of the eyes.

5. Leading Question:

Why is water important to the growth of seeds?

Materials:

Seeds (lima, butter bean or pea), radish seeds, paper towels, shallow dishes, pots, soil, containers to hold water, measuring cup, balance scale

Procedure:

The children should examine the seeds and observe everything about the seed. (This should include size, color, shape, projections, indentations, etc.) List observations on the chalkboard. Using a balance scale, weigh six seeds and record the weight. (Use the metric system if possible.) Another way of comparing, is to arrange the seeds in a straight line and draw a line around the seeds (figure 1). This is a way of measuring seeds.

Place the seeds in a cup of water for four or five hours. Have the children observe the seeds during this time for visual changes. Have the children predict what will happen to the seeds. Remove the seeds, weigh or measure the seeds as before. The children will discover that the seeds no longer fit inside the line on the paper. Draw a new line around the seeds (figure 2). Measure the cup of water. What has happened to the water? Why?

Put the seeds back into the measured cup of water. Allow the seeds to remain overnight. Cover the water to prevent evaporation.

The next morning remove the seeds and again measure both seeds and water. (Depending on the seeds used, they may or may not have absorbed more water.)

Lead a discussion about the size of the seeds and the reasons for changes. Have the children note the visual changes of the seeds.

Give the children a dry seed and one that has been soaked. Ask the children to split open both seeds and comment. (The soaked seed should be easier to open.) Why is this important to the seed?

The child may be given additional seeds to plant in soil. Allow the child complete freedom in planting and caring for the seeds. The teacher should require the child to record all things done to the seed and all observations. After a few days a discussion may be held and the children will discuss reasons for growth or lack of growth.

Note to teacher: Encourage the child to measure in both the English and metric systems. If additional exercises are needed, substitute different seeds in order to discover differences or similarities.

Fig. 1

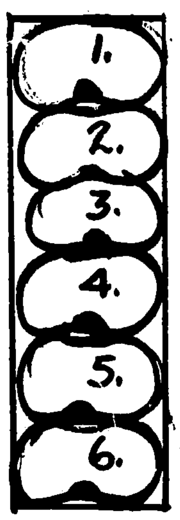
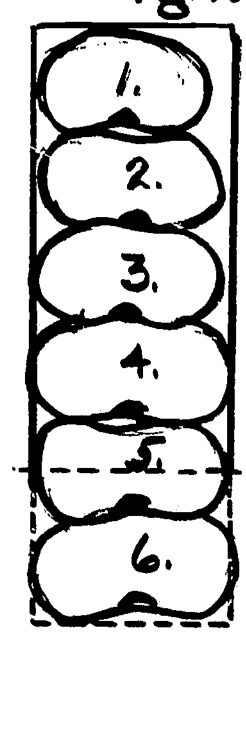


Fig. 2



6. Leading Question: <u>What's in our aquarium?</u>

Materials: An aquarium (balanced)

Procedure: During the observation and discussion of the aquarium, have the children arrange the list of materials into groups. (The children will group in several ways.) Once the children have divided the contents into living and non-living things, have them suggest ways to sub-divide. The children might divide the living things into plants and animals. The animals could be sub-divided into animals with shells and animals with scales. Encourage the children to sub-divide whenever possible.

7. Leading Question: <u>Are we able to feel the weight of objects by holding them in our hands?</u>

Materials: Small metal ball, styrofoam ball or block (The styrofoam is chosen because it is heavier than the metal ball)

Procedure: Hold up the metal ball and styrofoam object. Ask the children which object is heavier. The teacher might also ask how many times heavier each object is and record the remarks on the chalkboard. Have the children hold each object to feel the weight. The child may change his mind about the objects if he desires. (Most children will agree that the metal ball "feels" heavier.) Using a balance, check the weight. Encourage the children to discover the reasons why the styrofoam "feels" lighter but actually is heavier.

Note to teacher: The size of the objects and the weight being distributed over the area of the hand is less sensitive to the nerves in the hand.

8. Leading Question: <u>What's the difference between positive and negative numbers?</u>

Materials: A number line or centigrade thermometer

Procedure: Use the thermometer and compile a list of temperature readings. The children could make a list, or a table of temperature readings, of high and low temperatures from around the country. These statistics may be secured from a science book or other source. When using the number line, any list of numbers could be used. In both cases both positive and negative numbers must be used.

The children could chart the temperatures on a drawn thermometer and count the units between two given temperatures. Example: from -1 to +1 would be two degrees warmer, from - 20 to -10 would be ten degrees warmer, from +20 to +10 would be ten degrees cooler.

9. Leading Question: <u>How could these shapes be grouped?</u>

Materials: Colored paper shapes (several of each color and shape)

Procedure: Have the children discuss the reasons and importance of grouping. Ask the children to arrange the objects into groups. (Give no assistance.) Some children will arrange according to color, others will arrange by shape or by other ways. Encourage the children to rearrange the objects as many times as possible. Use the overhead projector for a variation to this activity.

10. Leading Question: <u>How does water affect different surfaces?</u>

Materials: Pie plate filled about an inch with dirt or sand, funnel

Procedure: Before pouring water through the funnel, ask the children to predict how deep an impression the water will make as it drops into the pie plate? Vary the height of the funnel. What happens to the impression? Why? Can the dirt be moved so the impression won't be as great? How?

Place gravel or grass over the dirt. Repeat the experiment. What happens? Why?

Note to teacher: This activity can be correlated with soil erosion in geography.

11. Leading Question: <u>What do the clouds say?</u>

Materials: Weather chart for bulletin board, individual charts for each child, easy to read thermometers

Procedure: Discuss the effects of weather and climate by associating clothes worn, games played, and how one feels (warm, cool, sticky).

Introduce the symbols to be used on weather charts either as they occur or as decided by the teacher.

Take the temperature daily, in the same shady place, at the same time.

The following descriptions of the weather chart and symbols can be used:

1. Temperature - Using a large Fahrenheit thermometer the children should record the temperature by using a numeral. In some classes it may be useful to use only color.

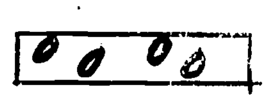
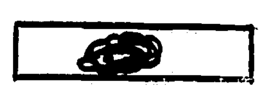
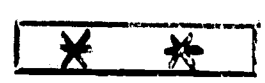
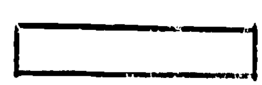
2. Clouds - To classify the type of cloud an exact measurement is not intended, only that a careful estimation is given.

Sky	Symbol	Meaning
Clear		No clouds
Partly cloudy		More than half sky clear
Mostly cloudy		More than half sky covered
Sky overcast		Sky completely covered

3. Wind - The description of winds is one the child should compare to his own surroundings, therefore the descriptions below should be observed by the children.

Calm		No air moving
Breezy		Wind felt on face, leaves rustle
Windy		Wind raises dust, small limbs sway
Very windy		Whole trees in motion, hard to walk against wind

4. Other weather - In this section other common forms of weather are noted.

Rain	
Fog	
Snow	
None	
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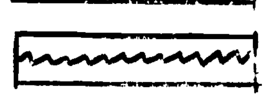
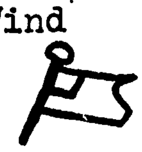
Frost	

Discussion point: The teacher should lead the children to frequent discussion of the weather changing.

Note to teacher: Further suggested use of the weather chart would be to use it during the seasons of the year. When the last recording is finished the degree differences may be compared on a number line.

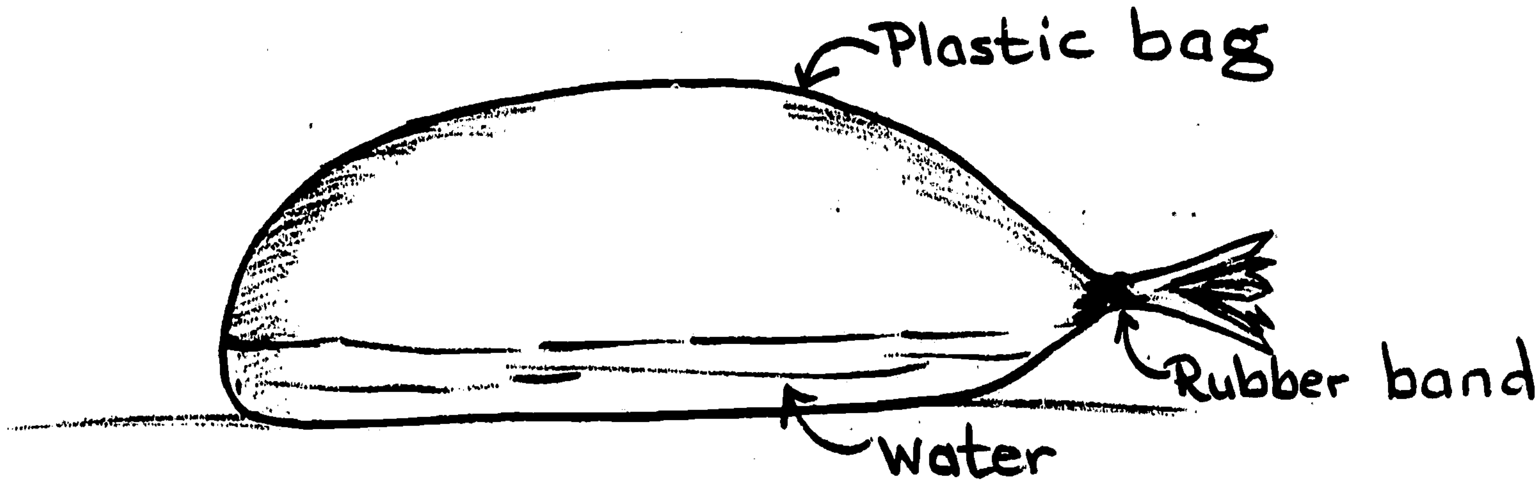
DAY DATE	Mon	Tues	Wed	Thur	Fri	Mon	Tues	Wed	Thur	Fri	Mon	Tues	Wed	Thur	Fri
Temperature 															
Clouds 	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Wind 	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Other	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Name															

Extended Study: Children may record results on bar graph indicating amount of cloudy days, rainy days, etc.

12. Leading Question: <u>Why is rain water safe to drink?</u>

Materials: Several plastic bags, rubber band, ink or food coloring, soil, soap powder

Procedure: Pour about one inch of water into the plastic bag. Seal the bag with a rubber band and place in a warm or sunny spot. What happens at the top of the bag? If the water was colored red, would the drops be red? Repeat the activity using water with food coloring, water with soil added, water with soap powder added or any combination the child desires. Have the child relate the information discovered to the water cycle.



13. Leading Question: <u>How do things change?</u>

Materials: Several clear plastic boxes or jars with lids, plastic freezer bags, items to observe: milk, bread, tobacco, nail, dried fruit, powdered sugar, flour, orange juice

Procedure: Display the items on a table and allow them to be exposed for two or three days. Observations should be noted by the children and statements (inferences) made about the observations. (What changes have you noticed? What caused the changes? How could the changes be slowed down or speeded up? Will the changes always be this way?)

Note to teacher: In answer to the last question, the children should use controlled experiments. One way is to place two similar foods, one wet and one dry, in pairs of containers. Place the containers in the same location of the room or school, and keep records of happenings. Additional pairs of containers could be made and again placed in the same location. The pairs of containers could be placed in sunlight, dark places, refrigerator, outside the window or anywhere.

14. **Leading Question:** How can we measure the volume of uneven containers and objects?

Materials: Bottles or containers of various shapes and sizes, several rocks of various shapes and sizes, cardboard containers, frozen juice can, bucket or large container to hold water and dry sand

Procedure: Instruct the children to measure the volume of the containers or objects in relation to each other. Records should be kept and the children should be able to explain how the task was accomplished.

Note to teacher: By using the smallest container (juice can) as a standard, the child will be able to measure water and fill the containers to determine the volume. The cardboard containers could be filled with sand that has also been measured in the juice can. (Care must be used with sand, because some children will pack the sand harder than others; thus causing a difference in the amount the container will hold.) The rocks could be placed in a bucket of water and the water that is displaced will equal the volume of the rocks. (The water remaining in the bucket will have to be measured and subtracted from the original amount in the bucket.)

The child will express answers in relation to the juice can (standard). Example: The box is equal to eight juice cans. Other objects could be brought to school and measured in similar ways.

15. **Leading Question:** Can salt be separated from sand?

Materials: Sand, salt, baby food jars or small containers, filter paper, funnel, flat dishes or aluminum pans, hand lenses, microscopes

Procedure: Distribute a quantity of salt and sand to each group or each child. Examine the shape of salt and sand by using lenses or a microscope. Mix the salt and sand in a jar. Examine the mixture and have the children try to pick out the salt from the sand.

Explain to the children that scientists are faced with similar problems constantly. Scientists use their previous knowledge to solve new problems. A scientist knows that salt will dissolve in warm water but sand will not. Water will evaporate into the air but salt will not. How could we use this knowledge to separate the salt and the sand?

Note to teacher: Dissolve the salt-sand mixture in warm water. Filter the mixture to separate the sand and allow the sand to dry. Place the water-salt solution in a shallow pan and allow the water to evaporate. The salt will remain in the pan. Encourage the children to try other mixtures and note the results. Example: Salt and oil, salt and flour, salt and sugar, sugar and sand.

16. Leading Question: <u>How are rocks grouped?</u>

Materials: Several rocks for each child and hardness scale

Procedure: Have the children arrange the rocks on their desks or a table. (Allow the child to use his imagination in arranging.) The child should be able to explain his reason for his grouping. Encourage the child to arrange the rocks into additional groups. (Size, shape, hardness, etc.) The child's reasons for grouping should be different for each method of grouping.

What other objects could be grouped in a similar way?

17. Leading Question: <u>Do we really see what we see?</u>

Materials: Any pair of objects that seem to be alike such as; iron nail and aluminum nail, hollow ball and solid ball, shaving cream and whipped cream, real fruit and artificial fruit, water and alcohol, flour and powdered sugar, etc.

Procedure: Place the objects around the room making sure the pairs are placed together. Do not allow the children to touch the objects. After the children become curious and begin to ask questions, poll the class for opinions about the pairs of objects. Encourage the children to comment about each pair of objects.

Permit the children to examine and handle the objects and again make inferences with statements supporting their observations.

Note to teacher: The object of this lesson is to help the children discover. Statements about certain items should be made only after careful observation.

18. Leading Question: <u>What size is a drop?</u>

Materials: Medicine droppers of different inside diameter - one for each pair of children, several liquids - liquid detergent, Karo, alcohol, food coloring, test tubes - several for each pair of children

Procedure: Have the children mark the test tubes at the same height. Using one dropper, count the number of drops to fill the tube. Use the second dropper and the same liquid and note the drops used to fill the tube.

Using a second or third liquid repeat the experiment. A chart may be developed to compare results of several liquids.

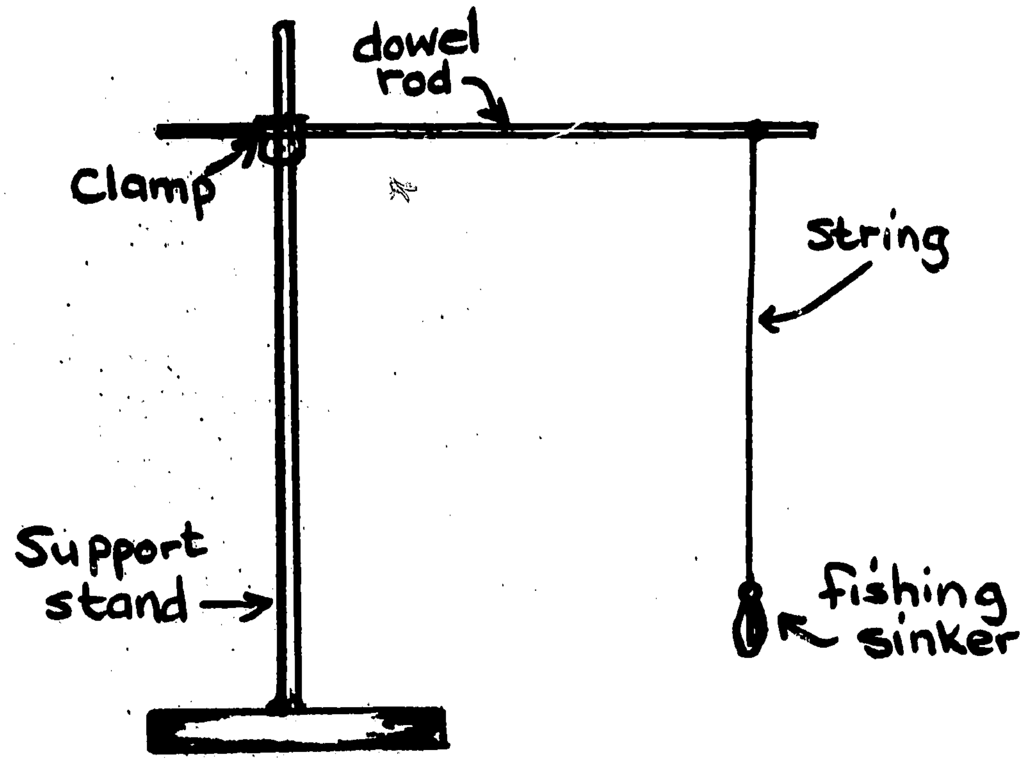
Encourage the children to make statements of their observations. What happens when things are added to the liquids? Water and detergent, alcohol and water, etc.

19. Leading Question: <u>How big is a pendulum swing?</u>

Materials: Support stand, dowel rods, string, assorted fishing sinkers

Procedure: After the children have made suppositions, they should begin to construct the pendulum. Several pendulums should be constructed by groups of three or four children. The children will count and time the number of swings. The children may change, or the teacher might have to suggest changing the weight of the sinker, the length of the string, or both.

The children should record and chart their findings. By changing several variables the children may draw conclusions about the findings.



20. Leading Question: Where does the water go when we water plants?

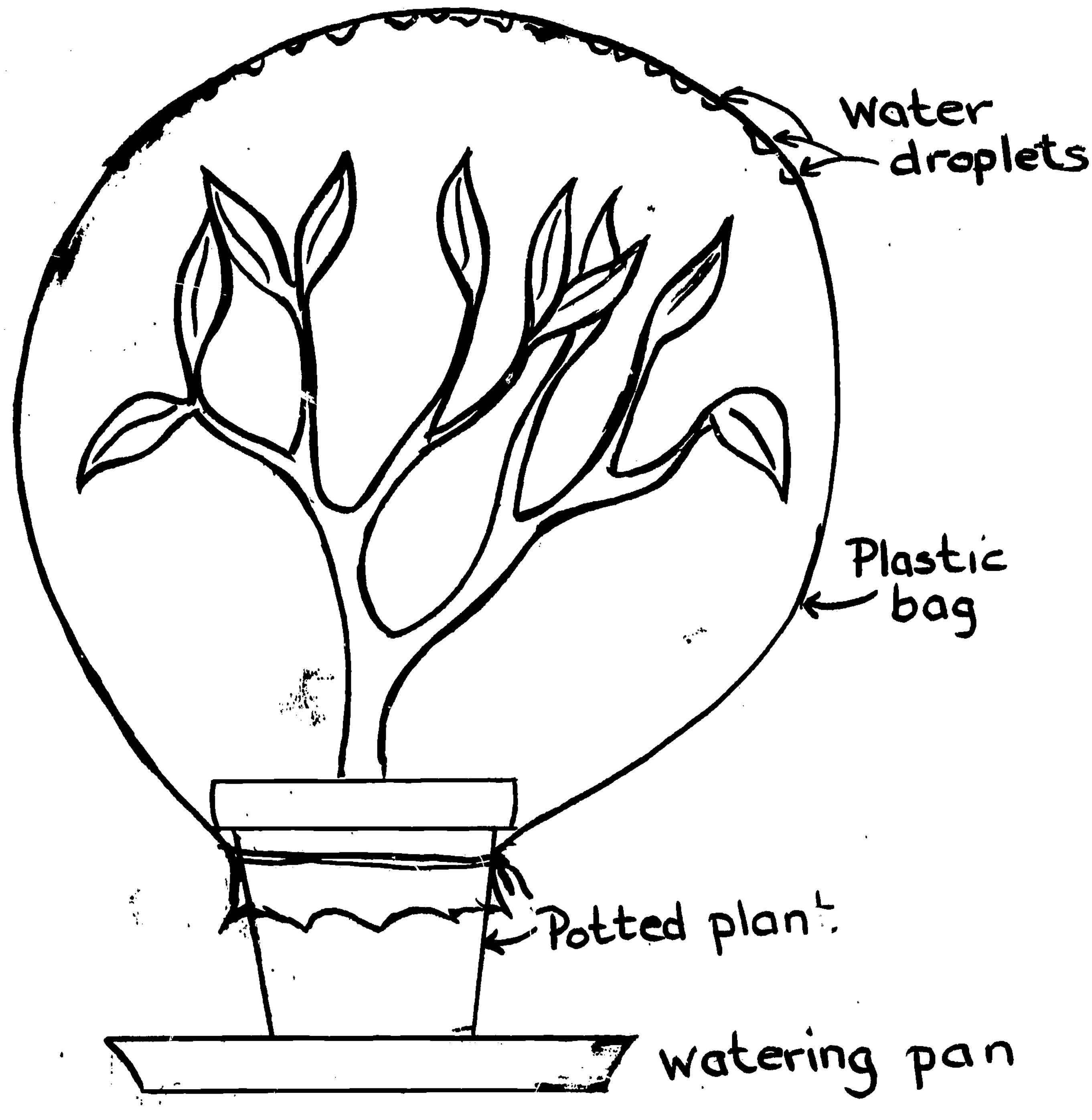
Materials: Several plants with leaves, branches of trees with leaves, stalk of celery, food coloring, plastic bags, tape

Procedure: After the children have watered the plants for a few days, the teacher may pose the question. The child will make a few inferences. (It could be pointed out at this time, that statements should be backed up with information and observations.)

Place a stalk of celery in a glass containing water, and a stalk of celery in an empty glass. Determine the freshness of the water soaked celery after a day or two. This may also be done with cut flowers or tree branches. (When celery is used, the stem should be cut on a slant underwater with a razor blade, so as not to injure the tubes or block the tubes with air.)

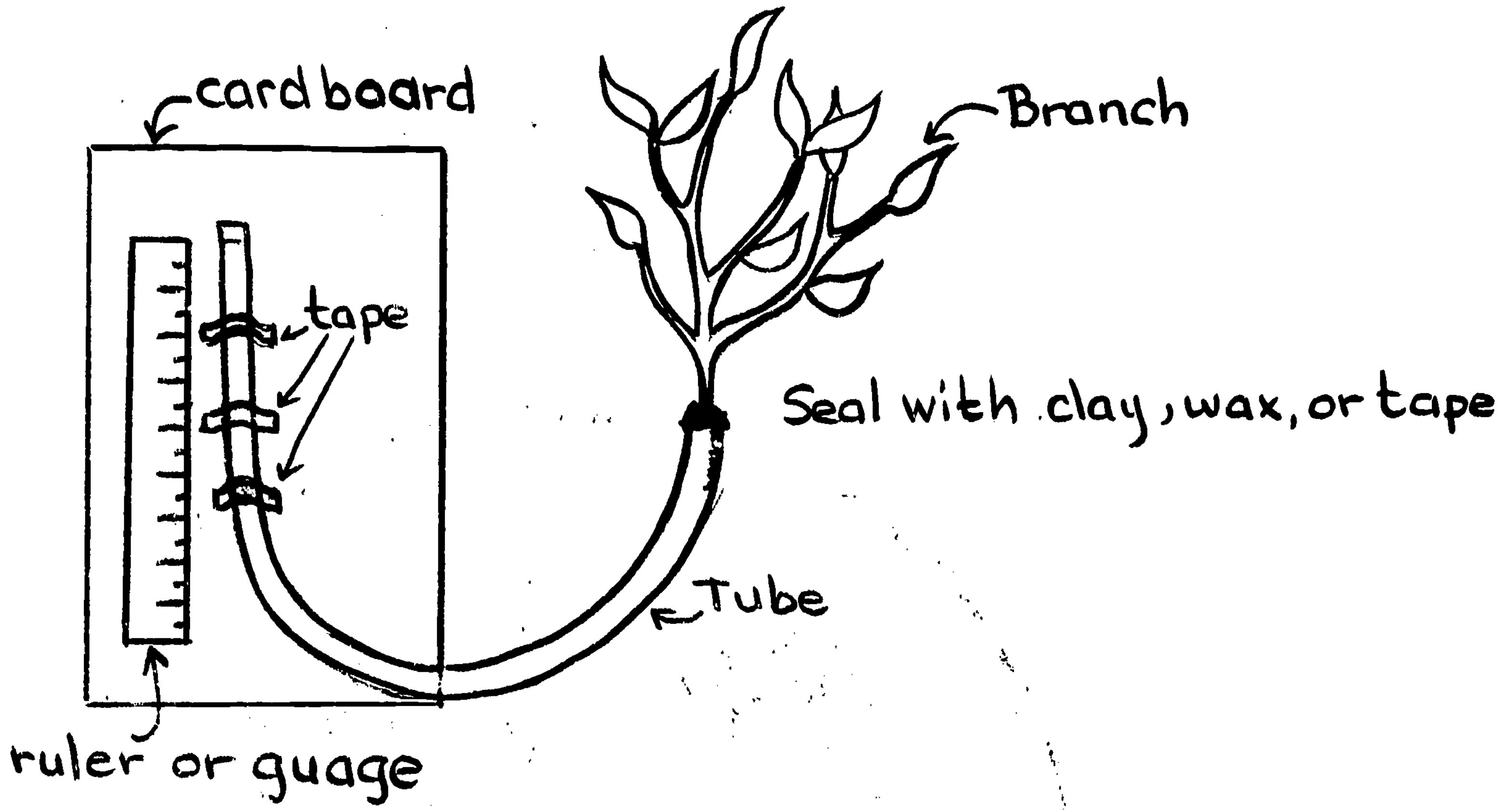
Continue the study by placing a stalk of celery in a containe. of water that has been colored. In a few hours the leaves of the celery will turn the color of the liquid. After the leaves have been colored, cut the stalk in two. The tubes should be very visible. The children may want to remove one of the tubes and examine the color.

Cover a growing plant with a plastic bag and tape the bag to the pot. Water the plant from the bottom. Place in the sunlight and observe the droplets of water that will appear on the plastic bag.



Repeat the activity using a bare tree branch. Why do droplets appear on the plants with the leaves? Do plants both use and give off water?

To determine how much water is used by a plant, put the end of a tree branch into the end of a plastic hose. Tape the hose to a cardboard and measure the amount of water consumed by the branch.



21. Leading Question: <u>What can be done with a strip of cardboard?</u>

Materials: Strips of cardboard 12 inches long and 2 inches wide cut from shirt cardboard, poster board, or manila folders. Enough should be out so that each child will have about six to work with.

Procedure: Each child should work individually and be allowed time for self-experimentation. Some activities which could be used to begin the activity are as follows:

a. How can a strip be used as a balance?
b. How can a strip be made into a spring?

c. How can the strip be made to give off sound by plucking, blowing, and snapping?
d. How does the strip travel when it is thrown? How can its flight be changed?
e. How can the strip be moved easily from place to place? (Roll it as a hoop.) How high can the hoop be made to bounce?
f. How can the thickness of the strip be measured? How many layers can be separated from the strip?
g. How can the strip be used to measure distance?
h. How can the shadow cast by the strip be changed?

Note to teacher: Many other activities can be developed as the children begin to experiment.

22. Leading Question: <u>Can you guess how many centimeters there are around the top of your desk?</u>

Materials: Meter sticks and rulers

Procedure: Have each child measure and record the perimeter of his desk top using a standard scale and the meter stick. (Metric System.) Let each child conceal his answer until the entire class has measured their desk tops. Put all the answers on the chalkboard to observe how well they agree. If there is a difference of opinion as to the correct measurement -- remeasure.

Repeat these measuring procedures and measure other areas such as the length of the room, the heighth of the doorway, the chalkboard, etc. What about that table in the back of the room?

Note to teacher: This activity is designed to provide fundamental practice with the metric system. Once the children are familiar with the metric scale, revert to it often. There will never be a precise and accurate measurement made. We get the best measurement possible within the scope of our limitations. Children should not be led to believe that science is exact.

For further help with the metric system, consult the booklet <u>Science in Action Measurement</u> ... Department of Public Instruction, 1964, available in each school.

2[illegible]. Leading Question: <u>What color is red?</u>

Materials: 60 - Watt yellow bulb, various colored objects, pieces of cloth

Procedure: Arrange various colored objects in one corner of a room that can be almost completely darkened. Cover the objects with pieces of cloth before permitting the children into the room. When the room is dark turn on the yellow light and uncover the colored objects. Encourage children to record the color of each object as it appears in the glow of the yellow light. (It is vital that the children do not know the colors of the object before hand.)

Next, turn off the yellow lights and turn on the ordinary lights. Direct the children to compare their notes to the actual objects. Investigate the conclusion.

Note to teacher: A colored object reflects only one color of light while natural light contains the full range of the color spectrum. If there is no red light, (as in this experiment) then a red object cannot reflect any light at all and must appear black.

SCIENTIFIC METHOD

GRADE 5

ACTIVITIES

Grade 5

1. Leading Question: Do fish float?

Materials: Wide-mouthed quart jar, medicine dropper, broken balloon, rubber band

Procedure: Fill the jar with water. Put a few drops of water in the medicine dropper. Slowly submerge the dropper into the jar of water. If the dropper sinks, remove a few drops of water. If it glides too near the surface, add a few more drops of water.

Note to teacher: The correct consistency will permit the dropper to slowly rise after tapping it to the bottom.

Stretch a thin piece of rubber over the mouth of the jar and secure it in place with the rubber band. Lightly press on this rubber covering. What happens to the medicine dropper? Release your fingers. Now what happens to the dropper? What occurs when the covering is pressed? What has happened to the water in the jar?

A fish has an air bladder inside its body. The fish can control the amount of air in its bladder enabling it to "float".

2. Leading Question: What makes one substance different from another substance?

Materials: Mystery powders (sugar, salt, baking soda, corn starch, plaster of Paris), white vinegar, candle, toothpicks, tincture of iodine, glass eye droppers, microscope

Procedure: Provide each group of children with five jars containing five unknown white powders. (If desired, the children can be told what the five powders are, but not in what container they are, so they will know what they will be testing for.)

It is important that the children be given ample time to work freely with the various powders. Discuss the different ways to determine the nature of a substance from careful observing to more involved chemical testing.

To vary the activity, try mixing two of the powders together or place food coloring in three liquids such as water, vinegar, and iodine and then let the children discover the composition of the substances.

This activity lends itself to careful record keeping on the part of the children. They should be encouraged to write their findings in terms of a scientific experiment.

Note to teacher: Prior to distributing the posters, the children should be instructed in the use of the basic tests to indicate the presence of various substances. Remember, heat causes sugar to turn black, iodine turns starch purple or black, and vinegar causes baking powder to fizz.

3. **Leading Question:** Which is longest -- the root or the stalk of a plant?

Materials: Samples of various plants and their root systems, yardstick or ruler

Procedure: Have the children collect various plants and their root systems. Measure the height of the plant above ground and at its widest circumference. Record the data. Now have them measure the length and breadth of the root system with the size of the plant. Is there a relationship between the two?

Investigate similar plants but from different types of soil and growing areas. How do they vary? Which has the largest root system? Does the amount of moisture in the soil seem to effect the root system. Do different types of plants have similar root systems?

Note to teacher: This activity may be performed in the classroom by using glass jars and controlling the various soil types, amount of water, etc. The children may wish to keep some type of scientific record of their observations.

4. **Leading Question:** What change does water cause on wood?

Materials: Toothpicks, small sticks of wood, glass jars, tape measures

Procedure: Begin by measuring the circumference of the tiny pieces of wood. Record the data. Place the wood in water. After a few hours, check the wood. Measure it. What has happened? Why?

Break the toothpicks in half and place them in the shape illustrated. Make certain that the broken edges are toward the center. Place a drop of water in the center. What happens? Why?

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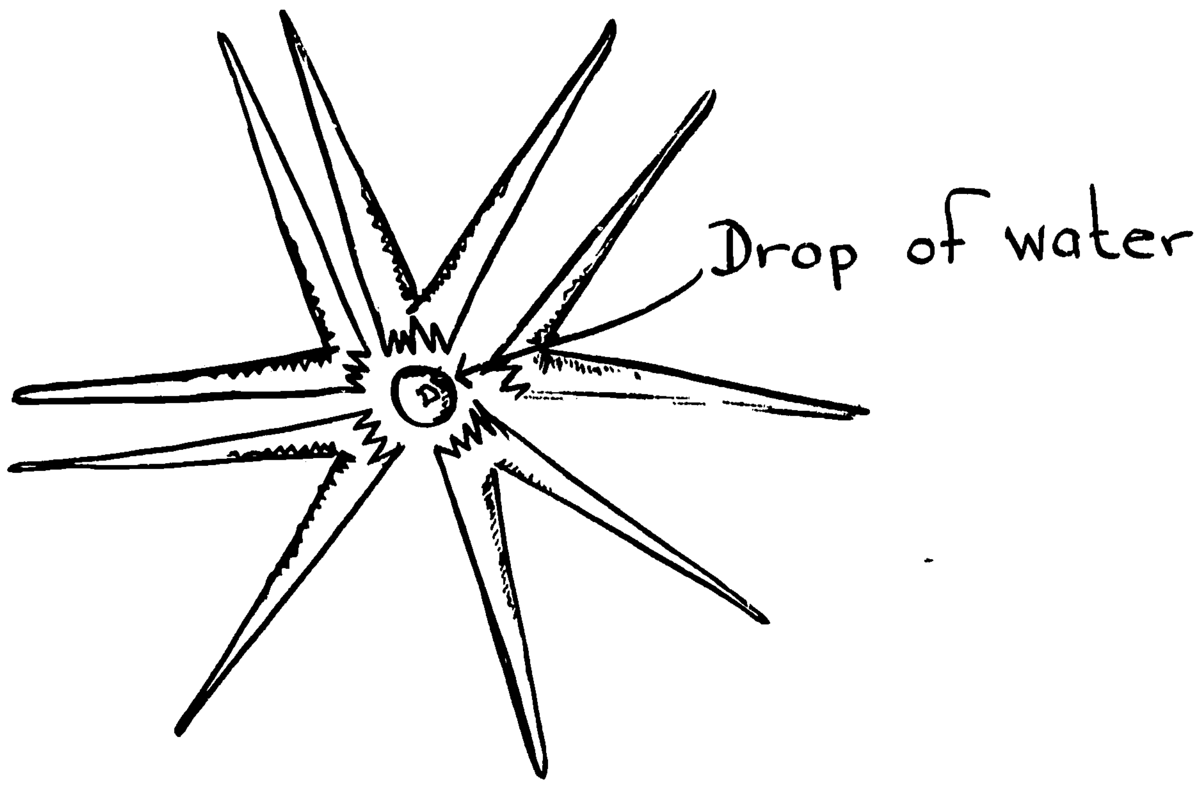

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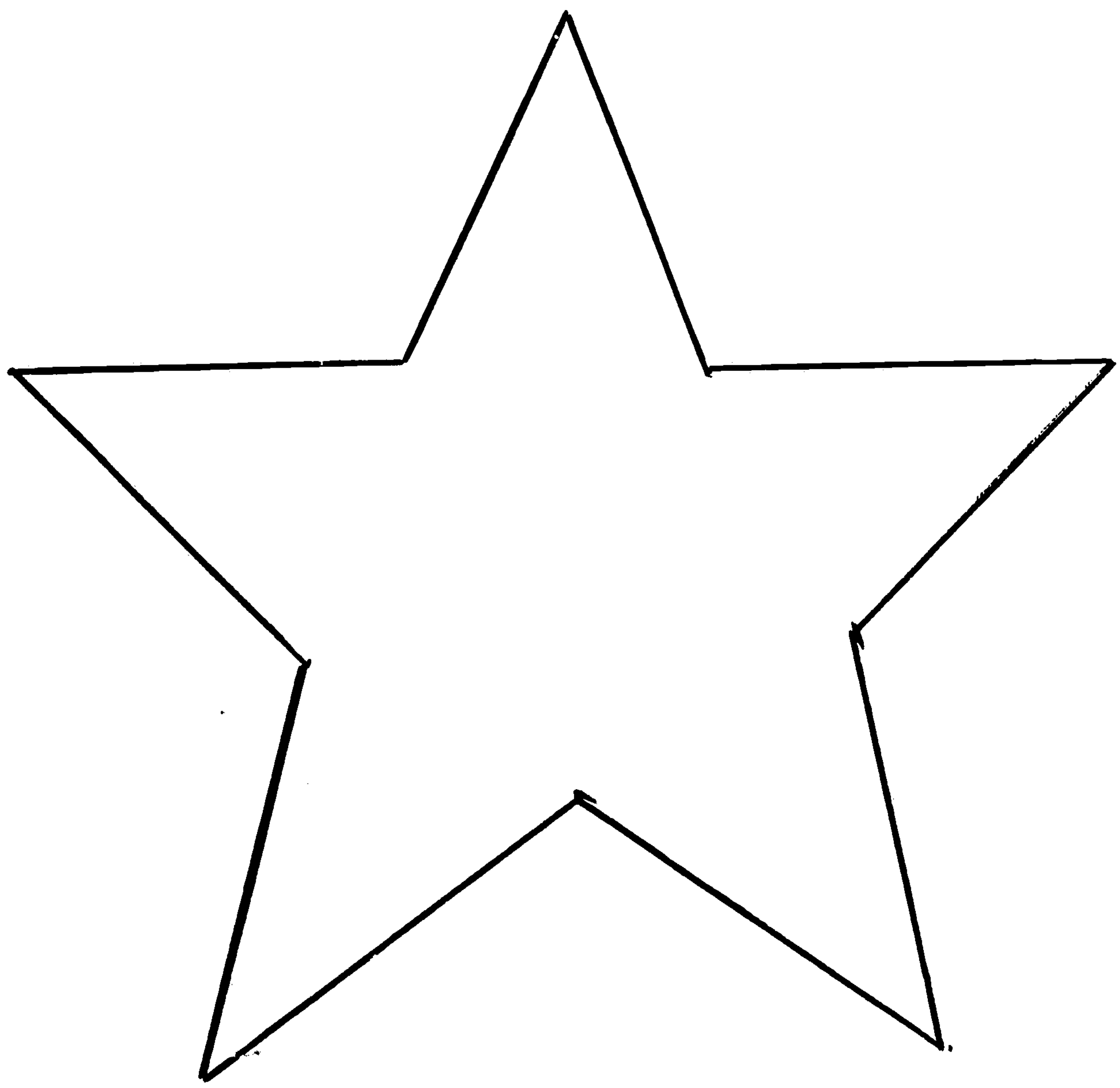


5. Leading Question: <u>Can water be weighed?</u>

Materials: Drinking straws, bowls, soft drink bottles, stoppers, scale

Procedure: Have the children fill their bowls half full with water. Give each group a bottle that has been filled with water and then sealed with a stopper. Have them invert the covered bottle in the water. Remove the stopper. What happens? Why?

Weigh the bowls before water is added. After the addition of water weigh them again. Do the same before and after the bottle of water has been added. What can the children conclude from the results?

Place several straws near the bottle. Ask the children how the water can be emptied from the bottle? Try blowing air through the straw. What happens?

Discuss the amount of water that flows out of the bottle? Can it be measured? Encourage the children to devise their own methods.

Now have the children empty all the bottles. See how many ways they can devise to fill the bottle using only the straw. What happens if the length of the straw is varied?

6. Leading Question: <u>What makes a board balance?</u>

Materials: Lightweight board, fulcrum, wooden blocks of equal size

Procedure: Working in small groups, have the children place the board on the fulcrum so that it will balance. Can two blocks be placed on the board so that it will balance? How? Will the board balance if two blocks are placed on one side and three are placed on the other?

Try spacing the blocks out equally? Do they balance? Vary the spacing by moving two blocks out three spaces and three blocks out two spaces. Do they balance? Why? Encourage the children to see how many combinations they can make that will balance the board. (Mathematically, if the sum of the blocks and spaces on one side equal the sum of the blocks and spaces on the other, the board will balance.)

Now have the children move the board off center. How does this affect the manner in which the board will balance? Try various combinations of blocks. Which balance? Which do not?

7\. Leading Question: How do seeds differ in their rate of growth?

Materials: Planting containers, potting soil, marking pencils, variety of seeds such as white radish, red radish, sunflower, roasted sunflower, radiated bean, non-radiated bean, or any seeds that can be compared

Procedure: Spend a day examining the seeds. Allow the children to predict things about the seeds from their observations. Which might grow the fastest? How many days will it take for a seedling to appear? Which seedlings will be similar in appearance? Suggest some simple method of recording data to the children.

As the plants develop, compare the seeds with the plants. Why aren't some seeds growing? Are some seedlings quite different than others? How? Are they all growing at the same rate?

Devise ways to measure and chart their growth. Perhaps the children would like to try making a grid on the leaves with a felt-tip marker.

Note to teacher:* It might be advisable to place some seeds in envelopes and then label the pots and envelopes with the same letter. In this way, the children will be able to compare the two. Also, the effects of the radiated and roasted seed can be more carefully determined.

* Refer to 3rd grade experimentation using germination pot.

8\. Leading Question: Why are some objects more stable than others?

Materials: Piece of board, various size wooden blocks, objects of different sizes

Procedure: In each group, place a piece of board flat on the table or floor and then have the children place various size wooden blocks on the board, two at a time. Allow the children time to guess which block will tumble first when the board is tilted?

Vary the activity by using different size objects. Does the height of the object effect the rate at which it will tilt? How? Try objects of various weights? How does this change the results?

9. Leading Question: <u>How are numerals related?</u>

Materials: Various numerals of all sizes placed on small cards

Procedure: Distribute a variety of cards to each small group of children. Without any discussion, ask the children to group the numerals in some meaningful way. Encourage any type of grouping which the children feel has meaning.

Discuss and compare the different methods of grouping.

10. Leading Question: <u>How long does a balloon stay in the air?</u>

Materials: Balloons of various sizes

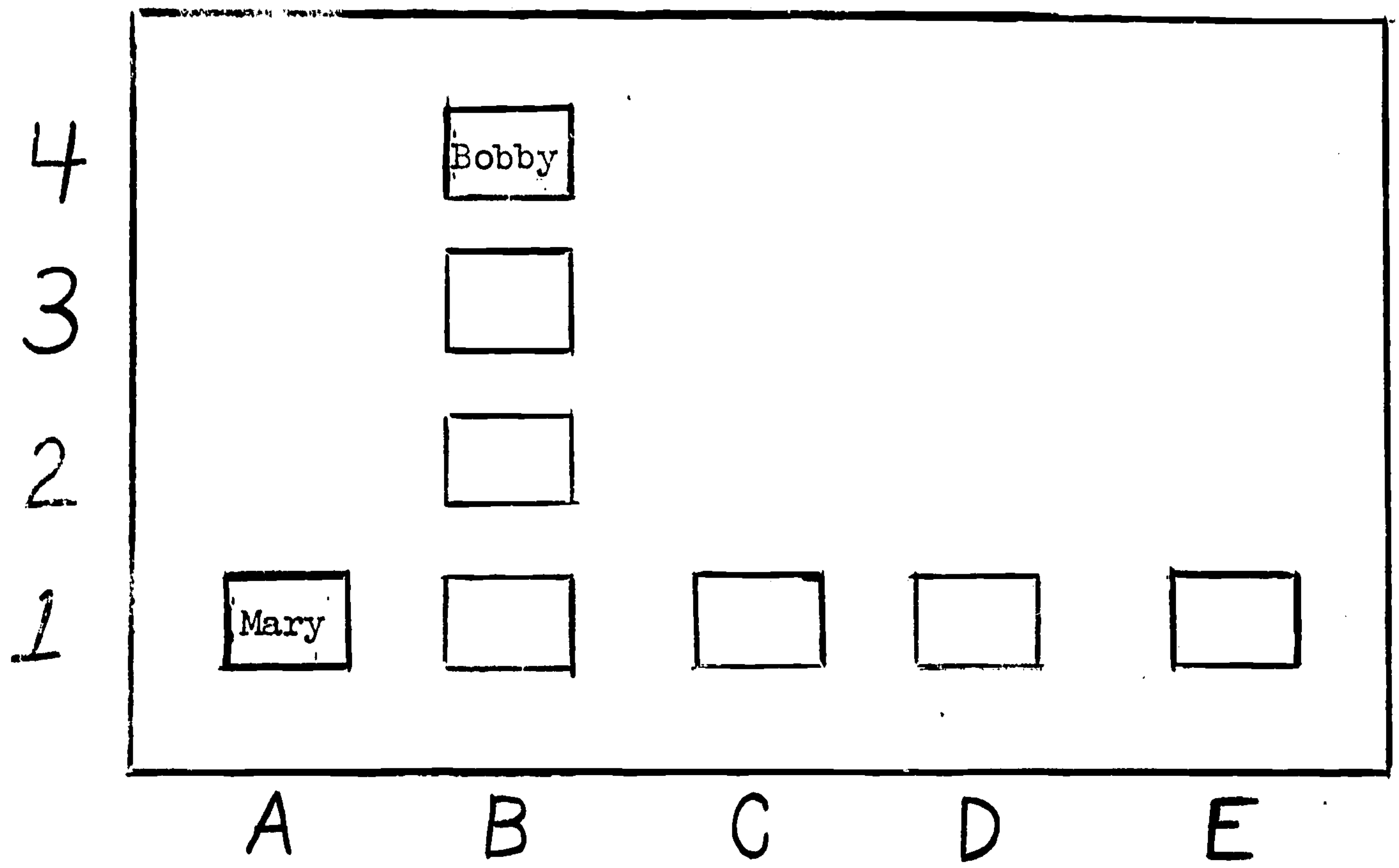
Procedure: Distribute a variety of balloons to each group of children. Discuss which balloons might stay in the air the longest. Test their guesses. Does the amount of air put into the balloon effect it's duration of flight in the air?

After all groups have had an ample time to experiment, conduct a flight duration test to see which group can keep their balloon in the air the longest.

11. Leading Question: <u>Why are codes and symbols used?</u>

Procedure: Discuss with the children how they might identify themselves without using names. Allow the children time to devise different ways of grouping such as by hair color, eye color, etc. Suggest that they actually move to various groupings.

Devise a diagram on the blackboard, similar to the one illustrated, with the children. Then allow them to invent symbols to designate the class members.



In the above diagram, Mary would now be A-1 and Bobby B-4. After the children have experimented with the code, suggest that they all leave their seats and then by allowing one child to call-off various coded locations, see if the children can return to their seats when their coded designation has been called.

Note to teacher: It is not necessary to remain with this code. Any that the children suggest should be tried, provided that they are practical.

12. Leading Question: <u>How are seeds different?</u>

Materials: Envelopes containing different kinds of seeds

Procedure: Distribute a variety of envelopes containing different types of seeds to each group of children. By carefully observing the seeds and noting their names, encourage the children to group them in some meaningful manner.

Note to teacher: The children should be able to devise many ways to group the seeds such as by color, by shape, by type of plant, etc.

13\. **Leading Question:** What makes objects bounce?

Materials: Rubber balls, pieces of board, slate, sponge, asphalt tile

Procedure: Allow the children to place the various types of surfaces on the floor. Encourage them to predict which surface is the hardest and the softest. Drop the balls on the surfaces. What happens to the height of the rebound on the different surfaces?

Try estimating the height of the rebound. Can it be measured? How? Suppose the size of the ball is changed. What happens? Vary the type of balls used. What happens then?

14\. **Leading Question:** How will the height from which a ball is dropped affect its bounce?

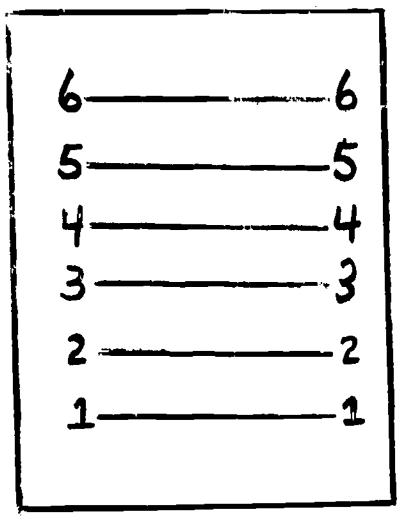
Materials: Five or six balls of various sizes and weights such as a golf ball, a tennis ball, a rubber ball, etc., brown wrapping paper, colored crayons, heavy sewing thread

Procedure: Drop the various balls, one at a time, and allow the children to view one complete bounce of each ball. Ask them to describe what they see. How did the ball rebound? Did it spin? Did it change its shape?

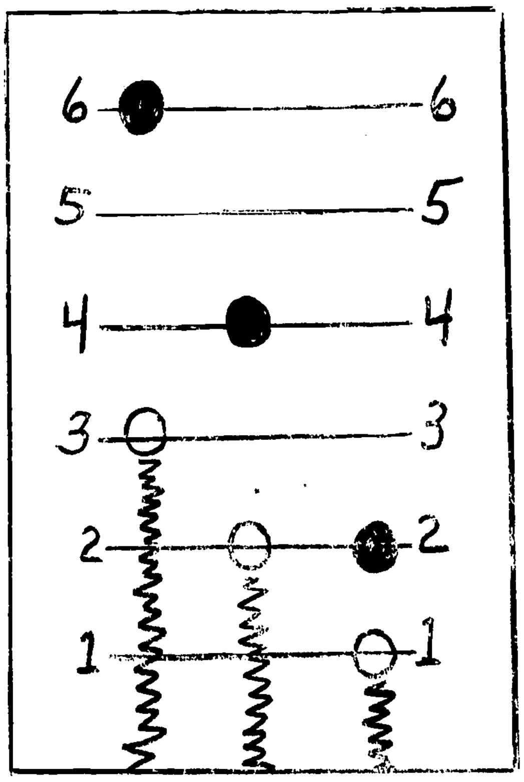
Vary the surfaces onto which the balls are dropped. How is the bounce affected? How can it be described?

Allow the balls to bounce several times. What happens to the height of the bounce as the ball bounces more than once? Is the height from which the ball is dropped related to the height of the first bounce in any way? How?

To provide the children with an opportunity to test their ideas, divide them into groups of four and five. Then fasten a sheet of brown wrapping paper to the wall, near the floor, for each group. Place the following information on the paper at equally spaced intervals as shown in the illustration.



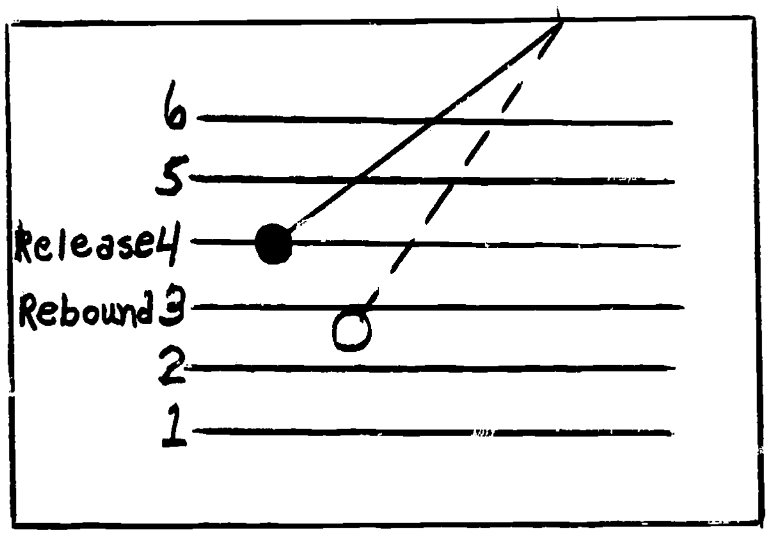
The children should begin their activities by first dropping one ball from the various lines on the chart, e.g. the 6-line, the 4-line, and the 2-line. As the ball rebounds, the children should note the height of the first bounce, first with their hands and then with colored crayons. Their charts should develop similar to the one noted below:



A Tennis Ball

Encourage them to proceed by trying to predict how far the ball will bounce from various other levels. Continue the activity by testing various other balls.

Another variation to this activity can be made by fastening a ping-pong ball to a length of string and then suspending the string from the top of the blackboard. Try testing the bouncing power of the ping-pong ball by holding it perpendicular to the board and then releasing it. Then allow the ball to swing as a pendulum. Note the height at the rebound. Allow the children to predict the height of the swing at the rebound. The data could be recorded as follows if desired:



Vary all procedures with the different types of balls and the complexity of the scales the children can devise.

15. **Leading Question:** How is the thermometer like a number line?

Materials: Learning Laboratory K105 number line, giant thermometer

Procedure: Refer to accompanying manual for number line activities.

Compare number line to thermometer. (Guide children into the discovery that a thermometer is a vertical number line.)

Extended Study: Introduce positive and negative numbers using the number line. Relate positive and negative numbers to the thermometer.

16. **Leading Question:** How tall are fifth graders? How can we find out?

Materials: Yard stick, meter stick, poster board, felt markers (several colors)

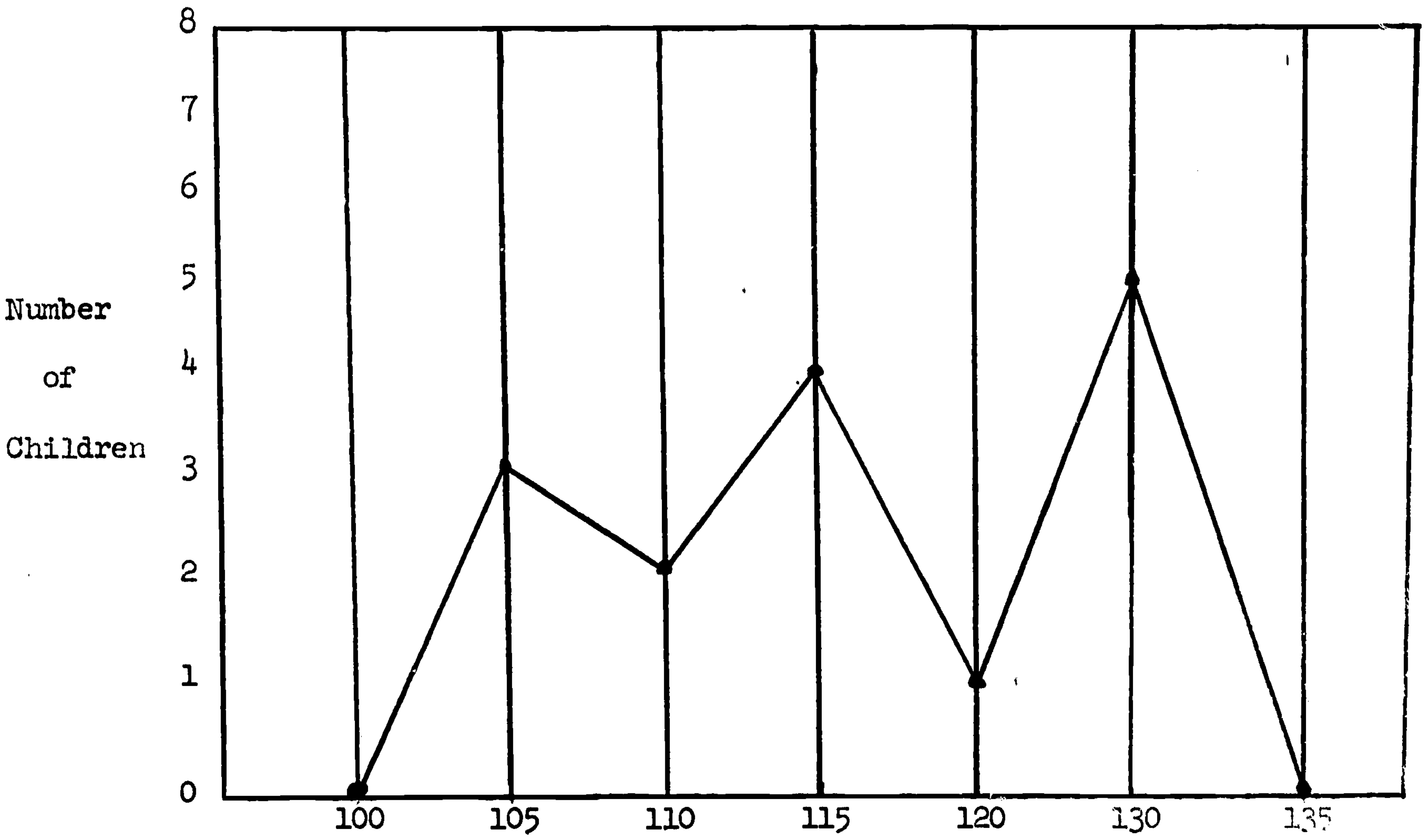
Procedure: Allow discussion and speculation regarding the average height of fifth graders. The children will probably suggest measuring as an accurate way to find the answer. Separate the children into small groups for measuring themselves using first the yard stick and later the meter.

The information should be charted in a variety of ways. The following are only suggestive:

Table of Height in Centimeters

Child	1	2	3	4	5	6	7	8	9	10
Height in Centimeters										

Height in Centimeters



Conclusions may be drawn such as: All members of the class are between 100 and 130 cm. tall and nine children are between 115 and 130 cm. tall.

Extended Study: The height of girls may be compared to boys. Compare other classes. Estimate average height in room. Compute the average.

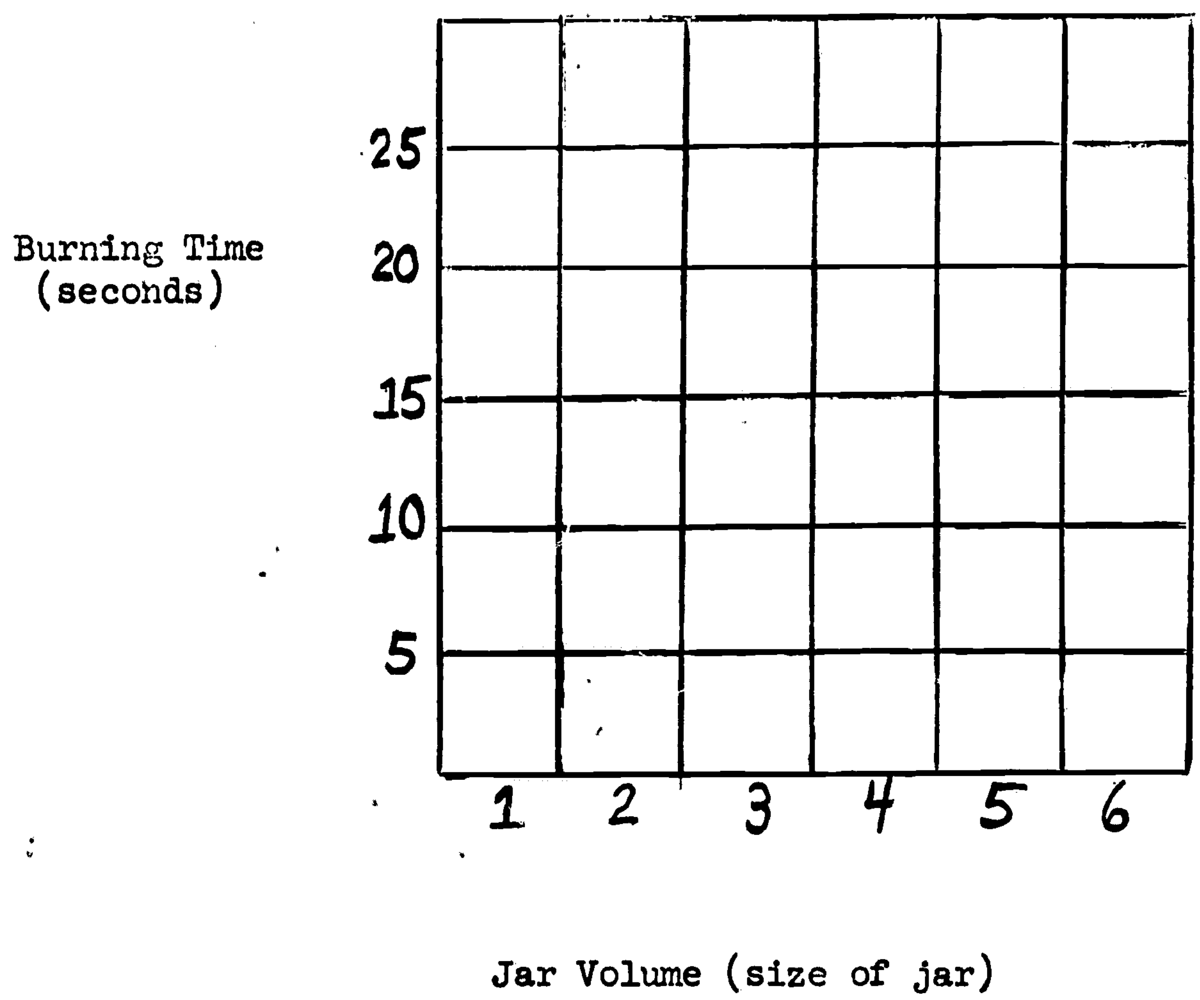
17. Leading Question: <u>Why do some candles burn longer than others?</u>

Materials: Various size candles, glass jars of different sizes, stop watch

Procedure: Give each group of children a candle. Light the candles and discuss what keeps the candles burning. Ask what might happen if a jar is placed over the flame? Have the children try it. Then have them predict how long it will take for the flame to be extinguished. What factors must be considered? Try timing the process with a stop watch.

Continue the activity by having some groups of children using different size jars and various size candles. How do the results differ?

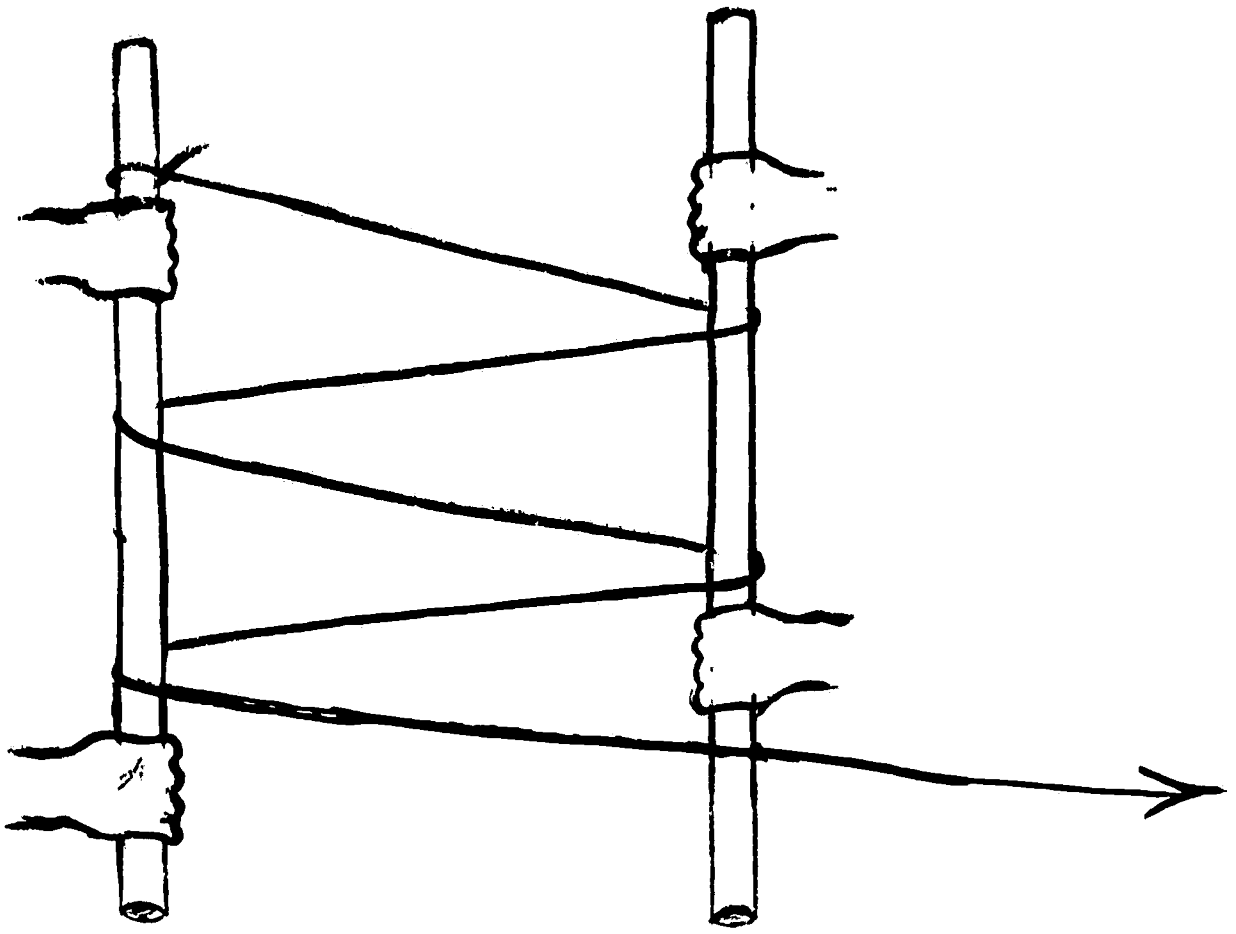
Suggest to the children that the various results could be best compared by using a graph. Encourage the children to devise one or use one similar to the one below.



18. Leading Question: Who is the strongest?

Materials: Two round sticks (e.g. broomsticks), a piece of clothesline

Procedure: Select two pupils and have them each grasp hold of a broomstick. With the children standing a few feet apart, tie a length of clothesline cord to one of the sticks and wrap it around both sticks so that a combination of pulleys is formed. See illustration below.



Ask a third pupil, smaller than the other two and preferably not as strong, to pull on the rope. The child will easily pull the two sticks together despite the efforts of the pupils holding the sticks. Discuss why?

Note to teacher: Using their knowledge of pulleys, the students should be able to infer what happens and why.

19. Leading Question: What causes fog?

Materials: Two glass milk bottles for each group, ice cubes, hot and cold water

Procedure: Arrange the children into groups so that each group will have two glass jars. Allow them to fill the one bottle with hot water. Then have them pour out most of the water, leaving about two inches in the bottom. Place an ice cube on the mouth of the bottle and have the children note what happens. Now have the other bottle filled with cold water in the same manner and place an ice cube at the opening. Why does fog form in one bottle and not the other?

Extended Study: Some children might be interested in further research as to the causes and effects of fog and air pollution.

20. Leading Question: <u>How fast do different substances settle in water?</u>

Materials: Quart jars with lids, various insoluble materials such as gravel, sand, rice grains, chalk dust, ground coffee

Procedure: Place various insoluble materials in quart jars and distribute the jars to the children. Encourage the children to discuss which substances will settle first. Why? Now have them shake the jars and watch the rate of settlement. Which settled first? Why? Suggest timing the procedure and graphing the results.

Next, have the children try mixing two substances together? What happens to the rate of settlement? Which settled to the bottom first? Why?

Vary the materials used in the jars. Allow the children to bring in other insoluble substances. The activity can be varied in a different manner by adding two liquids of unequal densities.

21. Leading Question: <u>What properties does a drop of water exhibit?</u>

Materials: Paper cups, small bowl, paper towels, food coloring, wax paper, pencil, birthday candles, soap chips, fountain pen

Procedure: What happens when a paper cup is placed mouth upward in a bowl? When the cup is pressed down with the hand what happens? Why?

Touch a colored drop with a paper towel. What happens? Why is a paper towel used when something is spilled?

Place several drops of water on a piece of wax paper. Hold the wax paper vertically and watch what happens. Do the small drops run down? Do the large drops run down? Which move faster? Why?

How would you describe the shape of a drop of water? Will it take this shape on a piece of paper? On a piece of wax paper? Why not? Look at the shapes of a small and a large drop of water. Are they the same? Why not?

Push some small drops together on a piece of wax paper. As the drop becomes larger, what happens to the rate at which it will move?

Touch a drop with the tip of a pencil. What happens? Why?

Poke a drop with the pointed tip of a small birthday candle? Does the drop seem to have a "skin" that cannot be penetrated? Do any insects have such a coating? (Water insects have this coating on their legs to aid them in moving over the water.)

Place the tip of a pencil in contact with one part of a drop and then move the pencil. Does the drop split apart or does it try to hold itself together? Why?

Apply a speck of soap or detergent powder on a drop of water. What happens to the drop and the paper? Why does soap make a better cleansing material than just water?

Place the wax paper over a printed page. Place some drops of water on the wax paper and then look at the print. Does it appear larger? Why? Try different sizes of drops.

Leave a colored drop of water on the wax paper overnight. What happened to the color? To the water?

Touch the top of a drop of water with the tip of a fountain pen. Does it leave a speck of ink on the drop? How many ink specks can you place on the drop?

Note to teacher: This activity is best illustrated by working in very small groups.

22. **Leading Question:** <u>How are standards of weight established?</u>

Materials: Balance scale, glass jars, weights, marbles, small nails

Procedure: Provide each group of children with a balance on which has been placed a weight on one side and an empty jar on the other. Have the children try to estimate how many nails it will take to balance the weight. Now try a larger weight. Does it still balance? Why not?

Count the number of nails in a jar and then place the same number of marbles in a jar on the other side of the scale. Does it balance? Why not? Do all pounds contain the same number of members? Why not?

Continue the activity by using different objects as standards and comparing the number of members it takes to balance each.

Note to teacher: This same activity could be performed using the Metric System.

23. **Leading Question:** <u>How can shadows be made larger or smaller?</u>

Materials: Bright light or slide projector, balls, objects of various sizes, beaded screen

Procedure: Have the children hold the balls and the various objects in the light beam. How do their shadows appear? What happens when the objects are moved closer to the source of light?

Now try cutting out circles of various sizes. Hold them in the light beam and begin moving them around. What happens to the sizes of the shadows? By moving the circles closer to the light, what happens to the size of the shadows? Try the light, what happens to the size of the shadows? Try holding a penny and a circle of a different size in the light beam. Can they be moved so that they will have the same size shadow? Continue with other objects and various size coins.

Now cut some circles in half. Taking different size halves, can they be moved so that their shadows form a complete circle? How?

Place a hole in a circle. Hold the circle in the light beam. Can the hole be made to appear larger and smaller? How?

Encourage the children to try various shapes and positions with the shapes. The entire activity can be varied by moving the light source.

Note to teacher: This activity can be done individually by using a shoe box and a tiny flashlight.

24. **Leading Question:** <u>How many ways can a balloon be inflated?</u>

Materials: Balloons, hot plate, small pan, test tubes, candles, bottles

Procedure: Provide each group of children with an empty bottle and a balloon. Ask the children how they could use the air from the bottle to inflate the balloon? Allow them time to test their guesses. Suggest placing the balloon over the bottle and placing the bottle in a pan of water. Begin to heat the water. What happens? Why?

Try varying the size of the balloons and bottles. Does it make a difference in the rates of inflation. Time it.

In what other way could a balloon be inflated? Encourage individual experimentation.

Note to teacher: Another method that can be employed to inflate the balloon is to place it on the end of a test tube that contains a burning candle.

25. **Leading Question:** <u>How do scientists determine the size of populations?</u>

Materials: Large glass jars, dried beans, marking pencils

Procedure: Place a bagful of beans in the glass jar. Ask the children for suggestions in counting the beans. Why isn't guessing satisfactory? Why not count each one?

After the children have discussed various ideas explain the following method of estimation. Take one handful of beans from the jar and count them. Before placing them back into the jar, mark each with the marking pencil. Now mix all of the beans thoroughly. Take another sample of the beans from the jar. Record the total number of beans, as well as the number of beans that contain the markings. (Sample: If there were 60 beans in your first handful, which were then marked and placed back in the jar and your second handful contained 45 beans in which three were marked, there should be about one marked bean for every 15 unmarked ones. Since 60 beans were originally marked multiplying 60 times 15 gives you the approximate total bean population.)

This activity can now be varied to include different size jars, as well as various materials to be placed in the jars.

Note to teacher: A simple variation of this is to count and mark the number of insects living under a rock and then estimate the insect population for that area.

26. Leading Question: Does it work?

Materials: Four pencils, two sheets of construction paper, one piece of aluminum foil (12 x 12 inches), ten thumbtacks, five rubber bands, ten paper clips, one cardboard square (12 x 12 inches)-- for each child or group of children

Procedure: Have the materials ready and tell the children that the materials are to be used to construct a workable piece of equipment. The only condition placed upon them should be that the apparatus must be able to perform, as well as demonstrate a scientific principle. Only the materials given should be used, although they can be cut, bent, or treated in any way.

The children will be limited only by their own creativity. All sorts of devices can be anticipated, such as a windmill, sailboat, or bird cage to name a few. Allow time for each child to discuss and demonstrate their finished product.

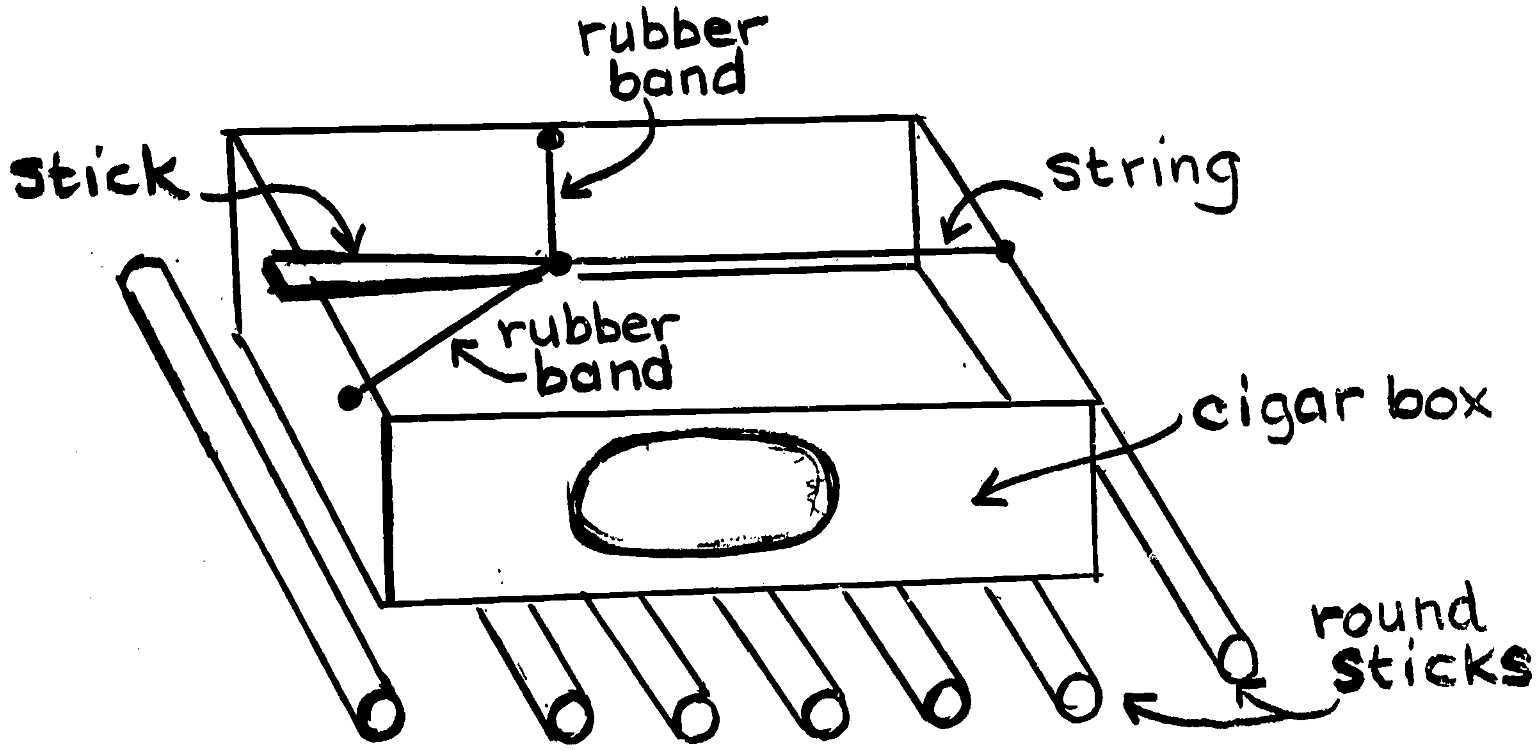
Note to teacher: The teacher must decide whether the students are to work individually or in small groups, and the amount of time that will be allowed for experimentation and construction.

27. Leading Question: What makes a rocket move?

Materials: Six empty cigar boxes, soda straws, 6 rubber bands, thumbtacks, several feet of string, safety matches, several sticks of various sizes from $\frac{1}{4}$ inch and 1 inch wide and $\frac{1}{2}$ inch thick, rulers, meter sticks

Procedure:

Divide the class into five or six different groups. Furnish each group with a cigar box, several straws, a rubber band, three thumbtacks, safety matches, a stick, a piece of string 12 inches long, a ruler, and a metric stick. Put the materials in an order as shown by the illustration.



Using the string, pull the rubber band taut, much as the rubber on a slingshot is pulled taut by the hand. When the string is burned in two, the rubber band will hurl the stick forward. (Only a few feet) What happens to the cigar box?

Measure the distance the cigar box (Rocket) moved when the stick (Fuel) was released. Use both the standard ruler and the meter stick. Did all the boxes move the same distance? Which ones moved farther? Less?

The children might then want to try more of this experiment using different sticks.

28. Leading Question: <u>Why don't icebergs sink?</u>

Materials: Equal balance scale, ice, marking pencil, six paper cups, several magnifying glasses

Procedure: Drop an ice cube into the glass filled with water. What happens? Recall that the ice is frozen water. Why doesn't it sink?

Examine pieces of ice. Crack a few ice cubes into pieces and carefully examine them with the magnifying glasses. Could ice be lighter than water?

Label three cups A, B, and C. Fill the paper cups with different amounts of water. Use a marking pencil and mark the water line on each cup. Put the water-filled cups into the freezer compartment of the refrigerator. When the water is frozen, look at the pencil marks on each cup. What happened to the water?

Label three more paper cups A, B, and C. Fill them with the exact amount of water as indicated on the water line of the other cups. Set cup A of water on one end of the balance scale and cup A of ice on the other end of the scale. What happens to the balance scale? Which is heavier, the cup of water or the cup of ice? Repeat this procedure with the other cups labeled B and C.

Note to teacher: Have the children practice their scientific reporting by recording this experiment.

29. Leading Question: <u>How far is a second?</u>

Materials: Ring stand with clamp or Welch Mechanic Kit (see illustration), or the horizontal bars on the rolling laboratory table, make a second pendulum. Attach a fairly heavy pendulum (two pound weight) to one end of a piece of light guage wire three or four feet long. Fasten the end of the wire to the support rod of the stand or table permitting the pendulum a free swing. Adjust the length of the wire until the pendulum makes one swing per second. Secure it firmly. What is the distance between the support bar to the center of the pendulum?

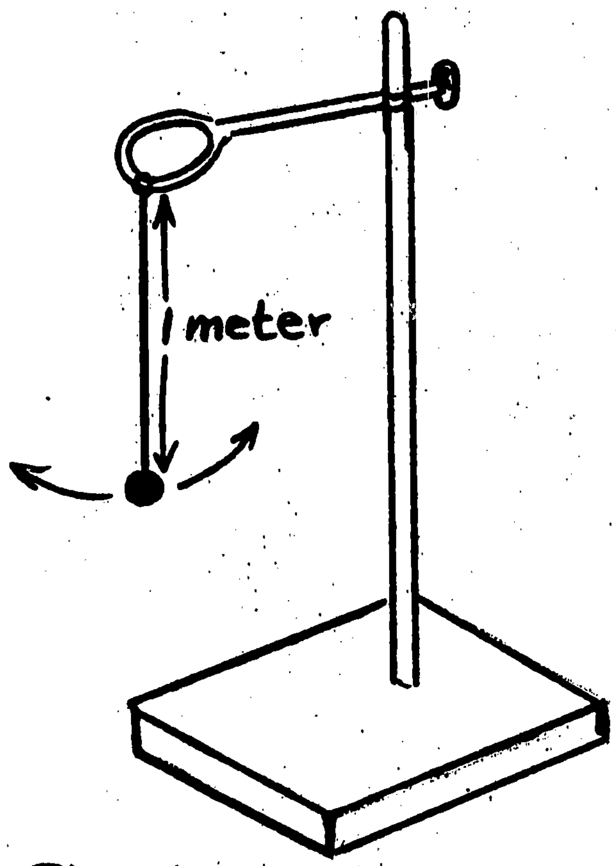
Once the children have determined the length to be exactly one meter, have them experiment to find how long the wire must be to produce a

SCIENTIFIC METHOD

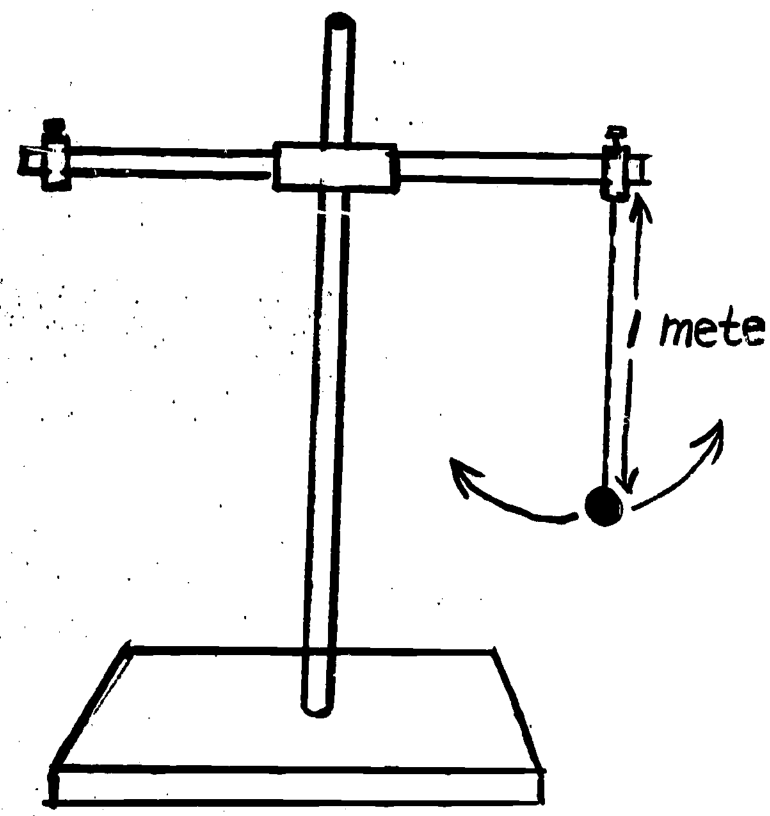
GRADE 6

swing of two seconds duration. A swing of one-half second duration is how long?

Extended Study: Perhaps some of the more able students could apply this activity to encompass the swings on the playground.



Ring Stand with Clamp



Welch Mechanics Kit

SCIENTIFIC METHOD

ACTIVITIES

Grade 6

1. Leading Question: How much does it weigh?

Materials: Materials of any size and composition.

Procedure: Have children guess weights of various objects before weighing them with the hand scale. Have them review some guidelines before they start guessing; paper is light, solids are heavier than hollow pieces of same material, etc.

2. Leading Question: Can both ends of a magnet do the same thing?

Materials: Long bar magnet, several small bar magnets, tape

Procedure: Have a group tape one end of the large bar magnet. Which end of the small magnet is pushed away (repulsed) by taped end of large bar magnet? Do the same with other small bar magnets. Will taped ends of small magnets pull (attract) or push away? Will opposite ends act the same way?

The group might try attaching magnets to one another, forming a train progression to formulate statements about magnets and different ends.

Note to teacher: Make sure children understand that magnetic forces are at work and responsible for the attraction and repulsion and that no adhesives are applied.

3. Leading Question: Am I plant or animal?

Materials: Children volunteers, scarf for blindfolding, rope for tieing feet, bits of construction paper

Procedure: Have a child volunteer to stand in front of the group while the teacher asks if volunteer is plant or animal. Teacher asks why to the response of animal. Here, children will need to know differences between plant and animal. They can get very technical. Some of the hasty responses might be movement, visual ability. Now have class try to make a plant out of the animal by using the materials above. The differences and similarities could lead to further study of plants and animals.

4. Leading Question: **<u>What are good living conditions?</u>**

Materials: Shoebox or cardboard box or cigar box, soil (dirt, sand, humus), earthworms, beetles, and any other animals children can collect for this type of discovery

Procedure: In crosswise sections of the box, put as many sections as kinds of soil the group has to work with. In lengthwise sections, divide the box in half into wet and dry soil. Place insects and animals into the container of different types of wet and dry soil. Then study the length of time creature takes to settle in each type of soil. Do same with other animals and record results. Have children check on facts as to why settlement was slow, hasty, or maybe no indication for settlement was evident at all.

5. Leading Question: <u>In what direction do seedlings grow?</u>

Materials: Shoebox or long narrow cardboard box, sprouting potato, pot of soil, tumbler gardens

A. Procedure: At one end of the box, place the planted sprouting potato plant. Cut a circular hole in the opposite end of box. Arrange baffles or barriers so that the vine must turn several corners and not grow in a straight line to reach the light.

B. Procedure: Directions for making a garden tumbler: Cut a rectangular piece of blotter and slip it inside around the drinking glass. Fill the center of the glass with peat moss, cotton excelsior, sawdust, or some other similar material. Push a few seeds between glass and blotter. Keep a little water in bottom of glass.

Select one of the tumbler gardens that contains one or more vigorous seedlings. Tie string around glass securely so that it will suspend when inverted. Observe what then happens to seedlings and growth of plant.

6. Leading Question: <u>Can you measure correctly?</u>

Materials: Milliliter graduated columns and beakers, water

Procedure: Provide each group with 0 - 50 ml. columns and 100 - 500 ml. beakers. Have children examine markings on each. Let each one give each other a required amount of water to put into the beaker and have each leader check to see if student is able to read and measure required amount. Have them read aloud the volume of liquid by units on the number lines.

7. Leading Question: How accurate a number judge are you?

Materials: Jars or cups of same size for measuring, scale, objects such as: tennis balls, lollipops, buttons, sugar cubes, pictures containing same object, wrapped hard candies, small magnets, toothpicks, infinite number of peas, beans, rice, etc.

Procedure: The teacher might begin by holding up picture (s) with several objects, preferably large, of same kind and ask students, randomly, for a guess. Teacher may continue with the larger objects (preferably of same size) then progress to smaller objects then to greater quantities from the larger to smaller objects. Record range of answers. Some students may take an accurate count and record to see how close their judgment is. It is important that this be continued with objects of same size in smaller quantities until near accuracy is achieved before the groups tackle smaller objects and greater quantities. Teacher might divide class into small groups and see that each group gets a piece of dark construction paper to accurately see and count quickly the smaller particles, as beans, peas, and rice. Then each group might choose one or more to estimate while someone else takes an accurate count while still another does the recording of the estimate and accurate answers on paper. Teacher can then take a handful of particles and have estimates given, then put same particles on construction paper to give students a chance to see them spread out if they care to change their minds. Then the counter can count and recorder can compare estimates with accurate count.

With some of the objects, some might want to weigh to reach an estimate. Some might want to square off objects and count objects along one edge and square this number to get an estimate of total number (good in aiding students to find area of square or rectangle).

Students can estimate numbers by getting a number using ratios. Children might suggest if they know how many peas, for example, fill a jar, they can figure how many rice grains will be used to fill the same jar. They will judge how many grains of rice fit the size of a pea and slowly fill a jar with peas and a jar with a proportionate number of rice grains. Children can incorporate ranges of estimates by using symbols > for greater than and < for less than. They will probably want to round off numbers when using small particles as rice grains. A picture with same objects on it may be compared with another picture with a multiplicity number as same object and questions can be asked. Which has the greater number? Does one picture have twice as many of (whatever picture contains) than other picture (with whatever picture contains) has?

8. **Leading Question:** <u>What makes a bean ready for germination?</u>

Materials: 2 lb. package of great northern or single-size lima beans, large coverings for pans, water containers, water, scale

Procedure: Divide class into groups, so that there are at least two groups working with same variables so comparisons can be charted and possible conclusions drawn. Any even-numbered groups will do; the more groups, the more experimenting, the more concluding. Pass out beans, starting with 50 in two groups, then pass out an additional 50 beans to two more groups, etc. Place the beans in a single layer, leaving a little space between each. Add 200 milliliters of water to each pan. Retard evaporation by covering one of the pans in each group overnight. Drain the remaining water, if any, in the uncovered and covered pans the following day. Observe the change in the beans in each pan. Have the students record information on differences of results and the 200 milliliters of water. Compare the results between the number of beans and the amount of water. Each group that started with the same number of beans will want to compare results and discuss reasons for variations (differences in bean sizes, bean distribution of beans, differences in beans covered and uncovered, and other variables the students might choose to use.)

9. Leading Question: What happens to light as it passes through substances?

A. Materials: Cup, coin, water

Procedure: Divide the class into groups of four. Have each student experience activity. The student who acts as experimenter sits at his desk with his head supported by placing his hands under his chin with elbows firmly on desk. Only the eyes may move from side to side. Put coin in bottom of empty cup and move cup across desk top (straight horizontal line) until coin is visible. Continue moving cup until coin cannot be seen. Do the same with a cup filled brimful with water. When was the coin seen more? (It was when water was in cup. Light traveled in straight line in empty cup and eventually the side of the cup obstructed the view of the coin as the cup was moved farther away. Light is bent when passing through one substance to another. Light reflected from coin through water to the eye.) Children might prove this by measuring with ruler the distance from the place on the desk at which the coin becomes visible to the eye, to the place on the desk where the coin becomes totally invisible in both the unfilled and the water-filled cups.

B. Materials: Drinking glass, water, pencil

Procedure: Fill glass halfway with water, then stand pencil in glass. What is the pencil's appearance where it meets with water? (Appears bent.) What is the appearance of the pencil above the water? (Straight.)

10. Leading Question: How can we see ourselves as others see us?

Materials: Two mirrors

Procedure: Place the two mirrors together so that their edges form a right angle. Look into the corner formed by the mirrors. Check closely at the images seen. How are they different from the images actually seen? (When motions, as winking, are performed, one mirror reverses the motion while the second mirror reverses the image of the first mirror.) Several activities can be used with the mirrors.

11. Leading Question: **Does a person really see himself as he actually is?**

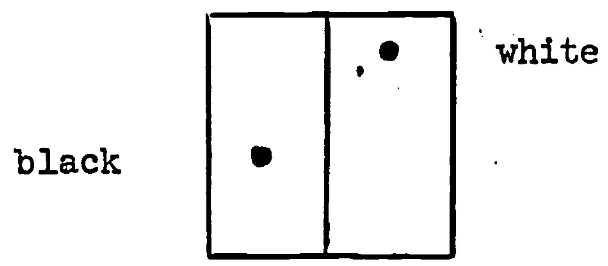
Materials: Table mirror or long mirror if available, needle, thread

Procedure: Sit at desk with table model mirror on desk top. Pocketbook-sized mirrors will work, but they need to be propped so slippage and breakage will not occur. What happens if a student touches the mirror with the right hand? Does the mirror image reach out with its right hand? (No, image in mirror is reversed.) Wink with left eye. Which eye winks back? (Right) Thread a needle, or use any activity which requires accuracy, by watching image in mirror. (Encourage the students to understand difficulty presents itself for plane mirrors reverse actions of performers.)

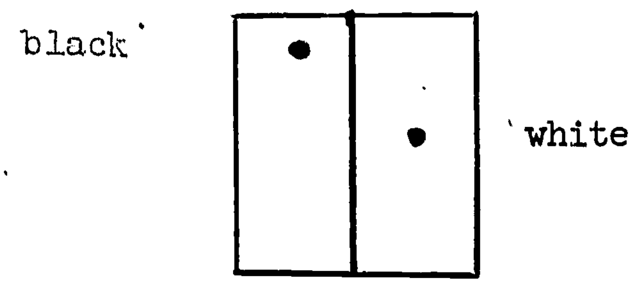
12. Leading Question: **Can you really see?**

Materials: Depth perception box (available from Central Science Library), stop watch

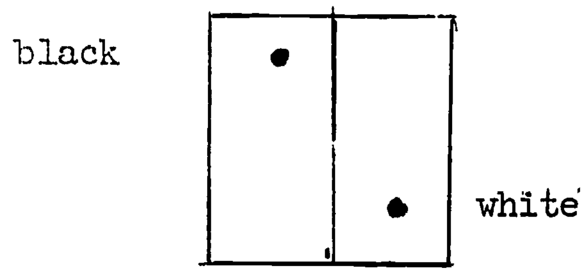
Procedure: Position yourself so that you only see the white and black sticks and not the divider in the middle. Position white stick approximately two inches from back of box. Allow each person to take one practice timed trail using both eyes. Manipulate strings so as to position the black stick adjacent to the white stick.



Position sticks as shown in the diagram. If you are right-handed, close right eye, and manipulate strings so as to position the black stick adjacent to the white stick. (If you are left-handed, close left eye.) Record time until subject feels he has sticks matched.



Position sticks as shown in the diagram. If you are right-handed, close right eye and manipulate strings so as to position the black stick adjacent to the white stick. (If you are left-handed, close left eye.) Record time until subject feels he has sticks matched. Use stop watch.



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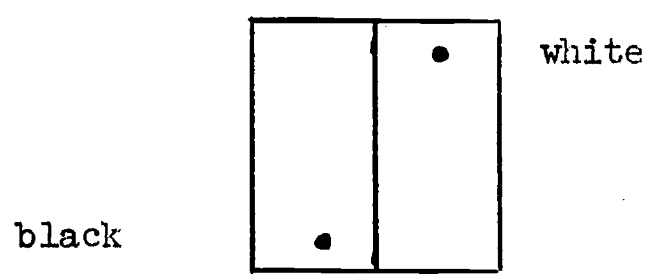


Record information on the following chart:

REACTION TIME IN DEPTH PERCEPTION

OBSERVATIONS

Name ______________________________

	Problem 1	Problem 2	Problem 3	Problem 4	Average*
Time					
Distance Error					

* Average only Problems 2, 3, and 4.

Author: John D. Trout III
School Psychologist
Bethlehem Area Schools

Extended Study: Compare and contrast individual scores.

13. Leading Question: How solid is milk?

Materials: A quart of skim milk, one cup white vinegar, double boiler, electric hot plate, several glass jars, plastic wrap, cheese cloth, sieve

Procedure: Put some skim milk in a glass jar and cover it tightly with plastic wrap. Place this jar in a warm place. What happens to the milk? How long does it take to come apart? Is it smelly?

Heat some water in the bottom of the double boiler. Put one measuring cup of skim milk into a clear glass jar and submerge this milk into the hot water for five or six minutes. Remove the jar and mix one-fourth cup of white vinegar to the milk. What happens?

Separate the curds (thick part) from the whey (water part) by pouring the mixture through a sieve. Place the curds on a piece of paper toweling and spread them out on a flat surface to dry. Do they feel different from the wet curds? What does the whey look like? Strain it through several thicknesses of fresh cheese-cloth several times. What color is it? Heat the whey in a double boiler. What happens to it? Cool the whey in the refrigerator and then reheat it. Do this several times until the remaining part of the liquid evaporates. What remains? (Milk sugar).

Extended Study: Some of the children may want to do research to find out what the casein (from the curds) and milk sugar (from the whey) can be used for. How does the body use these elements?

14. Leading Question: <u>What number system do computers use?</u>

Materials: Learning Laboratory K 112 Base and Place

Procedure: See manual which accompanies the Learning Laboratory.

Note to teacher: Most computers operate on the binary number system or Base 2.

Extended Study: After understanding of the binary system, individuals or the class may wish to try adding, subtracting, multiplying, and dividing in base 2.

15. Leading Question: <u>Are all soils the same?</u>

Materials: Samples of as many different types of soil as are available; i.e. soil from the school yard, the home garden, soil from around a tree, from the banks of a river or creek, from a roadbed, from the beach, from the mountains, from a field

Procedure: On a table or other flat area, arrange the soils into the classifications or groups the children suggest.

Note to teacher: Some possible suggestions for classification are:

a. color
b. texture
c. acidity (This can be tested with the soil testing kit)
d. geographical location

16. Leading Question: Which balls exert the greatest pressure when they strike an object?

Materials: Several balls varying in size, shape, weight, and composition, two or more sheets of corrugated cardboard, books or large blocks, a cardboard box, metersticks, ruler or yardstick, chalk, crayon, graph paper

Procedure: Make an inclined plane with the corrugated cardboard strips and the blocks. Roll the balls down the incline plane two at a time. Compare the times each ball takes to roll down the incline. Which ball took the least amount of time? Which ball took the most amount of time?

Note to teacher: Size and weight have nothing to do with the time it takes for an object to fall. All of matter is pulled with an equal force. When gravity pulls on an object, the pull is the same, ounce for ounce or pound for pound, regardless of the object.

Once the children have determined that the balls have rolled down the inclined plane with the same rate of speed, place the box at the bottom of the inclined plane. Now allow the children to roll each ball down the plane until it hits the box near the center of the base line. What happens? Mark the floor with a crayon or piece of chalk to indicate how far each ball moved the box. Which ball moved it the farthest? The least? Use a bar graph to record the conclusion of this test. Measure it with the meter stick and again use a bar graph to record your data.

Next raise the higher end of the corrugated cardboard plane by putting more books or blocks under the one end. Repeat the two previous procedures.

Change the weight of the cardboard box by putting rocks, pieces of wood, or other heavy objects on the top of the box. Again, roll each ball into the box. Record the results on the bar graph. Raise the angle of the inclined plane and again roll each ball into the box. Interpret this data on the bar graph.

17. Leading Question: What makes a rocket fly?

Materials: Broom, two chairs, glass bottle, two long strings, cork for bottle, funnel, two tbs. baking soda, $\frac{1}{4}$ glass of vinegar

Procedure: Place broom across the top of two chairs. Hang the bottle from the stick with the long strings. Have bottle a few inches from floor. Put the soda into the bottle and then with the aid of the funnel, pour in the vinegar. Place cork, not too tightly, into bottle. Observe results. Why does the cork pop off? Why does the bottle swing backward?

18. Leading Question: Does soap really clean clothes?

Materials: Test tube, water, cooking oil, soap powder

Procedure: Put an inch of water, then an inch of oil into the test tube. Close the end of the tube with your thumb and shake the contents well. What happens to the oil? (It forms drops, but blends together quickly and oil then gathers on top because it's less dense.)

Repeat same experiment but dissolve $\frac{1}{2}$ tsp. of soap powder in half cup of water and put an inch of this solution in the test tube. Now add an inch of oil. Shake it. What happens? (Solution keeps drops suspended in the water. Soap breaks up the grease film from your clothes so the dirt can be washed away.)

19. Leading Question: Why doesn't the Empire State Building topple?

Materials: Pencil, box, marble, tape, books, two forks, nail, cork

Procedure: Lay a pencil on the table and observe what happens. Now, stand its point and predict what will happen.

Get a round box with a flat edge and one that can roll. A cardboard cheese box works well. Fasten a marble with tape to the inside rim. So you know where the marble is, put a mark on the outside of the lid. Place one book on another to form a slope. Hold the box near the top of the slope, with the hidden weight a little on the downhill side of the box. In which direction will the box roll? Now, place the box near the bottom of the hill, with the marble weight a little on the uphill side. Now predict which way the box will roll. (Up the hill.) Why? (Center of gravity is where marble is attached. Center of gravity went down, but box had to roll up the hill for the weight to come down.)

Extended Study: Push a nail into a cork. Then stick a fork on each side of the nail. Put the nail on the rim of a glass and slide the nail slowly across the rim until the fork is balanced.

20. Leading Question: Does fire contain water?

Materials: Ordinary dinner knife, candle flame, cold water, towel

Procedure: Have a child breathe on the blade of a knife. Observe what happens. Chill the knife blade by running cold water over it, then dry it. Hold the blade for a few seconds and observe again the results. Why did a moist film appear? (When gaseous compounds of candle wax is combined with oxygen in air, water droplets are formed.)

21. Leading Question: How well can you guess?

Materials: Scale; any objects of different sizes, shapes, and weight; materials for recording

Procedure: Find the weight of each object. Permit each child to give an estimate of each object to be weighed, once they have weighed something to use as a standard. The difference in weights with each of the objects can be calculated by adding and subtracting. Do the same with the metric system, once the children have become acquainted with constituents of metric system. The students might use an object as a standard to go by when weighing same objects using the new system. Record results of estimating and accurate answers.

22. Leading Question: Which metals hold more heat? (Copper? Aluminum? Iron? etc.

Materials: Coins, foil, nails, balance scale (homemade), paper cups, copper pennies, sauce pan, burner, measuring cup, thermometer

Procedure: First construct a homemade balance scale (shown in the illustration) containing two balance cups.

1. Put six to eight pennies into one of the balance cups of the scale. Fold several large sheets of heavy aluminum foil into small lumps and place into the other cup until the scale is balanced. Heat some water on a stove. Remove the pennies from the cup and place the pennies in a small plastic bag with a string attached, so that you can drop them into the boiling water and remove them without burning your finger. While the pennies are warming up in the boiling water, pour some cold water into a measuring cup up to the $\frac{1}{4}$ cup line. Measure the temperature of the cold water and record it on the table as shown in illustration. Remove the pennies from the boiling water and lower them into the cold water in the measuring cup. Move the bag of pennies around in the cold water and watch for the recording of the highest temperature on the thermometer. Again record the temperature on the chart. How many degrees did the water temperature rise because of the hot copper? Now use the same procedure with other metals: aluminum, quarters, nickels, dimes, iron washers or nails, the new "sandwich-type" quarter. Each time your experiment is performed, record the temperature on the chart and make comparisons.

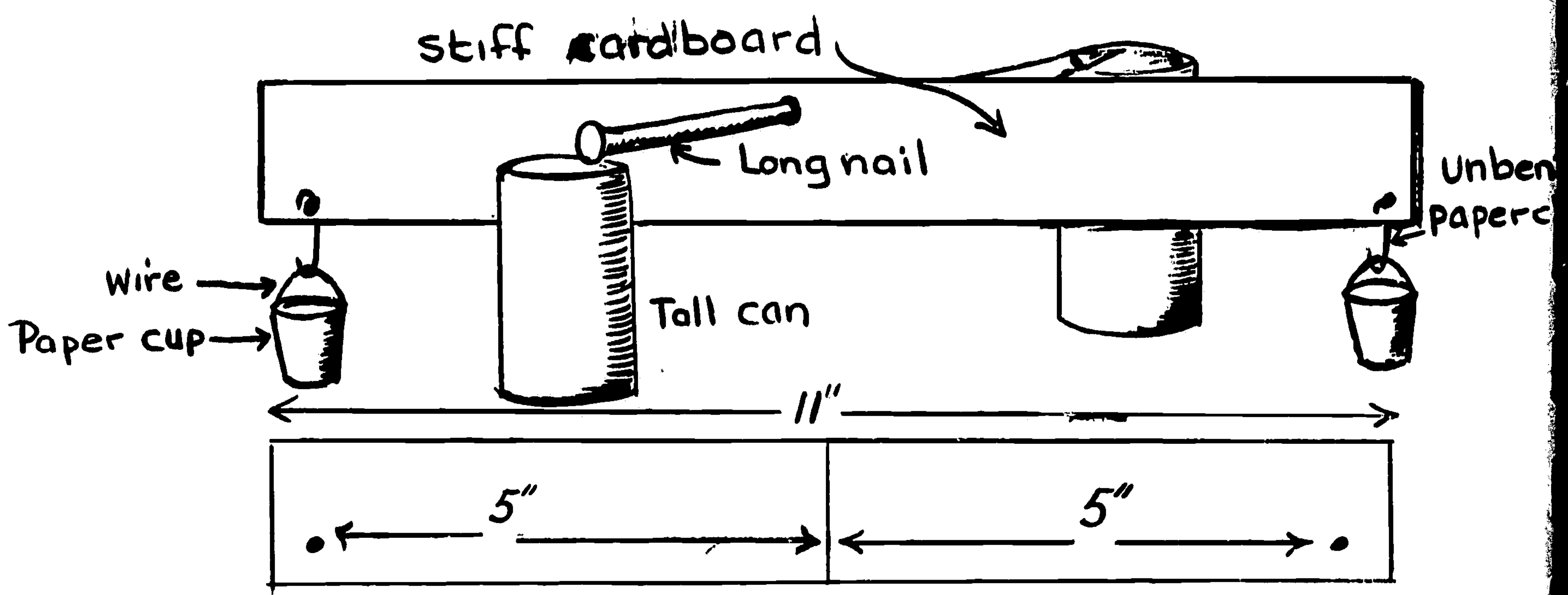
2. Try placing equal amounts of two metals in a freezer for a while and then add them to equal amounts of warm water. Which would cool the water? How would they compare with the cooling effect using an equal amount of ice water each time?

3. Which will melt more ice? To check up on your guess, place equal amounts of metal on some ice cubes and compare the holes they make.

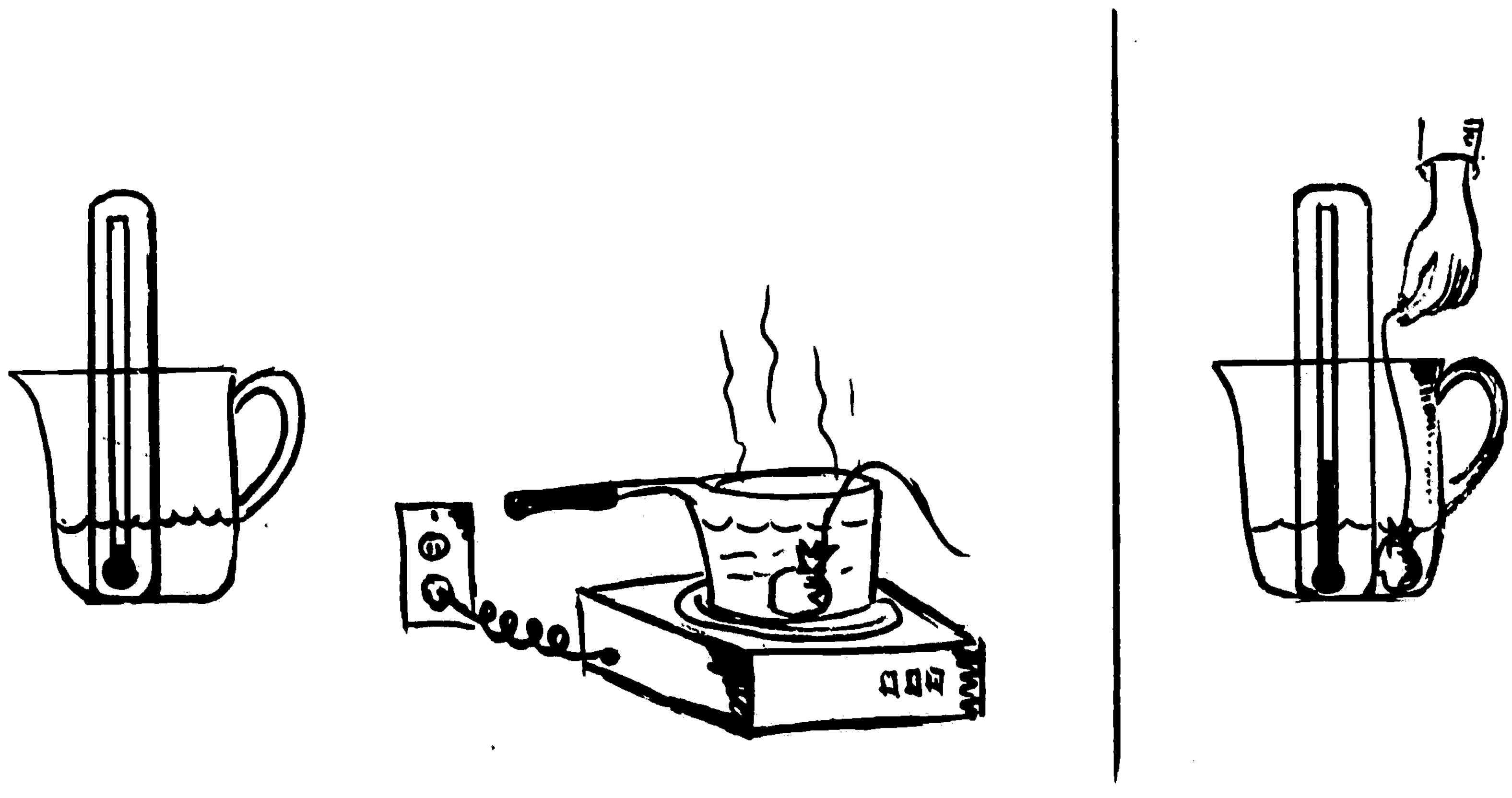
	Water Temperature		Rise in Temperature
	Cold	Heated	
Copper			
Aluminum			
Silver			
Nickel			
Iron			

Making a balance Scale: Cut a piece of stiff cardboard. Punch a hole in the center of the cardboard and insert a nail as shown in the diagram. Hang a weighing cup at each end of the strip of cardboard. Balance the scale on two tin cans until the beam is level.

Scale:



Experiment:



23. Leading Question: <u>Will objects of relatively the same size weigh the same?</u>

Materials: Scale, objects of same and different shape, ruler, meter stick, materials for recording

Procedure: Have the students measure all dimensions of an object and then estimate weight. Do this in both systems. See that they have some sort of an idea of something they can use as a standard to aid in estimating. Then have them weigh for accuracy. Let them record results to compare. Graphs can be used if variables are limited.

24. Leading Question: <u>How can heights be compared?</u>

Materials: Chalk, board, graph paper, pencil or crayon

Procedure: Have class choose several members to be measured. Plot results on board, using inches.

INCHES	BOYS
40	Ron
47	Don
53	Bob
61	Kurt

Which boy is tallest? Smallest? What is the difference in height of tallest and smallest? What is Don's height? Graph information, inserting numerals on horizontal axis and names on vertical axis or reverse placements.

Note to teacher: For neater work, omit every other vertical axis. Fill in one half of the block on either side of the vertical line used. Encourage child to read number line adverse to block counting.

How do you plan to numerate axis representing inches? Is it necessary to start with the numeral one? Does each axis have to progress by one inch? This can lead to a variety of written results which can be examined and discussed by all students.

This can be correlated with the metric system. Put a piece of paper on wall and designate with a marker the height of student measured. Height from floor to mark can be measured by meter stick, tabled, and graphed as above mentioned.

. Leading Question: <u>What makes differences?</u>

Materials: Musical instruments

Procedure: Have children bring in musical instruments. (Good activity on band day.) Let children group instruments into any kind of arrangement. Encourage varieties; size, compostition, type, sounds. Have children predict pitch of sounds by just examining instrument. Why does a shorter piano string have a higher tone than a longer string? Infer that when sound vibrations travel through a long string or tube, the pitch is low; when sound vibrations travel through a short string or tube, the pitch is high.

SCIENTIFIC METHOD

APPENDIX

PROBLEM SOLVING

MULTI-TEXTBOOKS

FIELD TRIPS

SOME HINTS IN THE SUCCESSFUL PRESENTATION OF EXPERIMENTS AND DEMONSTRATIONS

1. Experiments should be kept simple, using home made equipment wherever possible.

2. Children should be encouraged to think about the experiment. Telling children answers or reading the answers defeats the purpose of the experiment.

3. Involving pupils in the planning of the experiment is a good technique for motivation and provides children with insight into why experiments do or do not work.

4. Sweeping generalizations should not be drawn from one experiment - many experiments do not prove anything; they just help pupils understand an idea or question. For instance, just because a magnet picks up a nail, pupils must not say that magnets will pick up nails.

5. Pupils should be allowed to perform experiments insofar as is possible. Many science experiments need the other senses beside sight. For instance, feeling the force that a strong magnet exerts on an iron nail can be developed only through individual manipulation.

6. Insofar as it is possible the ideas gained through experimenting should explain things that happen every day.

7. It is not always necessary or desirable to have children "write up" each experiment as the results may be stultifying to developing natural interest in experimenting. However, teachers should be aware of the integrative value of science in the curriculum and should judiciously encourage written exercises in connection with science experiments.

8. In many cases it is best to work out experiments before showing the youngsters.

9. Don't be afraid to make mistakes - all demonstrations do not turn out as you plan.

10. Repeat demonstration because some children may be impressed by the showmanship. It takes time to develop science understanding.

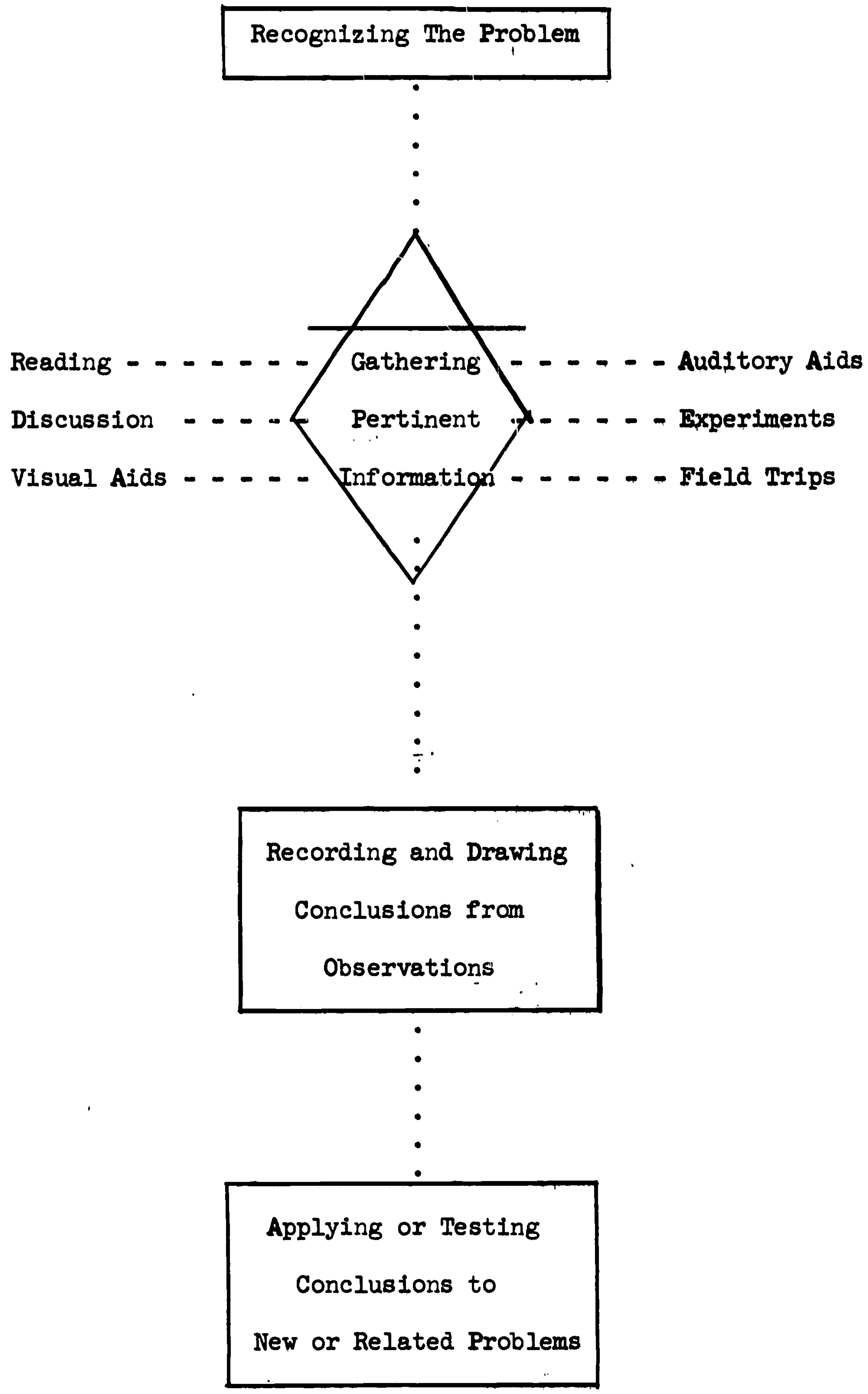
11. Any questions a child asks is an important one but don't answer every question - let pupils figure them out for themselves - let them experiment - "let's find out" attitude.

12. Allow children to draw conclusions - allow them to make decisions.

13. Encourage children to think about their answers - "show me what you mean" attitude.

Source: Hints 1-7: G.Blough & A Hugget: Elementary School Science and How to Teach It, Dryden Press, N.Y., 1951 pp. 23-42

STEPS IN PROBLEM SOLVING



Source: Elementary School Science
Lehigh County Public Schools
1959

CAN TESTING BE USED TO IMPROVE TEACHING?

We must find ways to measure the results of our teaching if the goal in science teaching is to develop understandings.

The basic goal for teaching science in the elementary school is to relate what they know to solving problems. Children grasp big ideas, the universal principles, only as they are put in situations where they must observe, test ideas, and think through what it is possible to believe. The very way science is taught determines to a great extent how we shall test and what is measured.

Asking quality questions is basic to good science teaching. By her questions the teacher should push boys and girls to a point where they do not know the answers, and then help plan activities to obtain them. Push children to a point where certain things the children believe cannot all be true.

At the close of an experience certain questions should be asked and adequate means for determining the answer should be found.

1. Has the child acquired and retained useful information?
2. Does he have an understanding of the principles involved?
3. Does he use his knowledge and understanding in daily life?

Source: Elementary School Science Bulletin, Number 51, January 1968.

The ordinary essay or objective-type test does not give answers to these questions. Consider the following approach.

I. State the question or problem: Why does a candle burn longer in one situation than in another?

II. Have the children relate their experiences with respect to the problem.

III. Demonstrate and experiment. Have 4 candles and three wide mouthed jars (or pint, quart, and 2 quart sizes). Place candles securely on glass or asbestos squares. Have children place jars over the three lighted candles at the same time. Observe the orders in which they go out. Observe one burning.

IV. Make a list of hypotheses. (Have ready a ditto sheet covering the remaining steps.) Check or choose the best hypothesis to explain what happened:

Hypothesis A. The candles burned until the weight of the air in the jars put them out.

Hypothesis B. The candles burned as long as there was oxygen.

Hypothesis C. The candles burned until the air was too warm.

V. Test the hypotheses. Below are several statements of fact. Some have been observed in other experiments such as weighing a jar after burning a candle in it, and burning candles in warm and cold air (indoors and outdoors).

Fact 1. The candle went out in the smallest jar first.

Fact 2. The air did not increase in weight as the candles burned.

Fact 3. There was less oxygen in the smaller jars.

Fact 4. The uncovered candle burned the longest.

Fact 5. Candles burn in both warm air and cold air.

Check for each hypothesis any facts which show it to be wrong. If none of the facts show a hypothesis to be false, we shall accept it as true.

Hypothesis A. The candles burned until the weight of the air in the jar put them out.
1.___ 2. ✓ 3.___ 4.___ 5.___

Hypothesis B. The candle burned as long as there was enough oxygen.
1.___ 2.___ 3.___ 4.___ 5.___

Hypothesis C. The candles burned until the air became too warm.
1.___ 2.___ 3.___ 4.___ 5. ✓

Therefore, hypothesis B. is true, while the others are false.

VI. Apply to a life situation. Jim was cutting a Jack-o-lantern. When he lit the candle inside he found that it did not burn very brightly and frequently it went out.

Check the statement that best explains the cause.

1. The candle was not large enough.

2. The pumpkin was too large for the candle to burn brightly.

✓3. The openings for the eyes, nose, mouth were too small to let enough oxygen for the candles to burn brighter.

Using multi-texts in the Elementary Science Program

A multi-text approach means that limited sets of texts from various publishers are placed in each classroom. The main criteria for selecting the texts that are in each classroom are:

1. Do the texts support the curriculum guide?

2. Are the multi-texts adapted to reading levels of the pupils in a particular grade?

Identifiable factors of a multi-text program:

1. The multi-text approach seems to facilitate learning for capable pupils on a broad level, and at the same time, provide a wide latitude of accessibility for slower pupils.

2. Teacher planning is an important part of this type of approach. It requires knowledge of both content and reading level of each textbook.

3. Multi-texts, carefully chosen, can present a variety of topics.

4. Multi-texts can present more information about a single topic.

5. Multi-texts can present a variety of views on a given subject.

6. The use of many different textbooks is particularly suitable to small group instruction where the groups have been formed on a reading ability basis.

THE SCHOOL FIELD TRIP

A field trip, if planned properly, can be a valuable asset as a science teaching tool. It can be an opportunity to develop basic skills such as observation, comparison, and inference. It can be an opportunity to practice activities such as note taking and specimen collecting. It can be an opportunity to develop public behavior.

A field trip must have a purpose. It should not be used as an escape from the daily teaching routine or as an award for good behavior. One of the primary purposes of a field trip should be to whet the student's interest in a particular matter and help to develop the powers of observation and inference in all students.

The teacher must carefully plan the field trip with the specific purposes and objectives in mind. Avoid a hurried trip and avoid covering too many points on one trip. Secure the proper permission and cooperation of the parents before taking the trip. If possible, the trip should be pre-run by the teacher several days before the class embarks upon it. Since most trips give the student a visual view of classroom learning, it is a wise idea to present a pre-trip orientation to the class.

The full benefit of any field trip is realized only with post-trip activities. The next scheduled class period would be an ideal time for the teacher and the class to evaluate and thoroughly discuss the trip. These activities will aid the teacher to evaluate the worth of the trip and help to decide upon future field trips.

A SAMPLE SUGGESTED FIELD TRIP PROCEDURE

The next day, after a word from the teacher on public behavior, the children boarded the bus for Lost Cave. At the cave, the children were put into two groups and along with a guide made a tour of the cave. As they toured the cave, the children made notes on small memo pads about the different formations they observed. Upon completion of the tour, the children were given time to browse through the mineral and rock gift shop and to ask the guides any further questions they had. On the bus trip back to school, the teacher, aware of the discussions among the children, jotted down any points of interest that were discussed highly by the children. The teacher also recorded any points that needed clarification.

Back in the classroom, the children and the teacher held a thorough discussion about the trip. They answered the questions on the mimeographed sheets passed out the day before as well as any others that came about as the result of their discussion.

The class then asked for and received permission to use one of the classroom bulletin boards to recreate their trip and to display the rocks and minerals they purchased in the gift shop.

A FIELD TRIP TO A COMMERCIALLY DEVELOPED LIMESTONE CAVERN

The class had been studying geology. One of the text books presented a unit on rock formations inside limestone caves. Realizing the opportunity to enforce this learning experience with a local resource, the teacher and the class planned a trip to Lost Cave, Hellertown, Pennsylvania.

The teacher first consulted with the Principal about such a trip to get his approval. Once approval was obtained, a phone call to Lost Cave set up a date and time for the trip. The next step was to arrange transportation. With the help of the school secretary, a school bus was obtained. The secretary also provided parental permission slips for each child.

Several days before the field trip, the teacher took a pre-run field trip. Since it was a local trip, rest stops and lunch stops did not need to be arranged. At the cave, the teacher jotted down points of interest for the class. With the help of the guide, other pertinent information and several pamphlets were obtained.

The day before the trip, the teacher handed out mimeographed papers about Lost Cave describing the location of the cave, the clothing the children should wear, and the cost of the trip. Several questions were listed about points of interest the children should be aware of, such as: How was this cave formed? What familiar cave formations are visible, such as stalactites, stalagmites, columns, helicites, ribbons, natural bridges, and water? Is any life inhabiting this cave? If so, what kinds? An opportunity was given to the children to ask any questions about the trip that they were concerned with.

Source: <u>Geo.' Earth Sciences Sourcebook</u>

WORKING IN THE LAB.

LABORATORY PRECAUTIONS

1. Acids and bases must be handled carefully.

   a. Wash off outside of acid and base bottles carefully under running water.
   b. Make sure stoppers on bottles are carefully in place and tightly fitted.
   c. Clean up any spillage on table, floor, or bottle.

2. Electricity can be a "shocking" discovery.

   a. Check for worn, threadbare wires.
   b. Use heavy duty extension cords.
   c. Wet areas and electricity do not mix.
   d. Use the correct current as specified by Underwriters Laboratory, Inc.

3. Gases can create explosions.

   a. Remember heat causes expansion and confinement of expansion results in explosions.
   b. Open flame or electric sparks may set off an explosion.
   c. Work in a well ventilated room or area.
   d. Wear safety glasses and other safety tools and equipment.
   e. Always wear a face mask.

4. Poisons are dangerous.

   a. Discard all unlabeled containers.
   b. Do not taste any chemical.
   c. Do not drink from beakers.
   d. Avoid unnecessary inhalation of chemical fumes.

5. What to do for that burn.

   a. Acid burn - flush with running water for five minutes. Apply a paste of sodium bicarbonate. Remove after ten minutes and apply olive oil.
   b. Base burn - treat as an acid burn. Apply boric acid instead of sodium bicarbonate.
   c. Bromine Burn - sponge off immediately with alcohol or a strong solution of sodium thiosulfate until the bromine color is gone. Wash off next with water and apply olive oil.
   d. Fire burn - sponge with picric acid solution. Apply ointment and wrap loosely.

6. Chemicals in the eyes.

   a. Wash well with water.
   b. Treat affected areas on face depending on the chemical.

7. Cuts.

   a. Flush area with warm water.
   b. Remove any foreign particles.
   c. Clean and apply antiseptic solution.

Source: Tips and Tables for Science Teachers
Publisher: G. & C. Merriam Co.

THE TEN COMMANDMENTS OF LABORATORY SAFETY

I. THINK IN TERMS OF SAFE PRACTICE CONTINUALLY.

II. BE FAMILIAR WITH EVERY STEP OF THE JOB YOU ARE GOING TO DO.

III. CHECK EACH APPARATUS ITEM AND CHEMICAL AT LEAST TWICE BEFORE PROCEEDING.

IV. MAINTAIN AN AWARENESS OF THE DANGER IN HANDLING CHEMICALS.

V. REMEMBER THE SAFE WAY TO ACCOMPLISH ANY JOB IS THE BEST WAY.

VI. GUARD YOUR CO-WORKERS SAFETY AND YOUR OWN.

VII. PREPARE YOUR COUNTER ATTACK AGAINST POSSIBLE ACCIDENTS BY FORETHOUGHT.

VIII. ACT PROMPTLY AND COOLY WHEN CONFRONTED WITH AN EMERGENCY.

IX. SUGGEST A SAFE PRACTICE IMMEDIATELY WHEN YOU SEE THE NEED FOR ONE.

X. BE CERTAIN YOUR LABORATORY HAS SAFETY EQUIPMENT AND CONDUCTS PERIODIC SAFETY MEETINGS.

Source: Tips and Tables for Science Teacher
Publisher: G. & C. Merriam Co.

LABORATORY PROCEDURES

MAKING A JET POINT

In order to make a pipette type of tube or a jet point rotate about $1\frac{1}{2}$ inches of glass tubing in the flame of a propane tank. When the glass is quite soft remove from the flame and draw it out with a determined pull. Do not hesitate once you have started - pull in one swoop. When the tubing has cooled, cut with a file.

HEATING LIQUIDS

Both glass and porcelain are poor conductors of heat, and may crack if heated only in one spot (even if the glass is Pyrex). The flame should be moved back and forth to achieve a degree of uniformity in heating, and avoiding over-heating at any one point. Better yet, the flame may be allowed to fall upon metal gauze, a better conductor of heat, which tends to spread out the heat.

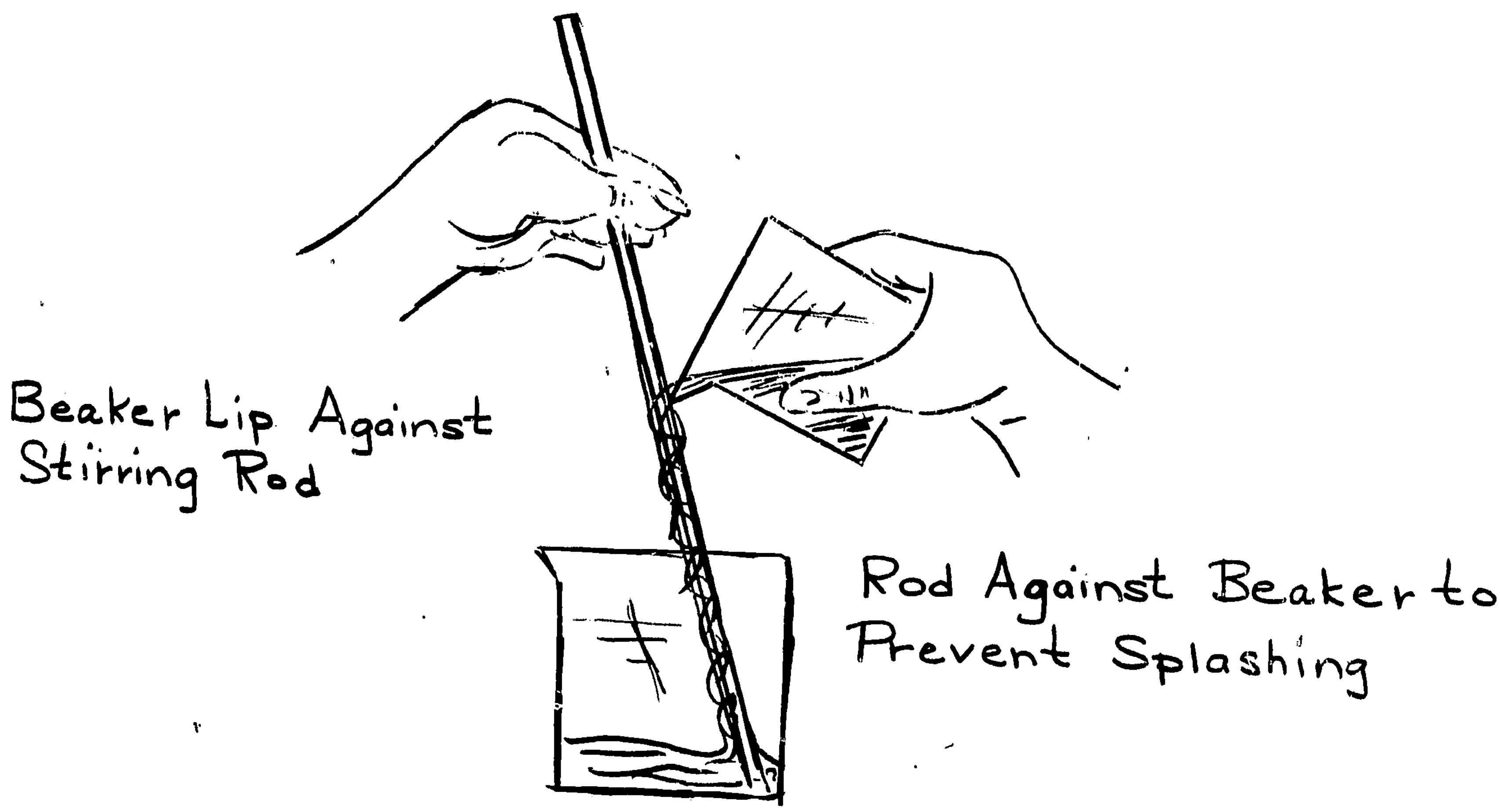
Heating liquids in test tubes - Small amounts of liquids may be heated in test tubes held by a clamp at an angle of about 45° over the flame. Do not apply the flame at the bottom of the test tube - the contents may shoot out with great force. NEVER point the mouth of the test tube toward anyone or yourself.

HEATING SOLIDS

Place the test tube on a stand and move the flame of the burner back and forth to heat the contents evenly.

POURING LIQUIDS

To avoid splashing when pouring liquids from a beaker, hold a stirring rod against the pouring edge. When pouring from a bottle, keep the glass stirring rod vertical, pressing against the mouth of the bottle.



INSERTING GLASS TUBES IN A RUBBER STOPPER

Always wet glass tubing and rubber stoppers with water before inserting the glass tubing into the rubber stopper. Use a to and fro twisting motion. DO NOT TRY to force or push through the stopper.

Rubber stoppers tend to stick to glass tubing when allowed to dry. Removing them from apparatus after use will help prevent accidents. For an added safety precaution, wrap a towel or cloth around the rubber stopper and glass tube.

WEIGHING CHEMICALS

When weighing out dry chemicals place equal size tissue or similar paper on the pans of the balance scale. NEVER pour a chemical directly on the pan.

DILUTING ACIDS

Concentrated acids are very dangerous chemicals. These should be handled with extreme caution and stored in a safe place where pupils do not have access to it.

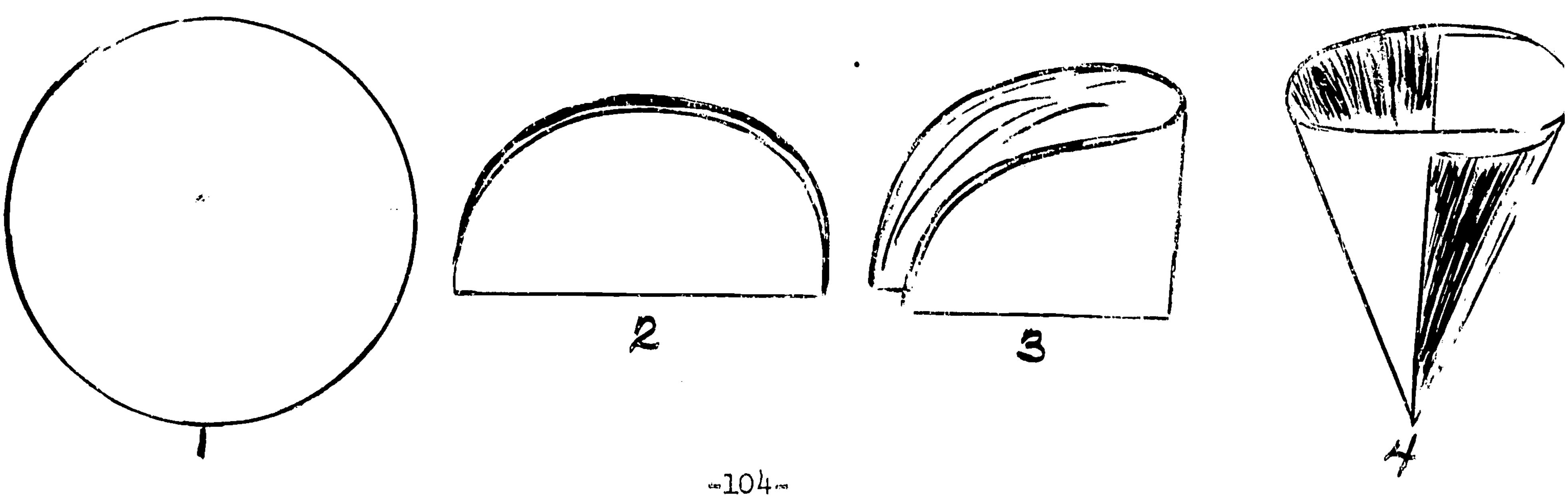
When diluting acids, slowly add acid to water with constant stirring. **NEVER ADD WATER DIRECTLY TO CONCENTRATED ACID.** Considerable heat is released when acid reacts with water. If this is done improperly a dangerous spattering may result.

If acid fumes or sprays get on the skin, wash the area immediately with water and continue washing with water.

FOLDING FILTER PAPER

Most schools have filter paper available, however, paper towel can be substituted.

Fold the paper along the diameter, then once more at right angles, making a quadrant. Nest it, then unfold it in a way to make a cone which has one thickness of paper along one side and three thicknesses along the other. Place the cone in a funnel moistened with water, and press snugly into the funnel in order to squeeze out all bubbles of air.



HOW TO MAKE AND USE A PIPETTE

Cut a 6" piece of glass tubing and smooth the ends by holding them over a flame just long enough to smooth off the sharp edges. Put the pipette in a test tube with water and place a thumb over the top end of the tubing. With the thumb firmly held over the top hole in the pipette, lift the tubing to an empty test tube. Permit a small quantity of air to enter the pipette by slightly lifting the thumb. With a little practice, water can be removed from the pipette drop by drop.

If glass tubing is not available, a temporary pipette can be made by cutting a clear plastic straw into a 6" piece or longer depending on the depth of the test tube.

Source: Learning Materials

M I C R O S C O P E

M I C R O - P R O J E C T O R

MAGNIFICATION POWERS OF THE KEN-A-VISION

The powers of magnification of the Ken-A-Vision vary according to which lens or combination of lenses are used, and how far away the image is projected. The following tables list the magnification powers of the various lenses at the projected distance from the stage to the base of the pedestal (ordinary upright position, mirror not used), and the magnification powers of the various lenses projected on a 30 x 40 screen 10 feet away (lamp housing tilted, mirror not used):

ORDINARY UPRIGHT POSITION, MIRROR NOT USED

Objective lens	Used alone	Used with the auxiliary lens	Used with the 10X eyepiece
16 mm	27X	42X	95X
10 mm (Tyro Model)	47X	80X	180X
6.5 mm	73X	126X	290X

LAMP HOUSING TILTED, MIRROR NOT USED

Objective lens	Used alone	Used with the auxiliary lens	Used with the 10X eyepiece
16 mm	178X	280X	965X
10 mm (Tyro Model)	330X	546X	1860X
6.5 mm	477X	864X	2750X

The highest magnification listed here (2750X) is the maximum magnification of the instrument at a projected distance of 10 feet. This is so great a magnification that the point of an ordinary pin is enlarged to almost 10 inches across, and the thickness of the pin is enlarged to about 58 inches - almost 5 feet!

It is possible to greatly increase or double this magnification as the projected distance is increased. In such experiments, however, remember that a large screen and a darkened room are necessary.

SELECTION OF THE PROPER LENS COMBINATION

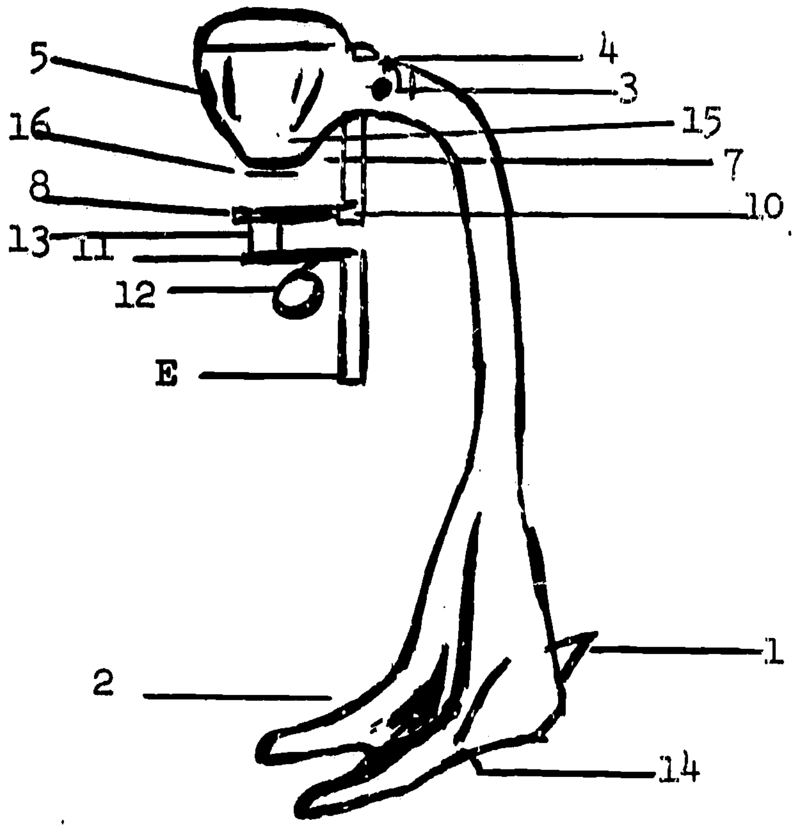
A cardinal rule to remember in the use of any microscope or the Ken-A-Vision is:

You will always get the clearest view at the lowest power you can see the object.

The higher the magnification, the darker the projected image will be. It is, of course, sometimes necessary to use the highest magnification which your Ken-A-Vision has. The preceeding tables may serve as guides in your selection of lens powers. The three objective lenses are marked 6.5 mm, 10 mm, and 16 mm. The 6.5 lens is the strongest, the 16 is the weakest.

When rotating the objective lenses in the turret care should be taken to raise the stage by turning the focusing knob counter clockwise. This is to prevent scraping the objective lens on the stage.

INSTRUCTIONS FOR OPERATION OF KEN-A-VISION



1. Cord and Plug
2. Switch
3. Swivel Bolt
4. Cap Screw
5. Lamp House
7. Polaroid Analyzer
8. Stage
10. Focusing Knob
11. Revolving Dust Proof Turret Disk
12. Mirror
13. 10MM Objective
14. Transformer
15. Condensing System
16. White Frosted Plastic Disc

E - 10X Eye Piece
A - Auxiliary
P - Polaroid Lens
C - Clear Opening

DIRECTIONS FOR OPERATION - After your Ken-A-Vision is unpacked, place on table in a semi-dark, or (preferably) dark room - plug (No. 1) into 110A.C., then switch on current (No. 2) (switch shows OFF or ON, if lamp does not light when ON, try some other outlet).
Place sheet of white paper on table directly under assembly.

FOCUSING SPECIMEN - Place slide on stage (No. 8), turn focusing knob (No. 10) until you see a sharp picture on paper placed on table top.

HIGH MAGNIFICATION - Mounted in revolving dust proof turret, disk No. 11 is a 10X eyepiece, auxiliary lens, Polaroid lens and clear opening. Notice on edge of disk No. 11, there are red letters **E - A - P - C**; when using the 10mm only, move disk No. 11 to where letter C lines up with red arrow on top of holder No. 17. Should you want 10X eyepiece and 10MM combination, move E to arrow.

USING AS A MICROSCOPE - Turn turret disk No. 11 to where E lines up to red arrow, then swing No. 16 frosted disk under light, tilt lamp housing No. 5 to horizontal position. Focus, then look through eyepiece.

POLARIZER - There are two polarizers, one at the top (No. 7), one in turret disk marked with letter P used in study of crystals, etc. They may be crossed by rotating one (No. 7), by turning larger ring back and forth with first finger and thumb. Caution: - **BE SURE** when not being used, push back out of light rays as light dims down.

SCREEN or WALL PROJECTION - When projecting on screen, place hand below focusing knob (No. 10) and raise up to horizontal position.

PROJECTION DISTANCE - Ten feet from your screen is about the proper distance, of course, depending on what lenses you are using, experimenting with distances will teach you that.

BUILT-IN HEAT FILTER - Harmful heat rays eliminated.

MIRROR - When using wet mounts, without glass covers, or any specimen that may fall off the slide, tilt mirror (No. 12) to project on screen. When not in use push mirror back as far as possible.

CHANGING LAMP - (occasionally the lamp is jarred out of line in shipment, see instructions below.)

Unscrew (No. 4) and the screw opposite on cap, remove cap, take out lamp (No. 17) to replace. It will go in only one way, as it is a prefocus socket and a prefocus lamp, and the light should focus directly on the objective. Should the pin point of the light be off, just loosen the two screws and move the socket holder (with the light on) until pin point of light strikes the center of objective, then tighten two screws, replace cap.

CARE OF THE KEN-A-VISION - Place plastic dust cover over instrument when not in use. Keep lenses clean with fine brush or lens paper. If 10X (letter E) shows dirt specks, unscrew bottom flange, letting the two lenses drop out. Clean with lens paper and replace in the same manner as they came out.

THE MICROSCOPE IN THE ELEMENTARY SCIENCE PROGRAM

Glenn O. Blough
Associate Professor of Education
University of Maryland

Many scientific things in the environment of children can stand more careful scrutiny. A closer look gives greater meaning. The E.M.E. Microscope Outfit (Educational Materials and Equipment Company, Box 63, Bronxville, New York) is designed especially to enhance the child's appreciation and understanding of the world that remains unseen with the unaided eye.

Because of the fascination which highly-magnified specimens hold for the viewer there is always the danger of allowing the microscope - a visual aid peculiar to science - to become an end in itself. For this reason a word of caution may be in order to avoid the "microscope show" approach and to correlate use of the instrument to the particular phase of science under consideration at the moment.

It is desirable to devote one introductory lesson to the technique of using a microscope and to making microscope slides. After that, the microscope can be brought out when the topic being studied will be more thoroughly understood through minute visual examination of one or more aspects of it. Here, as elsewhere in science teaching, the pupil is allowed to "discover" as much as he can for himself.

Following are a few suggestions for using a microscope in the elementary school They are intended as examples of how to use this scientific instrument to its greatest advantage in making the science curriculum more meaningful. There are, of course, innumerable other examples. Regional and seasonal variations will have a bearing upon specimens available. We suggest the microscope for examining:

1. A butterfly wing to see its minute scales and note how structure contributes to use.
2. A wing feather of a bird to see details of structure related to flight.
3. A drop of pond water to discover a world of otherwise invisible animals.
4. Pond scum (algae) in connection with food or water animals and interdependence of living things.
5. A very thin smear of blood cells, and a strand of hair, in connection with the study of the human body.
6. Blood flowing in the tail of a tadpole or gold fish, or in the web of a frog's foot, to understand more about circulation.
7. The tiny one-celled plants called bacteria to learn more about the causes and spread of disease. (A handful of hay soaked for a few days in water is a good source of harmless rod-like bacteria.)
8. A portion of a fish gill to more fully understand its function.
9. A fish scale to examine its growth rings.
10. The molted skin of a snake to see its construction.
11. A bee's stinger and other parts of a honey bee to see adaptation for protection, food getting, pollination and flight.
12. Mouth parts of mosquitos and butterflies as examples of sucking insects, and grasshoppers and beetles as examples of chewing insects, to discover various adaptations for food getting.
13. Antennae of various insects to see how they differ in structure- some knobbed, some tapering, some feathery, etc.

14. A section of any eye of a fly or grasshopper or other insect for an understanding of structure.
15. The breathing pores (spiracles) along the sides of an insect's body to help understand how it breathes.
16. A small piece of a paper wasp's nest to see its construction.
17. The silk threads from the cocoon of a silkworm moth or other moth to see its construction.
18. The cells of leaves in a study of food manufacture in plants.
19. A small portion of the inside of a leaf or flower bud before it has opened to see the cells.
20. The openings (stomata) in the surface of leaves to see how plants get air.
21. The channels or "pipes" in a thin slice of celery stem or fresh cornstalk, and the veins of leaves, to understand how plants get water and food to leaf cells.
22. Root hairs of a plant to develop a clearer understanding of their function. (Radish seeds in wet blotters are good.)
23. Pollen of different kinds of flowers in a study of plant reproductions.
24. Spores from ferns and mushrooms to see how these plants reproduce.
25. Yeast plants (the scum that forms on maple syrup and in pickle jars) in connection with the study of foods and non-green plants and to see how they bud to form new plants.
26. Mold on bread, fruit and cheese to see its structure and method of reproduction.
27. Small pieces of silk and wool cloth to see how it is woven and the difference in the fibers.
28. The torn edge of a piece of paper to see the fibers of which it is made.
29. The engraved line on a dollar bill and the type of a newspaper to see the different quality of line and how the paper absorbs ink.
30. A saturated solution of table salt and water to watch the salt crystals form. (Blowing gently hastens the process by promoting evaporation.)
31. Different shapes, colors and sizes of grains of sand to understand better what sand is and how, when driven by the wind or used as sand paper, it can wear away surfaces.
32. Prepared slides of microscopic materials which pupils themselves are not able to make.

Educational Materials and Equipment Co.
Box 63
Bronxville, New York

USING THE MICROSCOPE

Materials: Microscope, glass slide, cover glass.

Procedure: Description of the Use of the Microscope.

The compound microscope is the type most commonly used in the classrooms. The eyepiece lens and an objective lens is used to view the object to be viewed. Light strikes the mirror near the base of the microscope and then passes through an opening in the stage. The light passes through the objective lens, the tube, and the eyepiece until it reaches the observer's eye.

In magnifying an object, it is necessary that only a very thin segment of the object be used. For example, in magnifying onionskin, use a razor blade to cut off the thinnest possible layer. Place the layer on a glass slide and use a medicine dropper to aid a drop of water or iodine, diluted in water. Next, place a cover glass over the glass slide.

In focusing, place the microscope near a light source such as an open window or a lamp. Adjust the stage so that, when looking through the eyepiece, you see a bright circle of light. Next, lower the objective lens until it almost touches the cover glass. Look through the eyepiece and slowly turn the focusing knob to raise the objective lens. The onionskin should appear as rectangular, or brick-like shapes.

STAINING A TISSUE MOUNT

Some tissue slides are easier to observe if they are stained first. Mounts stained with ordinary iodine will produce a sharper image of the tissue section instead of water when preparing wet mount slides.

Safranin, a water-soluble red dye is also good to stain tissue slides. Simply add 1 or 2 drops of safranin to the tissue instead of water when preparing a wet mount.

MAKING A TEMPORARY WET-MOUNT SLIDE

1. Using a sharp, clean, single-edged razor blade or x-acto knife, cut through the tissue to be mounted with a slow, sawing motion. Use the thinnest cut for mounting on a glass microscope slide.

2. Place the specimen on a clean glass slide. If the tissue is transparent when held to the light, the specimen is probably cut thin enough.

3. Place a drop of water on the tissue and gradually slide a cover slip over the tissue mount.

4. Place under the microscope.

G E O L O G Y

PROPERTIES WHICH DETERMINE COMMERCIAL USE

TALC

face powder____________________

GYPSUM

heat insulation____________________

carved ornaments____________________

CALCITE

optical apparatus____________________

FLUORITE

flux in the steel industry____________________

FELDSPAR

glaze on porcelain____________________

abrasive____________________

QUARTZ

lenses____________________

abrasive____________________

TOPAZ

gemstone____________________

CORUNDUM

abrasive____________________

Some varieties of corundum have a clear, uniform color. These are ruby and sapphire, the precious gems.

GRAPHITE

in making the "lead" of leadpencils____________________

as a lubricant____________________

LIMONITE

an ore of iron____________________

coloring pigment (yellow ocher)____________________

GALENA

an ore of lead____________________

PYRITE

cheap jewelry____________________

was formerly used extensively for making sulphuric acid.

MINERAL IDENTIFICATION CHART

Name of Mineral	Chemical Composition	Hardness (Mohs Scale)	Color	Streak	Type of Luster	Type of Rupture: i.e., fracture and/or cleavage	Other Special Properties: Taste elasticity, etc.	Uses

IGNEOUS ROCK IDENTIFICATION CHART

Color	Texture	Minerals present (observed and probable)	Qtz or qtz	Structural features present	Composition (Salic, femic or intermediate)	Probable predominant chemical elements	Name of the Rock

IDENTIFICATION CHART FOR METAMORPHIC ROCKS

Foliated or Non-foliated	Identifiable Minerals Present	Other Characteristics: compactness; preservation of structures; closeness of foliation; presence of porphyroblasts; type of fracture color; etc.	Name of the Rock

IDENTIFICATION CHART FOR SEDIMENTARY ROCKS

Speci-men No.	Color	Texture	Composition	Other Characteris-tics	Name
Sample	White	rounded sand grains	quartz sand, with calcar-eous cement	thin-bedded; effervesces with HCl	calcareous sandstone

COMMON MINERAL COLORS

MINERAL	COLOR
Sulfur	Yellow
Calcite	Colorless and various shades
Kaolin	White
Gypsum	White
Milky Quartz	White
Graphite	Black or steel gray
Mica Sheets	Colorless
Biotite	Black or brown
Jasper	Red
Hematite	Red
Galena	Lead Gray
Pyrite	Brassy
Azurite	Sky Blue
Malachite	Green
Crysocolla	Aqua
Rose Quartz	Pink
Olivine	Yellow-green

Source: Geology and Earth Sciences Sourcebook

COMMON MINERAL STREAK CHART

MINERAL	STREAK	MINERAL	STREAK
Graphite	Black	Sulfur	Pale-yellow
Galena	Grey-black	Magnetite	Black
Limonite	Yellow-brown	Jasper	None
Hematite (red)	Red-brown	Kaolin	White
Pyrite	Black (greenish or brownish black	Malachite	Light green
Milky Quartz	None	Azurite	Light blue

MOHS STANDARD SCALE OF ROCK HARDNESS

1. Talc . . . . . .Softest of all the minerals, may easily be scratched by a fingernail. Feels soft and somewhat greasy.

2. Gypsum . . . . .Soft enough to be scratched by a fingernail but requires more pressure than talc. Does not feel soft and greasy.

3. Calcite. . . . .Can be scratched with the sharp edge of a copper penny.

4. Fluorite . . . .Easily scratched by a knife but will resist the scratching of a penny. Not hard enough to scratch glass.

5. Apatite. . . . .Barely scratch ordinary glass. Also can barely be scratched by a knife.

6. Orthoclase . . .Can be scratched by a file.

7. Quartz . . . . .Harder than most of the common minerals.

8. Topaz. . . . . .Will scratch quartz.

9. Sapphire or Corundum . . . .Any mineral that will scratch topaz.

10. Diamond. . . . .Hardest of all the minerals.

Since a diamond is the hardest of all stones it can scratch any of the other minerals. Therefore, a sharp piece of each mineral will scratch the surface of all that are before it on the scale of hardness but none that come after it. If a piece will scratch gypsum but will not scratch calcite, its hardness comes between 2 and 3 and may be considered about 2.5.

FOR FIELD USE, HERE ARE SOME OTHER CONVENIENT STANDARDS OF HARDNESS

fingernail	2.5
penny	3
knife blade	5.5
window glass	5.5
steel file	6.5

MINERALS ARRANGED ACCORDING TO HARDNESS

HARDNESS	MINERAL
1	Talc
1-2	Graphite
1-3	Bauxite
2-2.5	Chlorite
2	Gypsum
2-2.5	Kaolinite
2-2.5	Muscovite
2.5-3	Biotite
2.5-3	Chalcocite
2.5	Galena
2.5	Halite
3-3.5	Anhydrite
3	Bornite
3	Calcite
3.5-4	Azurite
3.5-4	Chalcopyrite
3.5-4	Dolomite
3.5-4	Sphalerite
4	Serpentine
4	Flourite
5	Apatite
5-6	Augite
5-6	Hornblende
5	Kyanite (along crystal)
5-5.5	Limonite
5.5	Uraninite
5.5-6.5	Hematite
6	Albite
6	Anorthite
6-7	Cassiterite
6	Magnetite
6	Orthoclase
6-6.5	Pyrite
6-7	Sillimanite
6.5-7.5	Garnet
6.5-7	Olivine
7	Kyanite (across crystal)
7	Quartz
7-7.5	Staurolite
7-7.5	Tourmaline
7.5	Andalusite
9	Corundum

COMPOSITION OF THE EARTH'S CRUST

ELEMENT	PERCENTAGE
Oxygen	46.46
Silicon	27.61
Aluminum	8.07
Iron	5.06
Calcium	3.64
Sodium	2.75
Potassium	2.58
Magnesium	2.07
All other Elements	1.76
	100.00

COMMON ROCKS

SEDIMENTARY	METAMORPHIC
Conglomerate	Slate
Sandstone	Schist
Shale	Gneiss
Limestone	Marble
Chert	Quartzite
Rock Salt	Hornfels
Coal	

M E A S U R E M E N T

DIRECTIONS FOR MAKING A GRAPH TO CONVERT FROM FAHRENHEIT TO CENTIGRADE

Materials Needed: Graph Paper

Procedure:

Plot the Fahrenheit scale along one axis of a sheet of graph paper. Locate the fixed points of 32° and 212°.

Plot the centigrade scale along the other axis, with a minimum of 0° to 100°.

Mark the fixed points (32°F and 0°C) for freezing, and (212°F and 100°C) for boiling. Draw a line connecting the two points.

To convert one scale to the other, read one temperature scale to the diagonal line, then read down to the other scale.

Source: DP1 Measurement

CENTIGRADE TO FAHRENHEIT CONVERSION TABLE

°C	°F	°C	°F	°C	°F	°C	°F
0	32	26	79	51	124	76	169
1	34	27	81	52	126	77	171
2	36	28	82	53	127	78	172
3	37	29	84	54	129	79	174
4	39	30	86	55	131	80	176
5	41	31	88	56	133	81	178
6	43	32	90	57	135	82	180
7	45	33	91	58	136	83	181
8	46	34	93	59	138	84	183
9	48	35	95	60	140	85	185
10	50	36	97	61	142	86	187
11	52	37	99	62	144	87	189
12	54	38	100	63	145	88	190
13	55	39	102	64	147	89	192
14	57	40	104	65	149	90	194
15	59	41	106	66	151	91	196
16	61	42	108	67	153	92	198
17	63	43	109	68	154	93	199
18	64	44	111	69	156	94	201
19	66	45	113	70	158	95	203
20	68	46	115	71	160	96	205
21	70	47	117	72	162	97	207
22	72	48	118	73	163	98	208
23	73	49	120	74	165	99	210
24	75	50	122	75	167	100	212
25	77						

EQUIVALENT TEMPERATURES ON DIFFERENT SCALES

	Absolute	Centigrade	Fahrenheit
Absolute zero.	0°A	-273°C	-459°F
Fahrenheit zero.	255°A	-18°C	0°F
Freezing point of water. . . .	273°A	0°C	32°F
Boiling point of water	373°A	100°C	212°F

TEMPERATURE CONVERSION FORMULAS

In these formulas C is Centigrade temperature, F is Fahrenheit temperature, and K is Kelvin temperature.

$C = 5/9\ (F - 32)$ $\qquad$ $F = 9/5\ C + 32$ $\qquad$ $K = C + 273$

TEMPERATURE CONVERSION

Centigrade to Fahrenheit $C^{o} = 5/9\ (^{o}F - 32)$
Fahrenheit to Centigrade $F^{o} = (^{o}C \times 9/5) + 32$

The numbers in the center columns refer to the temperatures in either degrees C or F which are to be converted into the other scale.

°C	°C or °F to be converted	°F	°C	°C or °F to be converted	°F
-273.33	-460	---	-67.78	-90	-130.0
-267.78	-450	---	-65.00	-85	-121.0
-262.22	-440	---	-62.22	-80	-112.0
-256.67	-430	---	-59.45	-75	-103.0
-251.11	-420	---	-56.67	-70	-94.0
-245.56	-410	---	-53.89	-65	-85.0
-240.00	-400	---	-51.11	-60	-76.0
-234.44	-390	---	-48.34	-55	-67.0
-228.89	-380	---	-45.56	-50	-58.0
-223.33	-370	---	-42.77	-45	-49.0
-217.78	-360	---	-40.00	-40	-40.0
-212.22	-350	---	-37.23	-35	-31.0
-206.67	-340	---	-34.44	-30	-22.0
-201.11	-330	---	-31.66	-25	-13.0
-196.56	-320	---	-31.11	-24	-11.2
-190.00	-310	---	-30.55	-23	-9.4
-184.44	-300	---	-30.00	-22	-7.6
-178.89	-290	---	-29.45	-21	-5.8
-173.33	-280	---	-28.89	-20	-4.0
-167.78	-270	-454.0	-28.34	-19	-2.2
-162.22	-260	-436.0	-27.78	-18	-0.4
-156.67	-250	-418.0	-27.23	-17	+1.4
-151.11	-240	-400.0	-26.67	-16	+3.2
-145.56	-230	-382.0	-26.12	-15	+5.0
-140.00	-220	-364.0	-25.56	-14	+6.8
-134.44	-210	-346.0	-25.00	-13	+8.6
-128.89	-200	-328.0	-24.44	-12	+10.4
-123.33	-190	-310.0	-23.88	-11	+12.2
-117.78	-180	-292.0	-23.33	-10	+14.0
-112.22	-170	-274.0	-22.77	-9	+15.8
-106.67	-160	-256.0	-22.22	-8	+17.6
-101.11	-150	-238.0	-21.67	-7	+19.4
-95.56	-140	-220.0	-21.11	-6	+21.2
-90.00	-130	-202.0	-20.56	-5	+23.0
-84.44	-120	-184.0	-20.00	-4	+24.8
-78.89	-110	-166.0	-19.44	-3	+26.6
-73.33	-100	-148.0	-18.89	-2	+28.4
-70.55	-95	-139.0	-18.33	-1	+30.2
-17.78	0	+32.0	+12.78	+55	+131.0
-17.22	+1	+33.8	+15.56	+60	+140.0
-16.67	+2	+35.6	+18.33	+65	+149.0
-16.11	+3	+37.4	+21.11	+70	+158.0
-15.36	+4	+39.2	+23.89	+75	+167.0
-15.00	+5	+41.0	+26.67	+80	+176.0

TEMPERATURE CONVERSION (continued)

Centigrade to Fahrenheit C° = 5/9 (°F - 32)
Fahrenheit to Centigrade F° = (°C X 9/5) + 32

The numbers in the center columns refer to the temperatures in either degrees C or F which are to be converted into the other scale.

°C	°C or °F to be converted	°F	°C	°C or °F to be converted	°F
-14.44	+6	+42.8	+29.44	+85	+185.0
-13.89	+7	+44.6	+32.22	+90	+194.0
-13.33	+8	+46.4	+35.00	+95	+203.0
-12.78	+9	+48.2	+37.78	+100	+212.0
-12.22	+10	+50.0	+43.33	+110	+230.0
-11.67	+11	+51.8	+48.89	+120	+248.0
-11.11	+12	+53.6	+54.44	+130	+266.0
-10.56	+13	+55.4	+60.00	+140	+284.0
-10.00	+14	+57.2	+65.56	+150	+302.0
-9.44	+15	+59.0	+71.11	+160	+320.0
-8.89	+16	+60.8	+76.67	+170	+338.0
-8.33	+17	+62.6	+82.22	+180	+356.0
-7.78	+18	+64.4	+87.78	+190	+374.0
-7.22	+19	+66.2	+93.33	+200	+392.0
-6.67	+20	+68.0	+98.89	+210	+410.0
-6.11	+21	+69.8	+104.44	+220	+428.0
-5.56	+22	+71.6	+110.00	+230	+446.0
-5.00	+23	+73.4	+115.56	+240	+464.0
-4.44	+24	+75.2	+121.11	+250	+482.0
-3.89	+25	+77.0	+126.67	+260	+500.0
-1.11	+30	+86.0	+132.22	+270	+518.0
+1.67	+35	+95.0	+137.78	+280	+536.0
+4.44	+40	+104.0	+143.33	+290	+554.0
+7.22	+45	+113.0	+148.89	+300	+572.0
+10.00	+50	+122.0			

Source: Tips and Tables For Science Teachers, Pages 19 and 20

THE BEAUFORT WIND SCALE

Beaufort Number	Equivalent in Miles per Hour	Specification for Use on Land
0	less than 1	Smoke rises vertically.
1	1-3	Direction of wind shown by chimney smoke, but not by wind vane.
2	4-7	Wind can be felt on face; wind vane moved by wind, leaves rustle.
3	8-12	Leaves and small twigs are in constant motion; wind extends flag.
4	13-18	Small branches in motion; wind raises dust and loose paper.
5	19-24	Small trees begin to sway.
6	25-31	Large branches of trees in motion; difficult to use umbrellas.
7	32-38	Whole trees in motion; difficult to walk against the wind.
8	39-46	Wind breaks twigs off trees.
9	47-54	TV antennae blown down; slate removed from roof.
10	55-63	Very seldom experienced on land; trees uprooted, considerable damage.
11	64-75	Very rarely experienced; tremendous damage occurs.
12	above 75	Hurricane force.

SYMBOLS FOR AMOUNTS OF CLOUDS

SYMBOL	SKY CONDITION	EXPLANATION
○	Clear	Sky less than one tenth covered by clouds.
⦶	Scattered	Sky covered by one to five tenths of clouds.
⦷	Broken	Sky six to nine tenths covered by clouds.
⊕	Overcast	Sky more than nine tenths covered by clouds.
/		Symbol preceding slant refers to clouds about 10,000 feet.
		EXAMPLES OF COMBINATIONS
⊕/	High Overcast	Sky covered by more than nine tenths clouds at elevations above 10,000 feet.
⊕ ⦶	Overcast, Lower broken	Sky covered by two layers of clouds, with upper layer covering more than nine tenths of sky and lower layer covering six to nine tenths of sky. Both layers below 10,000 feet.
⊕/⦷	High, Overcast, Lower broken	Same as above, except that upper cloud layer is above 10,000 feet.
⦶ ⦷	Scattered, Lower broken	Sky covered by two layers of clouds, with upper layer covering one to five tenths of sky and lower layer covering six to nine tenths of sky. Both layers below 10,000 feet.
⦶/⦷	High, Scattered, Lower broken	Same as above, except that upper cloud layer is above 10,000 feet.

CLOUD TYPES

FAMILY	TYPES	ABBREVIATIONS	MEAN HEIGHT
HIGH CLOUDS	1. Cirrus 2. Cirrostratus 3. Cirrocumulus	Ci Cs Cc	Above 20,000 feet
MIDDLE CLOUDS	4. Altostratus 5. Altocumulus	As Ac	6,500 to 20,000 feet
LOW CLOUDS	6. Stratocululus 7. Stratus 8. Nimbostratus	Sc St Ns	Below 6,500 feet
CLOUDS WITH VERTICAL DEVELOPMENT	9. Cumulus 10. Cumulonimbus	Cu Cb	1600 ft. to Cirrus level

RELATIVE HUMIDITY (PERCENTAGE), °F

Temperature of dry bulb (°F)	Depression of the wet bulb (°F) i.e. difference between wet and dry bulb readings																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
120	97	94	91	88	85	82	79	77	74	72	69	67	64	62	59	57	55	53	51	48
118	97	94	91	88	85	82	79	76	74	71	69	66	63	61	59	56	54	52	50	48
116	97	94	90	87	84	82	79	76	73	71	68	65	63	61	58	56	54	51	49	47
114	97	94	90	87	84	81	79	76	73	70	68	65	63	60	58	55	53	51	48	46
112	97	94	90	87	84	81	78	75	73	70	67	65	62	59	57	55	52	50	48	46
110	97	93	90	87	84	81	78	75	72	69	67	64	61	59	56	54	51	49	47	45
108	97	93	90	87	84	81	78	75	72	69	66	63	61	58	56	53	51	49	46	44
106	96	93	90	87	84	80	77	74	71	68	66	63	60	58	55	52	50	48	45	43
104	96	93	90	86	83	80	77	74	71	68	65	62	60	57	54	52	49	47	44	42
102	96	93	90	86	83	80	77	73	70	67	65	62	59	56	54	51	48	46	43	41
100	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47	45	42	40
98	96	93	89	86	82	79	76	72	69	66	63	60	57	54	52	49	46	44	41	39
96	96	93	89	85	82	78	75	72	68	65	62	59	57	54	51	48	45	43	40	38
94	96	93	89	85	81	78	75	71	68	65	62	59	56	53	50	47	44	42	39	36
92	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49	46	43	40	38	35
90	96	92	88	84	81	77	74	70	67	63	60	57	54	51	48	45	42	39	36	34
88	96	92	88	84	80	77	73	69	66	63	59	56	53	50	47	44	41	38	35	32
86	96	92	88	84	80	76	72	69	65	62	58	55	52	49	45	42	39	36	33	31
84	96	92	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38	35	32	29
82	96	91	87	83	79	75	71	67	64	60	56	53	49	46	43	40	36	33	30	27
80	96	91	87	83	79	74	70	66	63	59	55	52	48	45	41	38	35	31	28	25
78	95	91	86	82	78	74	70	67	62	58	54	50	47	43	40	36	33	30	26	23
76	95	91	86	82	78	73	69	65	61	57	53	49	45	42	38	34	31	28	24	21
74	95	90	86	81	77	72	68	64	60	56	52	48	44	40	36	33	29	26	22	19
72	95	90	85	80	76	71	67	63	58	54	50	46	42	38	34	31	27	23	20	16
70	95	90	85	80	75	71	66	62	57	53	49	44	40	36	32	28	24	21	17	14
68	95	90	84	79	75	70	65	60	56	51	47	43	38	34	30	26	22	18	15	11
66	95	89	84	79	74	69	64	59	54	50	45	41	36	32	28	23	20	16	12	8
64	94	89	83	78	73	68	63	58	53	48	43	39	34	30	25	21	17	13	9	5
62	94	88	83	77	72	67	61	56	51	46	41	37	32	27	23	18	14	10	5	
60	94	88	82	77	71	65	60	55	50	44	39	34	29	25	20	15	11	6	2	
58	94	88	82	76	70	64	59	53	48	42	37	31	26	22	17	12	7	2		
56	94	87	81	75	69	63	57	51	46	40	35	29	24	19	13	8	3			
54	93	87	80	74	68	61	55	49	43	38	32	26	21	15	10	5				
52	93	86	79	73	66	60	54	47	41	35	29	23	17	12	6					
50	93	86	79	72	65	59	52	45	38	32	26	20	14	8	2					
48	92	85	77	70	63	56	49	42	36	29	22	16	10	4						
46	92	84	77	69	62	54	46	40	33	26	19	12	6							
44	92	84	75	68	60	52	45	37	29	22	15	8								
42	91	83	74	66	58	50	42	34	26	18										
40	91	82	73	65	56	47	39	30												

NUMBER SYSTEMS IN SCIENCE

Name	Prefix	Common System	Decimal System	Exponential System
One million	Mega	1,000,000	.....	10^{6}
One thousand	Kilo	1,000	.....	10^{3}
One hundred	Hekta	100	.....	10^{2}
Ten	Deka	10	.....	10^{1}
One	Mono	1	.....	10^{0}
One-tenth	Deci	1/10	0.1	10^{-1}
One-one hundredth	Centi	1/100	0.01	10^{-2}
One-one thousandth	Milli	1/1,000	0.001	10^{-3}
One-one millionth	Miero	1/1,000,000	0.000.001	10^{-6}

Source: Symbols - Colandia

TABLE OF MEASURES

1 Kilogram	=	100 Grams
English Measure		Scientific Measure
1 Ounce	=	Approximately 28 grams (accurately 28.35 grams)
1 Pound	=	453.5 Grams
2.2 Pounds	=	1 Kilogram

DISTANCE

1 Kilometer	=	1000 Meters
1 Meter	=	100 Centimeters
English Measure	=	Scientific Measure
1 Inch	=	2.54 Centimeters
1 Foot	=	30.48 Centimeters
39.37 Inches	=	1 Meter
1 Mile	=	1.6 Kilometer

VOLUME

1 Liter	=	1000 Milliliters

The milliliter is sometimes referred to as the cubic centimeter

English Measure		Scientific Measure
1 Teaspoon	=	5 Cubic centimeters
1 Fluid ounce	=	Approximately 30 cubic centimeters
1 Pint	=	473 Cubic centimeters
1 Quart	=	.946 Liters
1 Gallon	=	3.8 Liters

Source: Science Today For The Elementary School Teacher

DECIMAL AND METRIC EQUIVALENT OF FRACTIONAL PARTS OF AN INCH

FRACTION	DECIMAL EQUIVALENT	MILLIMETERS	FRACTION	DECIMAL EQUIVALENT	MILLIMETERS
1/64"	.0156	0.3969	33/64"	.5156	13.0969
1/32"	.0312	0.7937	17/32"	.5312	13.4937
3/64"	.0468	1.1906	35/64"	.5468	13.8906
1/16"	.0625	1.5876	9/16"	.65[illegible]	14.2875
5/64"	.0781	1.9844	37/64"	.5781	14.6844
3/32"	.0937	2.3812	19/32"	.5937	15.0812
7/64"	.1093	2.7781	39/64"	.6093	15.4781
1/8"	.1250	3.1750	5/8"	.6250	15.8750
9/64"	.1406	3.5719	41/64"	.6406	16.2719
5/32"	.1562	3.9687	21/32"	.6562	16.6687
11/64"	.1718	4.3656	43/64"	.6718	17.0656
3/16"	.1875	4.7625	11/16"	.6875	17.4625
13/64"	.2031	5.1594	45/64"	.7031	17.8594
7/32"	.2187	5.5562	23/32"	.7187	18.2562
15/64"	.2343	5.9531	47/64"	.7343	18.6531
1/4"	.2500	6.3500	3/4"	.7500	19.0500
17/64"	.2656	6.7469	49/64"	.7656	19.4469
9/32"	.2812	7.1437	25/32"	.7812	19.8437

DECIMAL AND METRIC EQUIVALENTS OF FRACTIONAL PARTS OF AN INCH (continued)

FRACTION	DECIMAL EQUIVALENT	MILLIMETERS	FRACTION	DECIMAL EQUIVALENT	MILLIMETERS
19/64"	.2968	7.5406	51/64"	.7968	20.2406
6/15"	.3125	7.9375	13/16"	.8125	20.6375
21/64"	.3281	8.3344	53/64"	.8281	21.0344
11/32"	.3437	7.7312	27/32"	.8437	21.4312
23/64"	.3593	9.1281	55/64"	.8593	21.8281
3/8"	.3750	9.5250	7/8"	.8750	22.2250
25/64"	.3906	9.9219	57/64"	.8906	22.6219
13/32"	.4062	10.3187	29/32"	.9062	23.0187
27/64"	.4218	10.7156	59/64"	.9218	23.4156
7/16"	.4375	11.1125	16/16"	.9375	23.8125
29/64"	.4531	11.5094	61/64"	.9531	24.2094
15/32"	.4687	11.9062	31/32"	.9687	24.6062
31/64"	.4843	12.3031	63/64"	.9843	25.0031
1/2"	.5000	12.7000	1"	1.0000	25.4001

WEIGHTS AND MEASURES

LINEAR MEASURE

12 inches (in.)	= 1 foot (ft.)
3 feet	= 1 yard (yd.)
$5\frac{1}{2}$ yards	= 1 rod (rd), pole, or perch = $16\frac{1}{2}$ feet.
40 rods	= 1 furlong (fur) = 220 yards = 660 feet.
8 furlongs	= 1 statute mile (mi) = 1,760 yards = 5,280 feet.
6,076.103 feet (1,852 meters)	= 1 international nautical mile. This value was adopted effective July 1, 1954, for use in the United States. The value formerly used in the United States was 6,080.20 feet = 1 nautical (geographical or sea) mile.

AREA MEASURE[1]

144 square inches (sq.in.)	= 1 square foot (sq ft).
9 square feet	= 1 square yard (sq yd) = 1,296 square inches.
$30\frac{1}{4}$ square yards	= 1 square rod (sq rd) = $272\frac{1}{4}$ square feet.
160 square rods	= 1 acre = 4,840 square yards = 43,560 square feet.
640 acres	= 1 square mile (sq mi)
1 mile square	= 1 section of land.
6 miles square	= 1 township = 36 sections = 36 square miles.

CUBIC MEASURE[1]

1,728 cubic inches (cu in).	= 1 cubic foot (cu ft).
27 cubic feet	= 1 cubic yard (cu yd).

GUNTHER'S OR SURVEYORS CHAIN MEASURE

7.92 inches (in.)	= 1 link (li).
100 links	= 1 chain (ch) = 4 rods = 66 ft.
80 chains	= 1 statute mile (mi) = 320 rods = 5,280 feet.

LIQUID MEASURE[2]

4 gills (gi)	= 1 pint (pt) = 28.875 cubic inches.
2 pints	= 1 quart (qt) = 57.75 cubic inches.
4 quarts	= 1 gallon (gal) = 231 cubic inches = 8 pints = 32 gills

APOTHECARIES FLUID MEASURE

60 minims (min or M)	= 1 fluid dram (fl dr) = 0.225 cubic inch.
8 fluid drams	= 1 fluid ounce (fl oz) = 1.804 cubic inches.
16 fluid ounces	= 1 pint (pt or O) = 28.875 cubic inches = 128 fluid drams.
2 pints	= 1 quart (qt) = 57.75 cubic inches = 32 fluid ounces = 256 fluid drams.
4 quarts	= 1 gallon (gal) = 231 cubic inches = 128 fluid ounces = 1,024 fluid drams.

WEIGHTS AND MEASURES (continued)

DRY MEASURE

2 pints (pt)	= 1 quart (qt) = [illegible] cubic inches.
8 quarts	= 1 peck (pk) = 537.605 cubic inches = 16 pints.
4 pecks	= 1 bushel (bu)= 2,150.42 cubic inches = 32 quarts.

AVOIRDUPOIS WEIGHT[4]

(The "grain" is the same in avoirdupois, troy, and apothecaries weight.)

27 11/32 grains	= 1 dram (dr).
16 drams	= 1 ounce (oz) = $437\frac{1}{2}$ grains.
16 ounces	= 1 pound (lb) = 256 drams = 7,000 grains.
100 pounds	= 1 hundredweight (cwt).[5]
20 hundredweights	= 1 ton = 2,000 pounds.[5]

In "gross" or "long" measure, the following values are recognized:

112 pounds	= 1 gross or long hundredweight.[5]
20 gross or long hundredweights	= 1 gross or long ton = 2,240 pounds.[5]

TROY WEIGHT

(The "grain" is the same in avoirdupois, troy, and apothecaries weight.)

24 grains	= 1 pennyweight (dwt).
20 pennyweights	= 1 ounce troy (oz t) = 480 grains.
12 ounces troy	= 1 pound troy (lb t) = 240 pennyweights = 5,760 grains.

APOTHECARIES WEIGHT

(The "grain" is the same in avoirdupois, troy, and apothecaries weight.)

20 grains	= 1 scruple (s ap).
3 scruples	= 1 dram apothecaries (dr ap) = 60 grains.
8 drams apothecaries	= 1 ounce apothecaries (oz ap) = 24 scruples = 480 grains.
12 ounces apothecaries	= 1 pound apothecaries (lb ap) = 96 drams apothecaries = 288 scruples = 5,760 grains.

Source: Tips And Tables For Science Teachers, Pages 9 and 10.

CONVERSION FACTORS

LENGTH

1 centimeter.................. 0.3937 inch
1 inch.......................2.540 centimeters
1 meter...................... 3.2808 feet
1 foot....................... 0.305 meter
1 meter...................... 1.0936 yards
1 yard....................... 0.9144 meter
1 kilometer.................. 0.62137 mile
1 mile....................... 1.60935 kilometers

AREA

1 square centimeter....... 0.1550 square inch
1 square inch............. 6.452 square centimeters
1 square meter............10.764 square feet
1 square foot............. 0.09290 square meter
1 square meter............ 1.1960 square yards
1 square yard............. 0.8361 square meter
1 square kilometer........ 0.3861 square mile
1 square mile............. 2,590 square kilometers
1 acre (U.S.)............. 4,840 square yards

VOLUME

1 cubic centimeter........ 0.0610 cubic inch
1 cubic inch..............16.3872 cubic centimeters
1 cubic meter.............35.314 cubic feet
1 cubic foot.............. 0.02832 cubic meter
1 cubic meter............. 1.3079 cubic yards
1 cubic yard.............. 0.7646 cubic meter

CAPACITY

1 milliliter.............. 0.03382 ounce (U.S. liquid)
1 ounce (U.S. liquid)....29.573 milliliters
1 milliliter.............. 0.2705 dram (U.S. Apothecaries)
1 dram (U.S. Apothecaries) 3.6967 milliliters
1 liter................... 1.05671 quarts (U.S. liquid)
1 quart (U.S.liquid)...... 0.94633 liter
1 liter................... 0.26418 gallon (U.S. liquid)
1 gallon (U.S. liquid)... 3.78533 liters

MASS

1 gram....................15.4324 grains
1 grain................... 0.0648 gram
1 gram.................... 0.03527 ounce (Avoirdupois)
1 ounce (Avoirdupois)....28.3495 grams
1 gram.................... 0.03215 ounce (Troy)
1 ounce (Troy)............31.10348 grams
1 kilogram................ 2.20462 pounds (Avoirdupois)
1 pound (Avoirdupois).... 0.45359 kilogram

CONVERSION FACTORS (continued)

POWER

1 watt	0.73756 foot pound per second
1 foot pound per second	1.35582 watts
1 watt	0.056884 BTU per minute
1 BTU per minute	17.580 watts
1 watt	0.001341 Horsepower (U.S.)
1 Horsepower (U.S.)	745.7 watts
1 watt	0.01433 kilogram-calorie per minute
1 kilogram-calorie per minute	69.767 watts
1 watt	1 x 107 ergs per second
1 lumen	0.001496 watt

METRIC SYSTEM

The metric system was established in France in the 1790's. The meter's length is based on nothing found in nature. It is the distance between two scratches on a platinum bar kept in the International Bureau of Weights and Measures in France. Standards are established in every country and then compared to the one in France. The gram is the mass of a particular cylinder of platinum that is located in the International Bureau of Weights and Measures. The meter and gram are units that were decided by man.

In the metric system, larger units are formed from smaller units in a series of regular sequences. Each unit is ten times the size of the next smaller unit. The names of the units are formed by adding a prefix to the basic unit. In measuring length, the basic unit is the meter. The prefix tells how many meters or how many parts of a meter the unit contains.

Milli	means	1/1000 part
Centi	means	1/100 part
Deci	means	1/10 part
Deca	means	ten
Hecto	means	one hundred
Kilo	means	one thousand

Scientists use the metric system so all will understand each other.

Source: Macimillan Series Science for Tomorrow's World.

THE METRIC SYSTEM

Measures of length

10 millimeters (mm)	= 1 centimeter (cm)	= 0.3937 in.
10 centimeters	= 1 decimeter (dm)	= 3.937 in.
10 decimeters	= 1 meter (m)	=39.37 in. or 3.28 ft.
10 meters	= 1 decameter (dkm)	=393.7 in.
10 decameters	= 1 hectometer (hm)	=328 ft. 1 in.
10 hectometers	= 1 kilometer (km)	= 0.62137 mi.
10 kilometers	= 1 myriameter (mym)	= 6.2137 mi.

Measures of surface

100 sq. millimeters (mm^2)	= 1 sq. centimeter (cm^2)
100 sq. centimeters	= 1 sq. decimeter (dm^2)
100 sq. decimeters	= 1 sq. meter (m^2)
100 sq. meters	= 1 sq. decameter (dkm^2)
100 sq. decameters	= 1 sq. hectometer (hm^2)
100 sq. hectometers	= 1 sq. kilometer (km^2)

Measures of capacity

The standard unit of capacity is the liter, equal to 1 cubic decimeter or 0.9081 dry quart or 1.0567 liquid quarts.

10 milliliters (ml)	= 1 centiliter (cl)	= 0.338 fl. oz.
10 centiliters	= 1 deciliter (dl)	= 6.1025 cu. in.
10 deciliters	= 1 liter (l)	= 0.9081 dry qt. or 1.0567 liquid qts.
10 liters	= 1 decaliter (dkl)	= 0.284 bu. or 2.64 gal.
10 decaliters	= 1 hectoliter (hl)	= 2.838 bu. or 26.418 gal.
10 hectoliters	= 1 kiloliter (kl)	=35.315 cu. ft. or 264.18 gal.

Weights

The standard unit of weight is the gram, equal to 15.432 grains.

10 milligrams (mg)	= 1 centigram (cg)	= 0.1543 gr.
10 centigrams	= 1 decigram (dg)	= 1.5432 gr.
10 decigrams	= 1 gram (g)	= 15.432 gr.
10 grams	= 1 decagram (dkg)	= 0.3527 oz.
10 decagrams	= 1 hectogram (hg)	= 3.5274 oz.
10 hectograms	= 1 kilogram or kilo (kg)	= 2.2046 lb.
10 kilograms	= 1 myriagram (myg)	= 22.046 lb.

Measures of volume

The standard unit of volume is the cubic meter, equal to 1.308 cubic yards.

1,000 cu. millimeters (cu.mm)	= 1 cu. centim. (cm^3)
1,000 cu. centimeters	= 1 cu. decim. (dm^3)
1,000 cu. decimeters	= 1 cu. meter (m^3)

THE METRIC SYSTEM (continued)

Equivalents

1 inch	=	2.54 centimeters
1 foot	=	30.48 centimeters
1 quart (liquid)	=	0.9464 liter
1 quart (dry)	=	1.101 liters
1 pound av.	=	0.4536 kilogram
1 centimeter	=	0.3937 inch
1 meter	=	39.37 inches
1 liter	=	1.051 quarts (U.S. liq.)
1 liter	=	0.9081 quart (U.S. dry)
1 liter	=	0.8809 quart (British)
1 kilogram	=	2.205 pounds

Common Prefixes

Prefix	Meaning
mega -	million
kilo -	thousand
centi -	one-hundredth
milli -	one-thousandth
micro -	one-millionth

Miscellaneous

1 U.S. gallon of water weighs 8.33 lb.
1 British gallon of water weighs 10 lb.
1 Cubic foot of water weighs 62.3 lb.
1 British billion means 1 million millions.
1 U.S. billion means 1 thousand millions.
1 British trillion means 1 million billions.
1 U.S. trillion means 1 thousand billions, or
1 U.S. trillion = 1 British billion.

SPACE SCIENCE

SATELLITES OF THE SOLAR SYSTEM

Name	Distance From Planet (Miles)	Period (Days)	Diameter (Miles)	Discoverer	Date
Earth					
Moon	239,100	27.32	2,162		
Mars					
I Phobos	5,830	0.32	7	Hall	1877
II Deimos	14,600	1.26	5	Hall	1877
Jupiter					
V	113,000	0.50	150	Barnard	1892
I lo	262,000	1.77	2,090	Galileo	1610
II Europa	417,000	3.55	1,870	Galileo	1610
III Ganymede	666,000	7.16	3,100	Galileo	1610
IV Callisto	1,170,000	16.69	2,850	Galileo	1610
VI	7,120,000	251	100	Perrine	1904
VII	7,290,000	260	35	Perrine	1905
X	7,300,000	260	15	Nicholson	1938
XII	13,000,000	625	14	Nicholson	1951
XI	14,000,000	700	19	Nicholson	1938
VIII	14,600,000	739	35	Melotte	1908
IX	14,700,000	758	17	Nicholson	1914
Saturn					
I Mimas	186,000	0.94	370	Herschel	1789
II Enceladus	238,000	1.37	460	Herschel	1789
III Tethys	295,000	1.89	750	Cassini	1684
IV Dione	338,000	2.74	900	Cassini	1684
V Rhea	527,000	4.52	1,150	Cassini	1672
VI Titan	1,200,000	15.9	2,950	Huyghens	1655
VII Hyperion	1,500,000	21.3	300	Bond	1848
VIII Lapetus	3,600,000	79	1,100	Cassini	1671
IX Phoebe	13,000,000	550	150	Pickering	1898
Uranus					
I Miranda	81,000	1.41	200?	Kuiper	1948
II Ariel	119,000	2.52	600?	Lassell	1851
III Umbriel	166,000	4.14	400?	Lassell	1851
IV Titania	273,000	8.71	1,000?	Herschel	1787
V Oberon	365,000	13.46	900?	Herschel	1787
Neptune					
I Triton	220,000	5.88	2,800?	Lassell	1846
II Nereid	5,800,000	785	200?	Kuiper	1948

TOTAL SOLAR ECLIPSES, 1963 to 2000 A.D.

Date	Path of Total Phase
1963, July 20.....	Japan, Bering Sea, Alaska, northern Canada, mid-north Atlantic Atlantic Ocean
1965, May 30.....	South Pacific: New Zealand - Marquesas Islands - Peru
1966, May 20.....	Atlantic Ocean, NW Africa, Mediterranean Sea, across Asia
1966, Nov. 12.....	Pacific, west of Galápogos Islands, across southern South America, across the south Atlantic to the Indian Ocean
1967, Nov. 2.....	Antarctic Ocean, Antarctica
1968, Sept.22.....	Arctic Ocean, northern Russia, to central Asia
1970, Mar. 7.....	Central Pacific Ocean, Mexico, Florida, to mid-north Atlantic Ocean
1972, July 10.....	Northeastern Asia, Alaska, northern Canada, to mid-Atlantic Ocean
1973, June 30.....	Northern South America, Atlantic Ocean, across northern Africa to mid-Indian Ocean
1974, June 20.....	Southern Indian Ocean and Antarctic Ocean, south of Australia
1976, Oct. 23.....	East Africa, across the Indian Ocean and Australia to a point near New Zealand
1977, Oct. 12.....	Mid-north Pacific Ocean, southeastward, extending into northern South America
1979, Feb. 26.....	North Pacific Ocean, northwest tip of United States, across Canada, Hudson Bay, into central Greenland
1980, Feb. 16.....	Atlantic Ocean, across central Africa, Indian Ocean, India, southern China
1981, July 31.....	Southeastern Europe, across Siberia, to mid-north Pacific Ocean
1983, June 11.....	South Indian Ocean, across the East Indies, to western Pacific Ocean
1984, May 30.....	Pacific Ocean, across Mexico, southern United States, across the Atlantic to northern Africa
1984, Nov. 22.....	East Indies, across the south Pacific Ocean to a point off the coast of Chile
1985, Nov. 12.....	Antarctic Ocean

1986, Oct. 3.....(A short eclipse.) In the Atlantic just off the southeast coast of Greenland

1987, Mar. 29.....Patagonia across the south Atlantic Ocean, across Africa

1988, Mar. 18.....Eastern Indian Ocean, across Sumatra, the Malay Peninsula, into the north Pacific, across the Philippine Islands to a point south of Alaska

1990, July 22.....Finland, the Arctic Ocean, northeastern Asia, across the north Pacific

1991, July 11.....Mid-Pacific Ocean, across Mexico, Central America, northern South America, into Brazil

1992, June 30.....Southeastern South America, across mid-south Atlantic to the Indian Antarctic Ocean

1994, Nov. 3.....Pacific Ocean south of the Galápagos Islands across South America and the south Atlantic Ocean to the western Indian Ocean.

1995, Oct. 24.....Southwestern Asia, across northern India, the Malay Peninsula, into mid-Pacific Ocean

1997, Mar. 9.....Central Asia, across N.E. Asia, into the Arctic Ocean

1998, Feb. 26.....Mid-Pacific Ocean, across the northern tip of South America, across the Atlantic Ocean to the Canary Islands

1999, Aug. 11.....Atlantic Ocean south of Nova Scotia, across the north Atlantic, across central Europe, southern Asia, and northern India

2000..............No total solar eclipse

Note: The next total solar eclipse over our area occurs on April 8, 2024.

ANNULAR ECLIPSES, 1963 to 1990 A.D.*

Date	Path of Annular Phase
1963, Jan. 25	South Pacific west of Chile, across southern South America, into the Antarctic Ocean and to Indian Ocean east of Madagascar
1965, Nov. 23	Northwestern India to coast near Calcutta, across Malay Peninsula, Borneo, and New Guinea, into mid-north Pacific
1969, Mar. 18	Across the Indian Ocean and the East Indies islands
1969, Sept. 11	Northern and eastern Pacific Ocean into Brazil
1970, Aug. 31	The East Indies and into the south Pacific Ocean
1972, Jan. 16	Marie Byrd Land and eastern Antarctica
1973, Jan. 4	South Pacific, South America, into the south Atlantic
1973, Dec. 24	Across northern South America, Atlantic Ocean, ending in North Africa
1976, Apr. 29	Atlantic, North Africa, Mediterranean sea, south central Asia
1977, Apr. 18	South Atlantic, across South Africa to the Indian Ocean
1979, Aug. 22	Across Amundseen Sea into western Antarctica
1980, Aug. 10	Mid-Pacific Ocean into Brazil
1981, Feb. 4	Pacific Ocean, from South of Australia to near South American coast
1983, Dec. 4	North Atlantic Ocean, across central Africa
1987, Sept. 22	Central Asia to mid-Pacific Ocean
1988, Sept. 11	West Indian Ocean to south Pacific south of New Zealand
1990, Jan. 26	South Indian Ocean and south Atlantic Ocean

* Annular Eclipse is an eclipse in which a thin ring of sunlight is visible encircling the dark moon.

TOTAL LUNAR ECLIPSES 1963 to 1984

Date	Time	Dur.	Region of Visibility
	h m	h m	
1963, Dec. 30...	6 7	1 24	Mid-Pacific, and partly in North America
1964, June 24...	20 7	1 38	Africa, Europe, South America, eastern North America
1964, Dec. 18...	21 35	1 4	South America, most of North America, western Africa, Europe
1967, Apr. 24...	7 7	1 22	Pacific Ocean and Australia
1967, Oct. 18...	5 16	0 56	Pacific Ocean, western North America
1968, Apr. 12...	23 49	0 56	Most of United States, Mexico, South America
1968, Oct. 6...	6 41	1 2	Pacific Ocean and Australia
1971, Feb. 10...	2 42	1 18	South Canada, United States, part of South America
1971, Aug. 6...	14 44	1 42	Part of Africa, India, west Indian Ocean
1972, Jan. 30...	5 53	0 42	Pacific Ocean, western North America
1974, Nov. 29...	10 16	1 16	Eastern Asia and Australia
1975, May 25...	0 46	1 30	Southern United States, Mexico, South America
1975, Nov. 18...	17 24	0 46	Europe and Africa
1978, Mar. 24...	11 25	1 30	Southern Asia and Australia
1978, Sept. 16...	14 3	1 22	Most of Africa, southern Asia
1979, Sept. 6...	5 54	0 52	Pacific Ocean, eastern Australia
1982, Jan. 9...	14 56	1 24	Part of Africa, eastern Europe, southern Asia
1982, July 6...	2 30	1 42	South Pacific Ocean, Mexico, western South America
1982, Dec. 30...	6 26	1 6	Central Pacific Ocean
1983.............	.. ..	. ..	No total Lunars in 1983-1984

PLANETARY DATA

	Mean Distance From Sun		Period of Revolution Around the Sun	Period of Rotation on Axis
	Miles	Astronomical Units		
Sun				25^d
Mercury	36,000,000	0.387	$87^d.969$	88^d
Venus	67,270,000	0.723	$224^d.701$	few wk.
Earth	93,000,000	1.000	$365^d.256$	$23^h\ 56^m$
Mars	141,700,000	1.524	$1^y.881$	$24^h\ 37^m$
Jupiter	483,900,000	5.203	$11^y.862$	$9^h\ 50^m$
Saturn	887,100,000	9.539	$29^y.458$	$10^h\ 14^m$
Uranus	1,783,900,000	19.182	$84^y.013$	$10^h.8$ *
Neptune	2,795,400,000	30.058	$164^y.794$	$15^h.8$ *
Pluto	3,675,000,000	39.518	$248^y.430$	?

* Approximately

	Diameter	Surface gravity (earth=1)	Density (earth=1)	Known Moons
Sun	865,400	28.	1.4	
Mercury	3,000	0.27	3.8	0
Venus	7,848	0.85	5.1	0
Earth	7,927	1.00	5.5	1
Mars	4,268	0.38	4.0	2
Jupiter	89,329	2.64	1.3	12
Saturn	75,021	1.17	0.7	9
Uranus	33,219	1.07	1.3	5
Neptune	27,700	1.4	2.2	2
Pluto	3,600	?	?	0

Note: The information above was taken from recent and reliable sources. However, the sources did not agree on a few of the above figures.

CHART OF THE CONSTELLATIONS OF THE ZODIAC

Spring signs

March	1	Aries
April	2	Tarus
May	3	Gemini

Summer signs

June	4	Cancer
July	5	Leo
Aug.	6	Virgo

Autumn signs

Sept.	7	Libra
Oct.	8	Scorpio
Nov.	9	Saggitarius

Winter signs

Dec.	10	Capricorn
Jan.	11	Aquarius
Feb.	12	Pisces

Source: 700 Science Exp. For Everybody

SCALE CHART OF THE SOLAR SYSTEM (TO BE USED FOR CLASSROOM CHARTS, ETC.)

PLANET	DIA. IN INCHES	DISTANCE FROM SUN IN INCHES
Mercury	1/6	2
Venus	3/8	4
Earth	1/2	6
Mars	1/4	9
Jupiter	5 1/2	30
Saturn	4	60
Uranus	2	120
Neptune	2	180
Pluto	1/4	240

INTERPLANETARY WEIGHT CHART

EARTH	MOON	SUN	VENUS	MARS	JUPITER
70 lbs.	11 lbs.	1952 lbs.	60 lbs.	27 lbs.	185 lbs.
80	13	2231	68	30	211
90	14	2510	77	34	238
100	16	2789	85	38	264
110	18	3068	94	42	290
120	19	3347	102	46	317
130	21	3626	111	49	343
140	22	3905	119	53	370
150	23	4184	128	57	396
160	25	4462	136	61	422
170	27	4741	145	65	449
180	28	5020	153	68	475
190	30	5299	162	72	502
200	32	5578	170	76	528

A TIME TABLE OF FIRSTS IN SPACE EXPLORATION

1912	Dr. Robert H. Goddard	explored mathematically the use of rocket propulsion to reach outer space and the moon.
1914	Dr. Robert H. Goddard	received first US patent on idea of multi-stage rockets.
1919	Dr. Robert H. Goddard	submitted first report on rocket propulsion to Smithsonian Institute.
March 16, 1926	Dr. Robert H. Goddard	developed and fired first liquid fuel rocket.
1932	Dr. Robert H. Goddard	developed first gyro control apparatus for rocket flights.
1929	Dr. Robert H. Goddard	shot first scientific payload into space. Payload contained barometer and camera.
1932	Dr. Robert H. Goddard	developed vanes for guidance in the rocket motor.
1935	Dr. Robert H. Goddard	fired first liquid fuel rocket at a speed faster than sound.
1937	Dr. Robert H. Goddard	launched first rocket with a motor pivoted in gimbals under the control of gyro r hanism.
June, 1946	White Sands, New Mexico	launching of first sound rocket V-2 for research.

Source: What's Up There NASA, 1964

C H E M I S T R Y

COMMON SODIUM COMPOUNDS FOUND IN THE HOME

COMMON NAME	CHEMICAL NAME
Baking Soda	Sodium Bicarbonate
Washing Soda	Sodium Carbonate
Soap Powder	Sodium Stearate
Borax	Sodium Borate
TSP	Trisodium Phosphate

TABLE OF COMMON ACIDS

NAME OF ACID	FORMULA	USE
Hydrochloric	HCl	It is found, naturally, in the stomach, where it aids digestion of certain foods; also used to clean metals.
Nitric	HNO3	To make explosives, like TNT and nitro-glycerine.
Sulphuric	H2SO4	To clean metals, refine oil, and make other acids.
Boric	H3BO3	An eye wash.
Carbonic	H2CO3	Found in soda water. It gives soda water a slightly sour taste.

TABLE OF COMMON BASES

NAME OF BASE	FORMULA	USE
Sodium Hydroxide	NaOH	Commonly called lye; used in cleaning drains and in making soap.
Calcium Hydroxide	$Ca(OH)_2$	Found in limewater and used by the chemist to test for CO2. Also used by farmers to neutralize acid in the soil
Ammonium Hydroxide	NH4OH	Commonly called ammonia water and used as a cleaning fluid.
Magnesium Hydroxide	Mg(OH)4	The chief ingredient in milk of magnesia; used to neutralize acid in the stomach.

Source: Lets Explore Chemistry

MATERIALS FOUND AROUND THE HOME AND SCHOOL

pans of various sizes
jars of various sizes
glasses of various sizes
plaster of Paris
straws
colored inks
pocket knife
combs
used electric bulbs
flower pots
empty thread spools
fur
used toothbrushes
nails, assorted sizes
screws, assorted sizes
bolts and nuts, assorted sizes
springs
mirrors
washers
sheet metal
metal rods
curtain rods
wire screening
needles, knitting
needles, sewing
needles, darning
watering cans
enameled pans
strainers
can opener
sand paper
steel wool
paint
hack-saw blades
metal balls
oil cans
thermos bottles
used storage batteries
spark plugs
fuses, home and auto
wire from old coils
model train transformers
plywood
sawdust
round dowel rods
old cameras
lenses
old eye-glass lenses
toys
used bicycle wheels
rubber grips from handlebars
cigar boxes
shoe boxes
oatmeal boxes
thin rubber sheeting
tablespoons
teaspoons
modeling clay
candles
food dyes
tin cans, various sizes
salt shakers
wire coat hangers
milk bottles
razor blades
cloth, various kinds
cork
aluminum milk bottle caps
tacks
screw eyes
fish-line
string, twine, rope, thread
hooks, assorted sizes
fishing weights, assorted sizes
egg beater
lamp chimneys
metal tubing
tongue depressors
aluminum foil
flower pots
garden tools
rubber balls, various sizes
rubber gloves
level
turn buckles
glue and household cement
varnish
scissors
wooden balls
oil
old rubber inner tubes
headlight lenses
gears
ball bearings
curved reflectors from headlights
boards of all sizes
masonite
scrap iron and lead pipe
rubber suction cups
old faucets
marbles
small wagons
ping pong balls
rubber bands
mailing tubes
blotting paper
paper towels
old roller skates

seeds and fruits
bird's nests
soils
insects
sealing wax
copper tubing
carbon rod (inside a dry cell)
old Christmas tree lights (series and parallels)
cloth - silk, cotton, wool, synthetics, linen, silk
old household appliances
- irons
- toasters
- mixers
- fans
- beaters

coal and charcoal
leaves
rocks and minerals
fossils
plants
steel wool
zinc (metal casing inside a dry cell)

TOOLS NEEDED FOR MAKING SIMPLE EQUIPMENT

soldering iron and solder
screw drivers
hammers
pliers
chisels
mallets
tin snips
files
wrenches
wood saw
hack saw
coping saw
small block plane
brace and bits
round file
triangle file
flat file
glass cutter
small table vice
piece of heavy bench iron
sand paper

CHEMICALS FOUND IN THE HOME AND SCHOOL

COMMON NAME	CHEMICAL NAME
alum	potassium aluminum sulfate
ammonia (household)	dilute ammonium hydroxide
aspirin	acetyl-salicylic acid
baking soda	sodium bicarbonate
beet sugar	sucrose
benzine	gasoline
bleaching powder	calcium chloro-hypochlorite
blue vitriol	copper sulfate
boracic acid	boric acid
borax	sodium tetraborate
camphor, artificial	pinene hydrochloride
cane sugar	sucrose
chalk	calcium carbonate
chlorox	dilute sodium hypochlorite
dry ice	solidified carbon dioxide
epsom salts	magnesium sulfate
gypsum (sheet rock)	calcium sulfate
iodine	tincture of iodine
lemon juice	citric acid
lime	calcium oxide
marble	calcium carbonate
milk of magnesium	magnesium hydroxide
muriatic acid	hydrochloric acid
plaster of Paris	calcium sulfate
peroxide	hydrogen peroxide
putty powder	stannic oxide
quick lime	calcium oxide
quicksilver	mercury
rock salt	sodium chloride
saccharin	bensoic sulfinide
sal ammoniac	ammonium chloride
salt	sodium chloride
slaked lime	calcium hydroxide
soap	sodium stearate
soda (washing)	sodium carbonate
vinegar	dilute acetic acid

COMMON ELEMENTS

Name	Symbol
Aluminum	Al
Antimony	Sb
Arsenic	As
Barium	Ba
Bismuth	Bi
Bromine	Br
Calcium	Ca
Carbon	C
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Fluorine	F
Gold	Au
Hydrogen	H
Iodine	I
Iron	Fe
Lead	Pb
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Nitrogen	N
Oxygen	O
Phosphorus	P
Platinum	Pt
Potassium	K
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Sulfur	S
Tin	Sn
Titanium	Ti
Tungsten	W
Zinc	Zn

SOME COMMON MOLECULES

COMMON NAME	SYMBOL FOR ONE MOLECULE	COMPOSITION OF ONE MOLECULE
cane or beet sugar, or sucrose	$C_{12} H_{22} O_{11}$	12 carbon atoms, 22 hydrogen atoms, 11 oxygen atoms
table salt	NaCl	1 sodium atom, 1 chlorine atom
cooking gas	CH_4	1 carbon atom, 4 hydrogen atoms
baking soda	NaHCO	1 sodium atom, 1 hydrogen atom, 1 carbon atom, 3 oxygen atoms
lemon juice of citric acid	$C_3 H_4 OH\text{-}(COOH)_3$	6 carbon atoms, 8 hydrogen atoms, 7 oxygen atoms
vinegar, acetic acid	$CH_3 COOH$	2 carbon atoms, 4 hydrogen atoms, 2 oxygen atoms
limestone	$CaCO_3$	1 calcium atom, 1 carbon atom, 3 oxygen atoms
silver tarnish	Ag_2S	2 silver atoms, 1 sulfur atom

TABLE OF ACID-BASE INDICATORS

INDICATOR	pH RANGE	COLOR	
		ACID	ALKALINE
Methyl violet	0.1- 1.5	yellow	blue
Metacresol purple (acid)	0.5- 2.5	red	yellow
Tropeolin OO	1.4- 2.6	red	yellow
Thymol blue (acid)	1.2- 2.8	red	yellow
Alizarin yellow R (p)	1.9- 3.3	red	yellow
Methyl yellow	2.9- 4.0	red	yellow
Methyl orange	3.1- 4.4	red	orange
Bromphenol blue	3.0- 4.6	yellow	blue-violet
Congo red	3.0- 5.2	blue	red
Alizarin sodium sulfonate	3.7- 5.2	yellow	violet
Bromcresol green	3.8- 5.4	yellow	blue
Methyl red	4.2- 6.3	red	yellow
Chlorphenol red	4.8- 6.4	yellow	red
Bromcresol purple	5.2- 6.8	yellow	purple
Bromphenol red	5.2- 7.0	yellow	red
Bromthmol blue	6.0- 7.6	yellow	blue
Neutral red	6.0- 8.0	red	yellow

TABLE OF ACID-BASE INDICATORS (continued)

INDICATOR	pH RANGE	COLOR	
		ACID	ALKALINE
Rosolic acid	6.8- 8.2	yellow	red
Azolitmin	4.5- 8.3	red	blue
Phenol red	6.8- 8.4	yellow	red
Naphtholphthalein	7.3- 8.7	rose	green
Cresol red	7.2- 8.8	yellow	red
Tropeolin 000	7.6- 8.9	yellow	rose-red
Metacresol purple (alkaline)	7.4- 9.0	yellow	purple
Thymol blue (alkaline)	8.0- 9.6	yellow	blue
Phenolphthalein	8.3-10.0	colorless	red
Thymolphthalein	9.3-10.5	colorless	blue
Tropeolin O	11.0-12.7	yellow	orange-brown
Poirroer's blue	11.0-13.0	blue	violet-pink
Indigo carmine	11.6-14.0	blue	yellow

ATOMIC WEIGHT AND NUMBER CHART

Name	Symbol	Atomic Number	Atomic Weight	Name	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227*	Mercury	Hg	80	200.61
Aluminum	Al	13	26.98	Molybdenum	Mo	42	95.95
Americium	Am	95	243*	Neodyminum	Nd	60	144.27
Antimony	Sb	51	121.76	Neon	Ne	10	20.183
Argon	Ar	18	39.944	Neptunium	Np	93	237*
Arsenic	As	33	74.91	Nickel	Ni	28	58.71
Astatine	At	85	210*	Niobium	Nb	41	92.91
Barium	Ba	56	137.36	Nitrogen	N	7	14.008
Berkelium	Bk	97	249*	Nobelium	No	102	----
Beryllium	Be	4	9.013	Osmium	Os	76	190.2
Bismuth	Bi	83	209.00	Oxygen	O	8	16
Boron	B	5	10.82	Palladium	Pd	46	106.4
Bromine	Br	35	79.916	Phosphorus	P	15	30.975
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.09
Calcium	Ca	20	40.08	Plutonium	Pu	94	242*
Californium	Cf	98	251*	Polonium	Po	84	210*
Carbon	C	6	12.011	Potassium	K	19	39.100
Cerium	Ce	58	140.13	Praseodymium	Pr	59	140.92

ATOMIC WEIGHT AND NUMBER CHART (continued)

Name	Symbol	Atomic Number	Atomic Weight	Name	Symbol	Atomic Number	Atomic Weight
Cesium	Cs	55	132.91	Promethium	Pm	61	147*
Chlorine	Cl	17	35.457	Protactinium	Pa	91	231*
Chromium	Cr	24	52.01	Radium	Ra	88	226*
Cobalt	Co	27	58.94	Radon	Rn	86	222*
Copper	Cu	29	63.54	Rhenium	Re	75	186.22
Curium	Cm	96	247*	Rhodium	Rh	45	102.91
Dysprosium	Dy	66	162.51	Rubidium	Rb	37	85.48
Einsteinium	Es	99	154*	Ruthenium	Ru	44	101.1
Erbium	Er	68	167.27	Samarium	Sm	62	150.35
Europium	Eu	63	152.0	Scandium	Sc	21	44.96
Fermium	Fm	100	253*	Selenium	Se	34	78.96
Fluorine	F	9	19.00	Silicon	Si	14	28.09
Francium	Fr	87	223*	Silver	Ag	47	107.880
Gadolinium	Gd	64	157.26	Sodium	Na	11	22.991
Gallium	Ga	31	69.72	Strontium	Sr	38	87.63
Germanium	Ge	32	72.60	Sulfur	S	16	32.006+
Gold	Au	79	197.0	Tantalum	Ta	73	180.95
Hafnium	Hf	72	178.50	Technetium	Tc	43	99*
Helium	He	2	4.003	Tellurium	Te	52	127.61

ATOMIC WEIGHT AND NUMBER CHART (Continued)

Name	Symbol	Atomic Number	Atomic Weight	Name	Symbol	Atomic Number	Atomic Weight
Holmium	Ho	67	164.94	Terbium	Tb	65	158.93
Hydrogen	H	1	1.0080	Thallium	Tl	81	204.39
Indium	In	49	114.82	Thorium	Th	90	232.05
Iodine	I	53	126.91	Thulium	Tm	69	168.94
Iridium	Ir	77	192.2	Tin	Sn	50	118.70
Iron	Fe	26	55.85	Titanium	Ti	22	47.90
Krypton	Kr	36	83.80	Tungsten	W	74	183.86
Lanthanum	La	57	138.92	Uranium	U	92	238.07
Lawrencium	Lw	103	257	Vanadium	V	23	50.95
Lead	Pb	82	207.21	Xenon	Xe	54	131.30
Lithium	Li	3	6.940	Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.99	Yttrium	Y	39	88.92
Magnesium	Mg	12	24.32	Zinc	Zn	30	65.38
Manganese	Mn	25	54.94	Zirconium	Zr	40	91.22
Mendelevium	Md	101	256*				

* Mass number of the isotope of longest known half-life or a better known one.

+ Because of natural variations in the relative abundance of the isotopes of sulfur, the atomic weight of this element has a range of ± 0.003.

APPROXIMATE pH VALUES

The following tables give approximate pH values for a number of substances such as acids, bases, foods, biological fluids, etc. All values are rounded off to the nearest tenth and are based on measurments made at 25°C. A few buffer systems with their pH values are also given.

ACIDS

Hydrochloric, N	0.1
Hydrochloric, 0.1N	1.1
Hydrochloric, 0.01N	2.0
Sulfuric, N	0.3
Sulfuric, 0.1N	1.2
Sulfuric, 0.01N	2.1
Orthophosphoric, 0.1N	1.5
Sulfurous, 0.1N	1.5
Oxalic, 0.1N	1.6
Tartaric, 0.1N	2.2
Malic, 0.1N	2.2
Citric, 0.1N	2.2
Formic, 0.1N	2.3
Lactic, 0.1N	2.4
Acetic, N	2.4
Acetic, 0.1N	2.9
Acetic, 0.01N	3.4
Benzoic, 0.01N	3.1
Alum, 0.1N	3.2
Carbonic (saturated)	3.8
Hydrogen sulfide, 0.1N	4.1
Arsenious (saturated)	5.0
Hydrocyanic, 0.1N	5.1
Boric, 0.1N	5.2

BASES

Sodium hydroxide, N	14.0
Sodium hydroxide, 0.1N	13.0
Sodium hydroxide, 0.01N	12.0
Potassium hydroxide, N	14.0
Potassium hydroxide, 0.1N	13.0
Potassium hydroxide, 0.01N	12.0
Sodium metasilicate, 0.1N	12.6
Lime (saturated)	12.4
Trisodium phosphate, 0.1N	12.0
Sodium carbonate, 0.1N	11.6
Ammonia, N	11.6
Ammonia, 0.1N	11.1
Ammonia, 0.01N	10.6
Potassium cyanide, 0.1N	11.0
Magnesia (saturated)	10.5
Sodium sesquicarbonate, 0.1M	10.1
Ferrous hydroxide (saturated)	9.5
Calcium carbonate (saturated)	9.4
Borax, 0.1N	9.2
Sodium bicarbonate, 0.1N	8.4

FOODS

Apples	2.9-3.3
Apricots	3.6-4.0
Asparagus	5.4-5.8
Bananas	4.5-4.7
Beans	5.0-6.0
Beer	4.0-5.0
Beets	4.9-5.5
Blackberries	3.2-3.6
Bread, white	5.0-6.0
Butter	6.1-6.4
Milk, cows	6.3-6.6
Olives	3.6-3.8
Oranges	3.0-4.0
Oysters	6.1-6.6
Peaches	3.4-3.6
Pears	3.6-4.0
Peas	5.8-6.4
Pickles, dill	3.2-3.6
Pickles, sour	3.0-3.4
Pimento	4.6-5.2

APPROXIMATE pH VALUES (continued)

Cabbage.........................5.1-5.4
Carrots.........................4.9-5.3
Cheese..........................4.8-6.4
Cherries........................3.2-4.0
Cider...........................2.9-3.3
Corn............................6.0-6.5
Crackers........................6.5-8.5
Dates...........................6.2-6.4
Eggs, fresh white...............7.6-8.0
Flour, wheat....................5.5-6.5
Gooseberries....................2.8-3.0
Grapefruit......................3.0-3.3
Grapes..........................3.5-4.5
Hominy (lye)....................6.8-8.0
Jams, fruit.....................3.5-4.0
Jellies, fruit..................2.8-3.4
Lemons..........................2.2-2.4
Limes...........................1.8-2.0
Maple syrup.....................6.5-7.0
Plums...........................2.8-3.0
Potatoes........................5.4-6.0
Pumpkin.........................4.8-5.2
Raspberries.....................3.2-3.6
Rhubarb.........................3.1-3.2
Salmon..........................6.1-6.3
Sauerkraut......................3.4-3.6
Shrimp..........................6.8-7.0
Soft drinks.....................2.0-4.0
Spinach.........................5.1-5.7
Squash..........................5.0-5.4
Strawberries....................3.0-3.5
Sweet potatoes..................5.3-5.6
Tomatoes........................4.0-4.4
Tuna............................4.9-6.1
Turnips.........................5.2-5.6
Vinegar.........................2.4-3.4
Water, drinking.................6.5-8.0
Wines...........................2.8-3.8

PREPARING CARBON DIOXIDE (CO_2)

To a test tube half-filled with a 25% solution of sodium bisulfate and water add 1 gm of sodium bicarbonate. CO_2 is present when the solution begins to fizzle.

PREPARING OXYGEN (O)

Add 1 gm of manganese dioxide to a test tube half filled with a solution of hydrogen peroxide. An immediate bubbling reaction will occur as the oxygen rises to the top of the solution.

PREPARING LIMEWATER

In a quart of water, mix a tablespoon of calcium hydroxide. Shake and filter the solution until the liquid becomes clear.

Place a straw into the solution and blow through the straw for approximately 2 minutes. The reaction between the carbon dioxide and limewater will result in the solution becoming milky-white.

FLAME TEST FOR CHEMICALS

Thoroughly clean a platinum or nichrome wire by dipping in concentrated hydrochloric acid. Make a small loop on the end of the wire and hold over an open flame until there is no change in flame color. Hold the wire loop in some mineral (powder form) which has been moistened with hydrochloric acid. Hold the wire in the open flame and note color. It may be necessary to view the flame through a cobalt blue glass which will mask the yellow sodium flame.

ELEMENT	FLAME COLOR	ELEMENT	FLAME COLOR
Strontium	Crimson	Barium	Pale green
Lithium	Crimson	Copper	Emerald green
Calcium	Orange	Potassium	Violet
Sodium	Intense, persisting yellow		

Source: Geo. & Earth Sciences Sourcebook.

CHEMICAL TESTS

A. Testing for STARCH:

Starch, or products containing starch, reacts with iodine and results in a characteristic blue-black color.

1. Place a drop of iodine on the substance to be tested. Always put a drop of iodine on a piece of white paper for comparison.

B. Testing for SUGAR:

Fehling's solution is used to test for the presence of sugar. Put a little of this solution in a test tube and boil it for 10 seconds (see section on how to heat materials in a test tube). Add a little of the material to be tested and boil for another 10 seconds. If a reddish-brown substance falls to the bottom of the test tube, sugar is present. There may be other color changes but the final stage will be reddish-brown if sugar is present.

C. Tests for ACIDS and BASES:

There are many ways to test for acids and bases:

1. Acids:

   a. Turn blue litmus paper pink.
   b. Turn Congo Red solution blue.
   c. Change pH papers from yellow to shades of red depending upon the strength of the acid.
   d. Change the color of Phenol red to yellow-orange.

2. Bases:

   a. Turn pink litmus paper blue.
   b. Turn phenolphthalein solution pink.
   c. Turn turmeric reddish-brown.
   d. Change the color of pH papers from yellow to shades of blue depending on the strength of the base.

Source: Earth's Crust Kit.

LIVING THINGS

THE CARE OF LIVING SPECIMENTS IN THE CLASSROOM

Animals	Habitat	Controlled Habitat	Food	Cause of Failure	Remarks
Ants	Common on the grounds everywhere	Miniature Vivarium tight fitting top	Sugar Fat Honey-water	Development of molds lack of water	
Caterpillars	Common everywhere	Insect cage, glass jar with screened top, screened box	Plenty of fresh leaves from plant specimen on which found	Lack of food and moisture	Should be isolated
Cocoons	Found on trees and bushes in fall and winter	Fasten outside window. If kept inside, sprinkle lightly with water each week	None	Lack of moisture, too warm	
Crayfish and Shrimp	Ponds	Semi-aquatic in balanced aquarium	Earthworms Fresh meat	Over-crowding Crowding Drowning	Provide rock or other hiding place
Earthworms	Gardens or Lawns rich soil	18" of soil, leaves, grass, and sphagnum moss, wooden container	Lettuce Vegetation leaves	Over-stock-too much heat lack of moisture	Keep cool Keep tub completely covered
Frogs	Ponds	Semi-aquatic aquarium	Mealworms Flies Earthworms	Too sudden change of temperature	Screen top of tank for ventilation
Toads	Woodlands Gardens	Woodlands aquarium or semi-aquatic	Mealworms Flies Insects	Lack of moisture	Provide leaf and branches for shelter. Do not keep with salamander.
Frog eggs Toad eggs	Ponds	Balanced aquarium in pond water	None	Chlorine in tap water Overcrowded	
Tadpoles (frog, toad salamander)	Ponds	Balanced aquarium	Tropical fish food	Overcrowding	
Crickets	Common in grass and fields	Screened cage or jar, inch or two of damp sand	Bread, lettuce, apples, meat, scraps, dead insects	Cannibalistic	Provide a hiding place such as a board. Will live through winter

mals	Habitat	Controlled Habitat	Food	Cause of Failure	Remarks
Grasshoppers	Common everywhere	Screened cage or meadow terrarium	Leaves, lettuce dipped in water	Parasites lack of food and moisture	Will die in late fall after mating and laying eggs
Katydids	On bushes and trees	Same as grass-hoppers	Same as grass-hoppers		Will die in late fall
Praying Mantis	In tall grass	Screened meadow terrarium	Living insects Fresh liver	Lack of food	
Goldfish Minnows and Guppies		Balanced aquarium allowing 1" of fish to 1 gal. of water	Commercial fish food (natural type)	Overcrowding	Remove excess food
White rats Hamster Rabbits		Screened cages wire bottoms with pan underneath	Dry dog food lettuce	Drafts direct sunlight	Plenty of drinking water. Field mice shoul be kept a day or two for observation and then released. Rabbits can be kept in captivity
Guinea Pigs		Screened cage of 72° temperature. Straw on bottom	Dry dog food lettuce carrots	Drafts	Cage must be cleaned daily
Snakes	Woods and fields	Screened woodland terrarium	Earthworms insects bits of meat Frogs	Sudden change in temperature. Lack of drinking water and humidity	Provide hiding space. Likes warmth. Skin dull before sheuding.
Salamander Newts Efts	In or near brooks and streams	Semi-aquatic terrarium	Live insects, fruit-flies, small earth-worms, raw liver		Must have living food or fed by moving the food offered.
Turtles	Ponds	Semi-aquatic	Ant eggs bit of raw beef earthworms mealworms at will	Too low temperature lack of means of getting out of water	Must n[illegible] put in a[illegible]m. Turt[illegible] company; turtles do better if more than one is in container.

FOOD PLANTS AND OVERWINTERING STAGES OF A FEW OF THE MORE COMMON CATERPILLARS

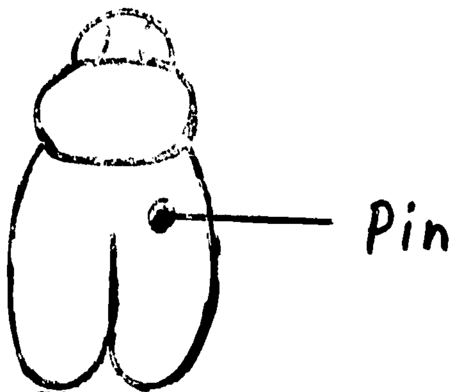
BUTTERFLIES

Kinds of Caterpillars	Principal Food Plants	Overwintering Stage
Monarch	milkweed	adults migrate south
Fritillaries	violets	young larva
Angle-wings	nettles, elm, hops	adult
Mourning-cloak	willow,elm, poplar	adult
Red-spotted Purple	willow, cherry	young larva,in leaf shelter
Cabbage Butterfly	cabbage	pupa (chrysalis)
Black Swallowtail	carrots, parsley	pupa (chrysalis)
Spicebush Swallowtail	spicebush, sassafras	pupa (chrysalis)
Tiger Swallowtail	wild cherry	pupa (chrysalis)
Zebra Swallowtail	papaw	pupa (chrysalis)
Silver-spotted Skipper	black locust	pupa

MOTHS

Kinds of Caterpillars	Principal Food Plants	Overwintering Stage
Tomato-Sphinx	Tomato,tobacco	pupa, in ground
Cynthia	ailanthus & other trees	cocoon, in leaf on twig
Cecropia	various deciduous trees	cocoon, on twig
Promethea	spice bush, sassafras	cocoon, in leaf on twig
Luna	walnut,hickory, etc.	cocoon, in leaves on ground
Polyphemus	various deciduous trees	cocoon, in leaves on ground
Io	various trees & shrubs, corn, etc.	cocoon, in leaves on ground
Royal Walnut	walnut, hickory, etc.	pupa, in ground
Imperial	various trees & shrubs	pupa, in ground
Wooly Bear (Tiger Moth)	grasses, herbacious plants	larva
White-marked Tussock Moth	various deciduous trees	egg
Gypsy Moth	various deciduous trees	egg
Tent Caterpillar	wild cherry	egg
Cankerworms	various trees	egg or pupa
Bagworm	conifers, etc.	egg, in bag

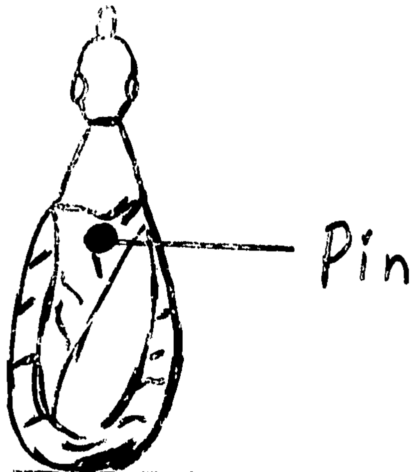
MOUNTING INSECTS FOR A PERMANENT COLLECTION



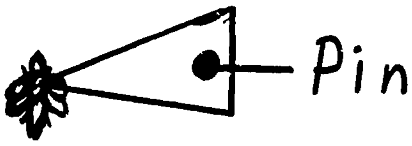
(DORSAL VIEW)

COLEOPTERA

If the larval form of the insect is too soft for pinning, these may be kept in tightly sealed bottles of alcohol.

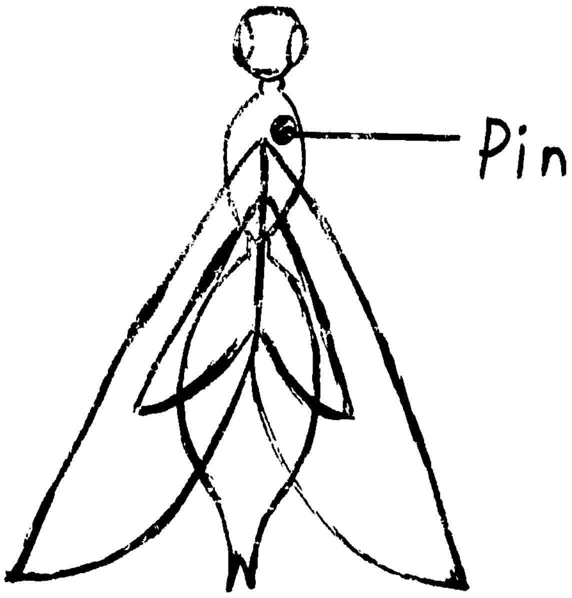


HEMIPTERA



SMALL INSECTS

Glue smaller insects under the thorax onto the point of a triangular piece of paper.



ALL OTHERS

AQUARIUM MANAGEMENT

INTRODUCTION

Fish in the classroom can be an exciting and interesting project. Aquaria are a duplicate of water plant and animals found in a natural biological environment. The classroom aquarium should not merely be a decoration, instead it should be used as a springboard for many ecological studies and other related learning activities.

The school district has made a considerable investment in aquaria supplies and fish. You have the responsibility of making the maximum use of your aquarium. This bulletin will give you basic ideas for establishing and managing aquaria. You and your class should make investigations in your science textbooks and the school and public libraries for more information. The Audio-Visual Aids Library is well stocked with interesting films, filmstrips and flat pictures dealing with fish and aquaria.

It is important that you and the children are prepared for the fish well in advance of delivery. The various supplies will be made during a three week period.

Week # 1 - delivery of non-perishable aquarium supplies
Week # 2 - delivery of plants
Week # 3 - delivery of fish

Your Principal will be notified in advance of the specific delivery dates for the plants and fish.

SETTING UP THE AQUARIUM

LOCATION

The aquarium should be placed in a location where the amount of light reaching it can be controlled. Ideally a north window is desirable, but an east window will do. Use your own judgement if your classroom does not allow for either a north or east window.

One to two hours of direct sunlight will provide the aquarium with adequate light. Periods of longer duration will cause algae to develop. Cardboard can be used to shield the aquarium from too much direct sunlight. Remember natural ponds receive only sunlight from the upper surface, while your aquarium receives light from all sides.

WATER SURFACE

A physical property of water is that it contains dissolved air. The cooler the water the more air it will hold.

Two important processes take place at the water surface. New air is absorbed here and carbon dioxide is liberated. For this reason, round fish bowls or globes usually do not make good aquaria.

FISH CAPACITY

The number of fish an aquarium will hold can be determined in several ways. A general rule often used is one inch of fish (excluding tails) to a gallon of water. A ten gallon tank will hold ten 1-inch fish or five 2-inch fish.

Another way of determining fish capacity is to allow 24 square inches of water surface to every inch of body length of fish. An 8" x 12" aquarium contains 96 square inches of water surface. The aquarium can support one 4-inch fish or four 1-inch fish. It should be noted that a 4-inch fish consumes more oxygen than four 1-inch fish.

When fish rise to the top of the aquarium "sucking bubbles" or gasping, this is an indication that there is an insufficient oxygen supply due to overcrowding of fish. This is not to be misinterpreted with hungry fish who often rise to the top of the aquarium at the approach of a person.

WATER TEMPERATURE

NO SUDDEN CHANGES is a good rule to remember when caring for fish. If heaters are used they should be set up three to seven days before the fish are received. This period will give you ample time to make necessary adjustments.

You will receive your fish in a sealed plastic bag. Because of the low outdoor temperatures the water in plastic bags has cooled off considerably. Float the unopened bag of fish in your aquarium for 20 to 30 minutes until the temperature of the water in the bag is equal to the temperature of the water in the aquarium. Release the fish by allowing them to swim out of the bag.

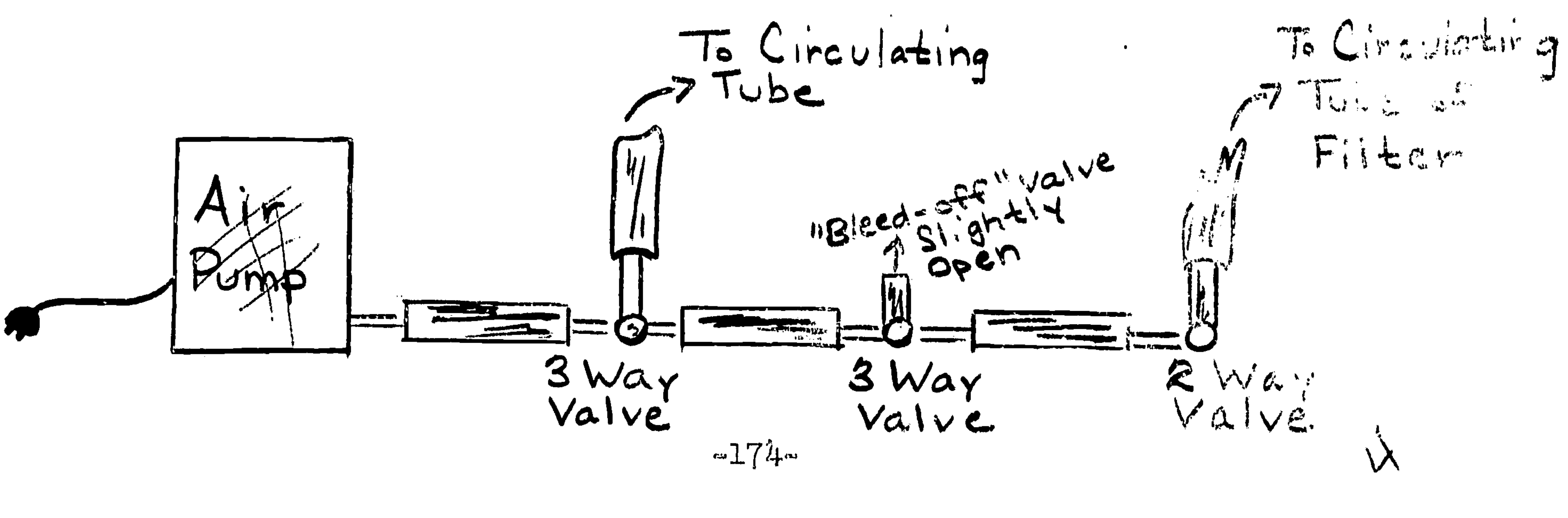
Goldfish survive in temperatures of 60° to 70° and therefore do not require heaters. Tropical fish do best at a water temperature of 76°. Heaters are mandatory for tropical fish if this temperature is to be maintained.

FILTER, AIR PUMP

Under gravel filters have the advantage of an absolute minimum amount of care. Follow instructions as pictured on the package containing the filter.

Three gang valves are included with your aquarium. There are 2 three-way valves and 1 two-way valve. The second two-way valve possibly not shown in the filter instructions is to be used to "bleed" air or supply air to an air stone or similar ornament. Be sure to always have the "bleed-off" valve slightly open allowing air to escape. These pumps are capable of supplying air to several aquaria. If the bleed-off valve is not used the air pump will be damaged in a short period.

The purpose of the air pump is to ensure a uniform oxygen content in the water by means of rapid circulation. The bubbles produced by the air pump remove carbon dioxide dissolved in water by a simple exchange. They do not produce oxygen as some people believe.



GRAVEL

Gravel must be thoroughly washed before being placed in the aquarium. Dump a few pounds of gravel into a clean pot or pail. Turn the faucet on allowing the water to fill and overflow from the bucket. Run your fingers through the sand to loosen up the dirt. Keep stirring until the water in the bucket is clear. Continue dumping the gravel in the pail until it is thoroughly washed.

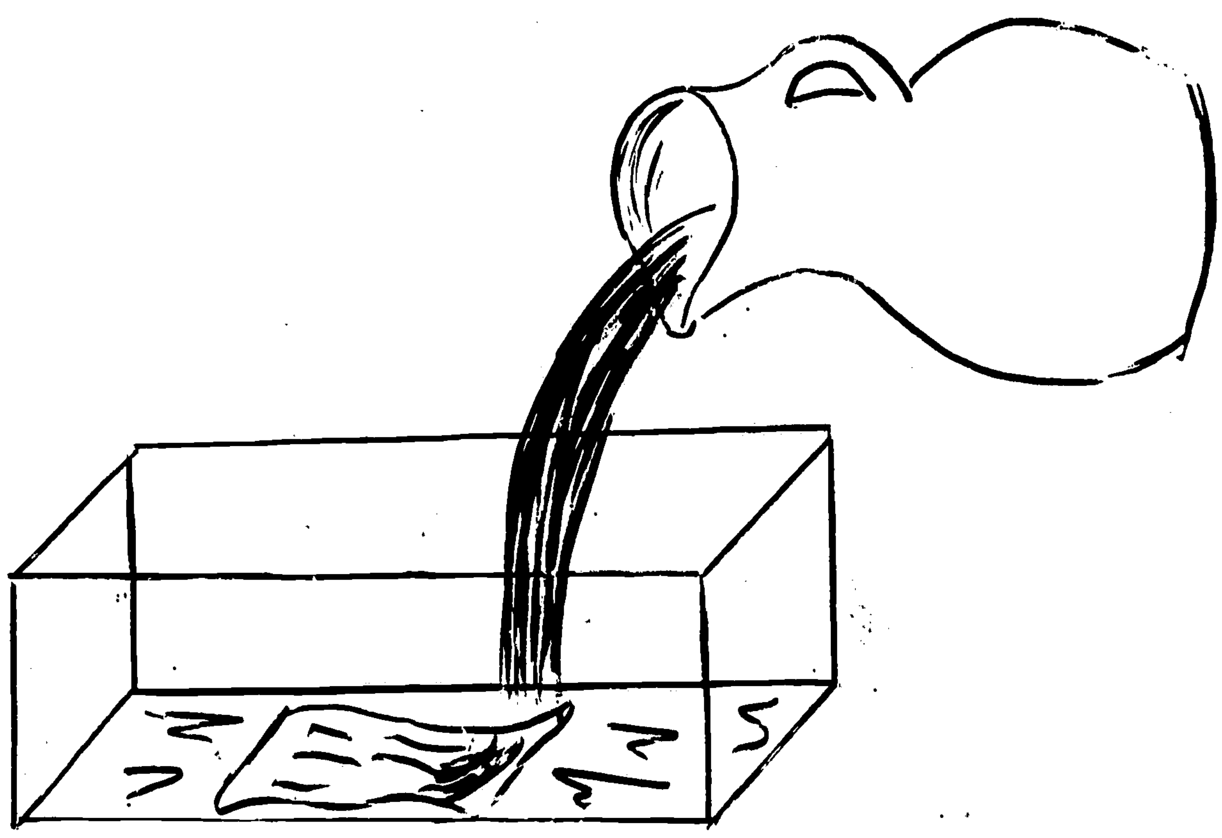
Put the gravel in the aquarium at a slant, graduating it from about one inch at the back to about one-half inch in the front. Add an equal amount of gravel after the plants have been planted. The slope not only makes a better appearance, but allows decayed matter to roll to the front of the aquarium where it can be siphoned or scooped out.

Stones, pebbles or ornaments tend to provide crevices or hiding places for food and debris. If rocks are used they should be used sparingly to avoid water displacement.

Igneous rocks such as granite, prophyry, basalt, slate may be used. Avoid rocks with sharp edges that might injure fish. Rocks with metal content, sandstone, limestone and sea shells should never be used. The latter two objects dissolve slightly and "harden" the water causing it to contain too much lime for the fish.

FILLING THE AQUARIUM

Place a shallow dish or oaktag on top of the gravel and slowly pour water into the aquarium to a depth of two to three inches. This procedure will keep the stirring of gravel to a minimum and prevent the clouding of water. Do not fill the aquarium completely until all planting is completed.



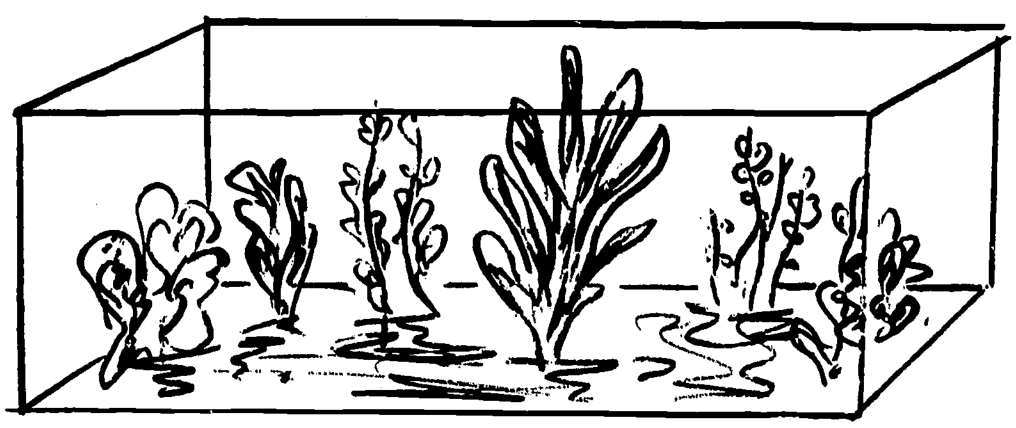
PLANTS

Plants serve a vital role in a balanced aquarium. Healthy water plants which receive adequate light produce oxygen. The oxygen is absorbed by the water. Plants also absorb carbon dioxide given off by the fish. In addition they absorb waste matter given off by the fish which acts as a fertilizer for the plants. Plants also supplement the diet of certain fish as well as provide a hiding place for many tropical fish to deposit their eggs.

A balanced aquarium is defined as "plant and animal life balanced with each other on a nearly equal exchange of chemical elements". Plants and animals are mutually benefited. Plants in an aquarium without fish will show very little growth. Obviously artificial plants have no place in an aquarium.

As soon as plants are received remove them from the plastic bag and rinse in cold water to shake loose any eggs or harmful animals.

Plants can be arranged in almost any fashion. Very often a horseshoe arrangement is used with the vegetation placed around the back and sides with the front left open. Smaller plants are best kept in the front with larger plants in the back.



With two to three inches of water in the aquarium, spread out the roots of the plants after arranging. Add gravel to bring the total depth to two inches in the back and one inch in the front of the aquarium. Do not cover any of the leaves or make the gravel deeper than necessary to hold the plants in position. Do not allow leaves to become even partially dry; sprinkle with water and work fast.

When this is completed, fill the aquarium with water.

COVER, REFLECTOR

The cover and reflector serve several purposes. They prevent fish from leaping out of the tank, keep the surface water free of dust and foreign objects, retard evaporation, and help maintain a constant temperature. They in no way reduce the amount of oxygen since it is not a tight seal.

The cover has holes on either side to allow the air hose to pass through. The larger hole in the middle is where the heater is inserted.

HEATER

Improper setting and tampering of heaters are one of the most common reasons for killing of fish. It is extremely important that the instructions included with the heater are read and thoroughly understood.

Heaters should be set up and regulated a minimum of three to four days prior to putting fish in the aquarium. Do not wait until fish are received and then attempt to set up and regulate the heater.

Insert the heater in the cover after the plants have been planted and the aquarium filled with water. Do not plug in the heater until the temperature of the element has become equal to the water.

The heaters are equipped with an automatic thermostat. A small pilot light in the glass tube indicates when the heater is working. Once set at the desired temperature the heater will automatically go on and off holding the temperature. During the initial period of regulating the heater do not have the incandescent light bulb on in the cover.

After the heater is in the water for 5-10 minutes plug the heater in and note the temperature on the thermometer. The heater pilot light should be off. Slowly turn the adjustment knob on top clockwise until the pilot light goes on. When the desired temperature is reached (76° for tropical fish) very slowly turn the knob counter-clockwise slightly to turn off the pilot light. Wait at least 30 minutes before making any further adjustments. After all adjustments are made, mark the graduations and numbers on top with a felt tip pen as a check for tampering. Place the plastic cover plate over the adjustment knob. No further adjustments need be made even if the temperature of your classroom drops over the weekend. The heater will automatically hold the temperature.

Remember - make all necessary heater adjustments before fish are placed in aquarium!

FEEDING

More fish die of overfeeding than from underfeeding. Feed sparingly, it is better to feed too little than too much. It is best if the same two or three children feed the fish throughout the year, rather than the whole class taking turns. It is a good idea to keep fish food in a closet or drawer out of sight to prevent outsiders from feeding the fish after school or when the class is not in the room.

Goldfish

Feed once per day and do not give more than can be consumed in five minutes. Fish know when to stop eating and they do not die from effects of too much food. It is from the effects of left-over foods that quickly decay in the warm water which set-up harmful bacteria.

Tropical Fish

The above rules also apply to feeding of tropical fish. Feed sparingly, removing all uneaten food after a five minute period. Train your fish to eat in the same corner of your aquarium by feeding them daily in the same location.

The dried fish food can be supplemented with the foods mentioned under goldfish.

PROBLEMS

Repeated changes of water are injurious to fishes. Add water to the aquarium that has stood in a wide mouth container for several days. Be prepared, for water is lost through evaporation.

Algae growth or "green water" as it is sometimes called is not a bad sign unless there is an excess growth. It is most often caused by too much sunlight. A fatal sign is when the "green water" suddenly turns to yellowish-brown. This indicates that the algae have died and are beginning to decay.

To eliminate algae, completely dismantle and sterilize the aquarium. Scrape the glass clean with a razor blade. Using table salt on a moist cloth, clean the glass and slate. Rinse thoroughly. Do not use any detergents. Boil the gravel to sterilize and then re-assemble aquarium.

Diseased fish should be removed and isolated from healthy fish immediately. Fish manuals or the Turtox Service Leaflets available in your building should be consulted for further procedures.

Always rinse fish nets with water after each use.

ACTIVITIES

The activities listed below are suggestions as to what can be done with aquaria. The study of this ecological community can be made while other units are being investigated in the classroom. Children are expected to research, take part in the setting up, maintaining and observing of the aquarium.

1. Air in Water

Let a tumbler of cold water stand in a warm room. Observe the bubbles of air leave the water and adhere to the sides of the glass.

2. Brook and Pond Aquarium

Collect aquatic animals and insects during the spring and make a brook and pond aquarium. Tadpoles, crayfish, dragonflies, damsel flies, water striders, water boatmen, and water beetles can all be used.

3. Self-sustaining Aquarium

Find a wide mouth gallon jar and fill with gravel, water, plants and snails. Place in area where direct sunlight is received. After a week when it has been determined that the aquarium is doing well, seal the aquarium with a lid. Observe how long the community will survive in this self-sustaining condition.

4. Locality Recognition

Fish kept a long time in aquarium very often select a particular area for their "home". Experiment by moving the aquarium around and note if the fish remains in his same "home".

5. Feeding Activities

Signals

a. Train fish to come to one corner of the aquarium by always feeding them in the exact location.
b. Train your fish to come for food by lightly tapping on one corner of the aquarium.
c. Train your fish to come for food by flashing a light or a bright color - try red, green, purple.
d. Observe how a fish reacts if a mirror is placed in one corner of the aquarium.
e. Try training your fish by blowing a whistle. (Fish can hear!)

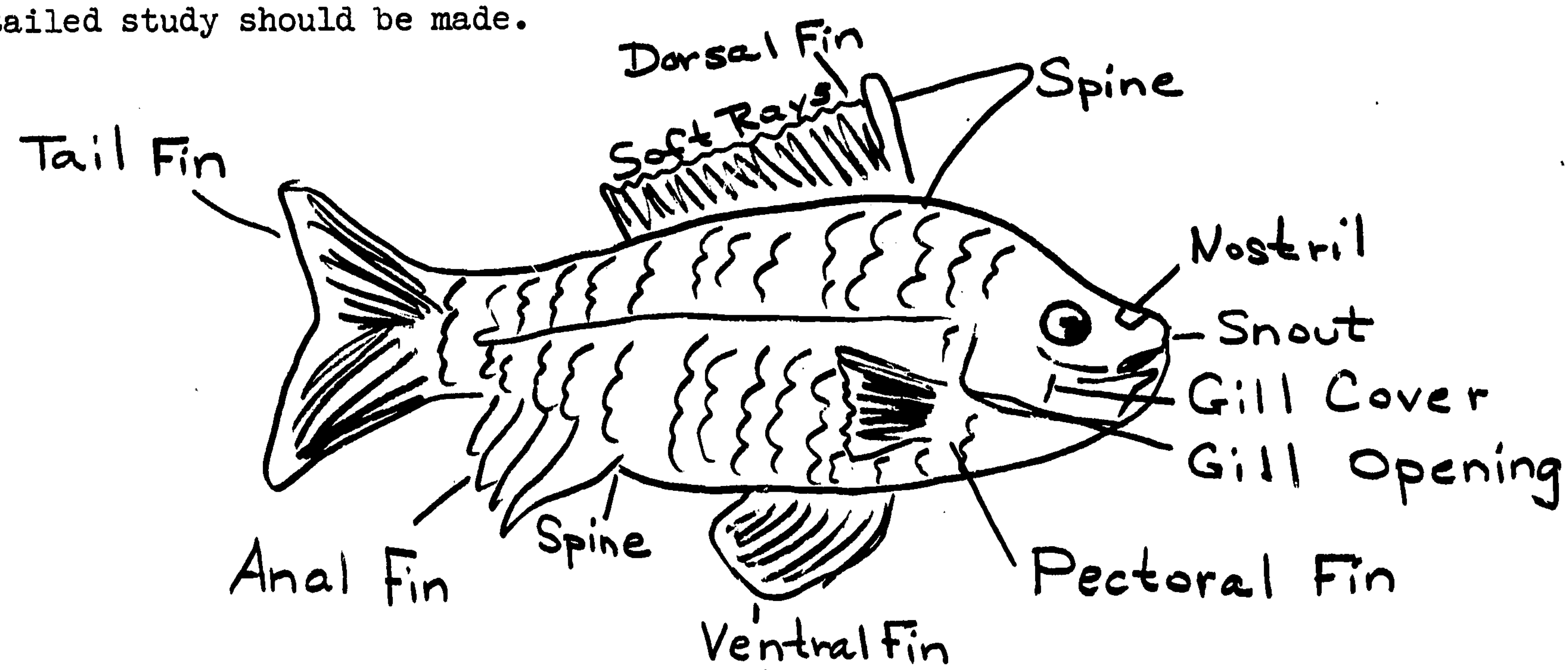
Finding Food

a. How do fish find food - by taste or sight? Find a small transparent pill capsule and enclose a small worm in it. Attach a thread to the capsule. Attach a thread to another worm (without capsule) of similar size and lower both simultaneously into the tank. Which worm is attacked first? Try successive trials on various days. Do all the fish react the same way?

6. Microscope - Microprojector

a. All aquaria contain various forms of microscopic life, some harmful, some negative, but mostly beneficial to fish. The majority of organisms are rotifers. They move in a steady revolving or rotating manner. Examples are paramaecium and euglena. Touch the tip of your finger lightly to the surface of the water, preferably to the side nearest the source of light. Place this drop on a glass slide and observe under the micrpscope and microprojector.
b. Examine a fish scale under a microscope or microprojector. The age of the fish can be determined by counting the growth rings on the scale. Each ring represents one year of growth.
c. Take some white Ich spots from a diseased fish with a sterile piece of cotton. Rub the cotton gently onto a microscope slide. Try growing a culture in malted milk. (For more details see Nature and Science, Vol. 2, No. 5, November 16, 1964.

7. Many observations can be made in the structure and uses of the various parts of the fish. The maturity and interest of the class will determine how much detailed study should be made.



OBSERVATIONS - FISH

a. Shape of Fish

What is the general shape of the body?
What is the shape when seen from above?
What is the widest part?
What is the shape when seen from the side?
How is the shape adapted to moving swiftly through water?
How does the body shape compare with that of fast (or slow) swimming fish?

b. Importance of coloring

What is the coloring as seen from above? From the sides? From below?
Compare the color of the undersides of the fish with the color of the back or dorsal region.
What happens to colors of goldfish if they are put in a brook with other fish? Would their colors change? Why?

c. Fins

How many fins does the fish have?
How many are in pairs? Where are they found? What are they called?
Do any of the pair of fins compare to our arms? Legs?
Describe the shape of the pectoral fins. How are they used? Are they always moving? Do they move together? How are they used when the fish swims backwards?
Describe the shape of the ventral fins. How are they used? How do they aid in swimming?
Observe a dorsal fin and anal fin. How are they used?
What fin is used to push the fish through water?
What position are the fins in when the fish is at rest?
Make a sketch of the tail. What is its shape? Square? Rounded? Notched at the end?
Note the size of the tail as compared to the length of body.

d. Covering

What is the nature of the covering of the fish?
Does the fish have scales? Are they large or small? What direction do they appear to overlap? What use might the scales have?
Observe if a line extends from the upper part of the gill opening along side of the tail (lateral line). What use can this possibly have?

e. Gill Covers

What are the uses of the gills?
Is there any relationship between the movements of the gill covers and the opening of the fish's mouth?

f. Mouth

Describe the mouth of the fish.
How does it open? Upward? Downward? Directly in front?
What kind of teeth does the fish have?
How does the fish catch its food?
Do both upper and lower jaws move in the process of eating?
Is the mouth constantly in motion?
Is the fish swallowing water all the time? What purpose can this serve?
Crop a piece of earthworm, liver or finely cut meat and describe the action of the fish as they eat it.

g. Eyes

Observe the eyes of the fish. Size? Color?
Where are they placed?
Describe the pupil and iris.
Can fish see in all directions?
Can the eyes be moved?
Does the fish have eyelids?
Can a fish wink?

h. Nostrils

Where are the nostrils located?
Are nostrils used in breathing?
What use are the nostrils?

i. Tongue

Can a tongue be seen in the mouth?
Does it move?

j. Research and identify the varieties of fish you have in your aquarium. Where do they originally come from? How are they bred?

OBSERVATIONS - PLANTS

What are the general shapes of the leaves?
How are they placed on the main stem? Dense? Sparse?
What are the colors? Dark? Light? Translucent?
What are the leaf margins like?
How does the plant reproduce? Seeds? Runners?
What happens if a plant does not receive any light?
Can bubbles be seen forming and rising from the leaves of plants? What are these bubbles?

OBSERVATIONS - SNAILS

Compare the aquarium snail with a land snail. Compare it to a slug.
How do snails move?
Note the size, shape, and purpose of the snail.
What do snails eat?
Where is its mouth?
Observe the tentacles. Where are they located? What are they used for?
Do snails have eyes?
How fast do snails move? Using a stopwatch compute the rate of speed and distance a snail travels.

Source: Science - A Process Approach
American Association for the
Advancement of Science. 1965.

OBSERVING SOME ANIMAL RESPONSES TO STIMULI

Objectives

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

1. identify stimuli in an environment.

2. identify the corresponding responses to identified stimuli.

Vocabulary

Stimulus, response.

Materials

Goldfish (guppies may be used but no other tropical fish), one for each group of three or four children
Small turtle, one for each group of three or four children
Two marbles for each group
Glass containers for the fish
Containers for the turtles
Fish food
Turtle food
Flashlight
Ice bucket
Tall glass jar (large fruit jar will serve, holding about two liters)
Droppers, one for each group of children

Originating the Problem

Arrange for an unusual sound to be made at the back or side of the classroom. After the children have responded to the sound by looking, jumping, or asking about it, ask them why their attention was called in that particular direction. (They heard something.) While the sound is being discussed, flash a light toward the ceiling. This may be done by holding a flashlight pointing upward or using a projector and flashing the light upward. Ask the children why they looked toward the ceiling. (Because of the light.)

Tell them that you have another name for the sound they heard and the light which they saw. (A stimulus.) Ask what they think the action with which they respond may be called. They may suggest the word response. Ask whether they can think of some other kinds of stimulus responses. Example, if you have a puppy, what does he do when he sees you coming home from school? What is the stimulus? (You.) What is the response? (Dog running, wagging his tail, and so on.) What does baby do when it sees its mother? (Holds up its arms to be picked up.)

Instructional Procedure

Activity I

Show the children a glass bowl with a fish in it. Ask the class if the fish will respond to stimuli. As the children suggest certain stimuli which are reasonable, try them out. Someone may suggest sound. Tap on the side of the glass and watch for responses. (The fish usually swim away from a tapping on the glass.) Ask the children to describe the response they see and raise the question: Would this fish respond this way another time? Repeat the stimulus. Try out other suggestions which children may make, such as:

Dropping a marble in the water (the fish will quickly swim away).
Lowering a paper clip from the end of a string into the water (the fish may swim away from it or approach it).
Bright light (the fish may not respond to the bright light).
Sprinkle food on top of the water (the fish may go to the top of the water to feed).

Would another fish respond this way?

Activity 2

Give each group or three children a glass bowl with fish in it. The fish should all be of the same kind, either guppies or goldfish. Ask the children whether they think their fish will respond to stimuli in the same way as the fish which we observed in the preceding activity. Ask how we could find out. With the children's help, list the stimuli which were used--Tapping sound, dropping a marble, lowering a paper clip, shining a flashlight into the water, and feeding. Discuss with the children rules to be followed, such as:

Do not put hands in the water.
Try to drop the marble at least five centimeters from the tail of the fish.
Tap on the side of the glass which is nearest the fish.
Lower a paper clip about two inches from the head of the fish.
Sift a very little fish food on the water.

Give each child a chart similar to the one on the following page on which to keep a record. Suggest that he fill in the squares with sentences or pictures or with sentences made up of both words and pictures.

Discuss with the class their observations of the responses of the fish for each of the stimuli. If there were differences in the opinions, these differences would be resolved if possible by repeating that particular part of the activity. To which stimuli did most of the fish respond? To which did most of the fish not respond? Ask the children whether they can be certain that fish respond to a stimulus in a particular manner if they have only one fish to observe. What are the advantages of having reported observation on several different fish? What are the advantages of having more than one observation on the same fish?

My Fish

Stimulus	Response
A tap on the side of the glass	
A marble dropped in the water	
A paper clip on a string lowered in the water	
A bright light flashed on the fish	
Food on top of the water	

The food stimulus is done last in order that the feeding will not be interrupted with other stimuli.

Activity 3

This activity should be done by the total group and teacher or by teacher demonstration. During the earlier discussions someone may have mentioned temperature as a stimulus in the environment of a fish. If not, raise the question by asking what fish do when water begins to cool. Fill a 2-quart glass jar within about 5 centimeters of the top with water. Allow the water to stand over night so that fish may be put in it the next day. Put three or four fish in it and observe their swimming about. (They will swim up and down in the jar.) Take the temperature of the water at both top and bottom. (It should be about room temperature.) Record the temperature. Set the fruit jar in an ice bucket which has a small amount of ice in it and pack ice around the jar to the height of about 5 cm.

After about five minutes observe where the fish are swimming. Observe and record the temperature of the water at the bottom of the jar, and near the top of the water. After another five minutes, again note the position of the fish and the temperature of the water at both levels. Ask how the fish respond. The fish will probably swim higher and higher in the water as it cools from the bottom.

If the children are aware that ice cubes float they may suggest putting ice cubes in the glass jar with the fish on the assumption that the fish will then go to the bottom of the jar. The difference in the temperature at the top and at the bottom will probably not be so great as in the earlier part of the activity since

.e cold water will quickly sink into the warmer water. If the experiment is tried, however, the children will be faced with another problem--why was there so little difference in the temperature of the water at the top and at the bottom? The children who raise this question should be permitted to plan and pursue experimentation to find out whether the cold water always sinks to the bottom.

Activity 4

Place a turtle at the bottom of a 2-liter glass jar which is about 3/4 full of water. Observe its movement. Observe closely what the turtle does when it reaches the top. Count the number of times the turtle takes in air in one minute. Turtles are air breathers and must come to the top of the water for air. Repeat this part of the exercise two more times. Did the turtle always take in air when it came to the top? (Yes.) What was the stimulus? (Need for air.) What was the response? (Swim to top.) Did the turtle appear to "gulp" air the same number of times, each time it came to the top? (No.)

Bring in front of the class a container with several turtles in it. The water in the container should be about ten degrees warmer than room temperature. Observe the turtle activity. (The turtles should be more active.) Ask each group of three or four children to put a small amount of the water from the large container in a small glass bowl and place one of the turtles in it. Ask the children whether the turtle had been stimulated when it was moved. If so, how did it respond? Now ask the children to change the water in the small glass bowl to water that is about 20 degrees colder. Observe the turtle. How did the turtle respond? (It may withdraw into the shell.)

Did all the turtles respond the same way? (Probably not.) Did most of them respond in the same way? (Probably so.)

Point out that the stimuli which we have used for both the fish and the turtles were not harmful to them and were kinds these animals might find in their normal environment. Tell the children they are now to select some other stimuli and to find out whether the turtle will respond to them and if so, how. Tell the children that they should include nothing in their plans which will endanger the turtles. Point out that you have made available to them several things which they may wish to use such as turtle food, ground beef, worms (if available), ice cubes, an electric bell connected up with dry cell and switch, droppers for dropping water on the head or feet of the turtle, and a flashlight. It is important to note that some turtles can swallow food only if they are under water.

Cold blooded animals such as turtles and fish are able to be without food for several days. Lack of food for a few days will make their responses to food greater at the time of the class activity.

Suggest that the children find out all they can about how turtles respond to stimuli of at least four kinds. Give each child a piece of paper marked off as in the chart and ask them to keep a record as they did for the fish.

When the children have finished this exercise for the day, they should be advised to wash their hands, since they have been handling animals. This is a general precaution it is always wise to follow since many diseases are transmitted by contact.

Stimulus	Response

Generalizing Experience

Ask the children to try to recall a pet which they know and think of as many ways as they can in which this pet responds to stimuli. In each case the stimulus and the response should be noted. Ask the children whether they think that most of the pets which they knew respond to the same kinds of stimuli. Ask whether they think they all respond in the same ways.

Appraisal

Bring another kind of animal such as a snail, parakeet, toad, or frog into the classroom. Ask the children to observe the animal closely. If it is possible to have several animals of a kind to be observed, more children can observe closely at one time. Discuss with the children what they have observed. Ask them how they might learn more about the animal. Someone may suggest that some stimulus-response observations might be made.

Discuss with them the stimuli which may be used. Ask them to make a chart on a given piece of paper on which they may record further observations. (A note of caution--nothing should be done which will in any way endanger the animal.) Organize the class in small groups to present the stimulus, observe and record the responses. This should be followed by a discussion and a repetition of any part of the exercise which was not clearly resolved.

AUDIO-VISUAL AIDS

Check your A - V catalog for specific details of the films listed below.

FILMS

No. 44	A Balanced Aquarium
No. 452	The Sunfish
No. 3381	Care of Pets
No. 145	Fish Are Interesting
No. 280	Life in an Aquarium
No. 45	Beach and Sea Animals
No. 3208	Sea Adventures of Sandy the Snail
No. 3433	What's Under the Ocean
No. 819	Animals Breathe in Many Ways

FILMSTRIPS

Breeding Tropical Fish
The Aquarium
Keeping an Aquarium
Tropical Fishes
The World We Live In - Part VII Creatures of the Sea
Life in an Aquarium
Life in Ponds, Lakes, Streams
Fresh-Water Turtles and Fish
Animals of Sea and Shore
Turn to the Ocean (with accompanying record)
Cycle of the Sea (with accompanying record)

FLAT PICTURES

SVE Fresh Water Fish
7x9 Perry Pictures of Fish

AVAILABLE IN YOUR SCHOOL

Turtox Service Leaflets

No. 5	Starting and Maintaining a Fresh-Water Aquarium
No. 11	Plants for the Fresh-Water Aquarium
No. 23	Feeding Aquarium and Terrarium Animals
No. 48	Aquarium Troubles: Their Prevention and Remedies

WILD FLOWERS

Everyone enjoys the beauty of wild flowers. There are rules that all should follow when walking through a meadow, a field, or the woods. Some flowers may be picked, but there are flowers that must be picked sparingly and others not at all.

Here is a list to follow:

DO NOT PICK

bellwort	birdfoot violet	bloodroot
columbine	hepatica	Dutchman's breeches
maidenhair fern	lady slipper	false Solomon's seal
Solomon's seal	trillium	marsh-marigold
	flowering dogwood	jack-in-the-pulpit

PICK SPARINGLY

mayapple	baneberry	squirrel corn
blue flag	spring beauty	yellow adder's tongue
yellow violet	toothwort	

PICK FREELY

blue violet	dandelion	wood sorrel
buttercup	chickweed	

INSTRUCTIONS FOR VIVARIUM

A terrarium or vivarium is a man-made home for terrestrial plants and animals wherein nearly natural conditions of humidity and temperature can be maintained for keeping the inhabitants in good health. The commonest and best terrarium specimens are those forms usually found in woodlands, and these hold a great variety of possibilities both of habitat and inhabitants. Species belonging to different climatic regions, such as desert and bog, cannot be kept in the same terrarium with satisfactory results.

Care and the Use of the Vivarium. Although the vivarium is carefully treated to waterproof it, care should be exercised to prevent the spilling of water between the pan and the bottom and sides, since the continued presence of water on the wood will in time damage the case. The medium size vivarium, because of its size, is best adapted to small group or class observation. The contents may be replaced at frequent intervals or may be made permanent by selecting the smaller plants and animals such as mosses, liverworts, lichens, tiny varieties of ferns, land snails, newts, slugs, insects, worms, and other denizens of the woodland.

Stocking the Vivarium. The health and growth of the living material in your terrarium will depend upon the soil used, the amount of moisture present in the soil, and the humidity of the air within the case. Desert forms, such as cacti, lizards, horned toads, desert snakes, and certain insects demand dry air, dry surface soil, and damp subsoil. Use coarse gravel in the bottom of the pan and finer sand or desert soil for the surface layer. Use just enough water to dampen the subsoil and give the vivarium plenty of sunlight and heat.

Terrestrial woodland plants and animals need a coarse sand or gravel subsoil to take care of excess water, and a good loam or humus surface soil. Use enough water to wet subsoil and to keep surface soil damp, but not soggy. Plant tiny species of ferns, mosses, liverworts, lichens, fungi on twigs and bark, and similar herbs, and stock with land snails, slugs, baby turtles, wooodland insects, tree frogs or newts. Give some exposure to sunlight but not too much light or excessive heat.

Boggy situations are adapted to this terrarium and can be made with a soil arrangement similar to that of the woodland terrarium, by using acid soil instead of loam and enough water to make the soil wet. Plant with sphagnum, moneywort, liverworts, riccia, sundew, and similar types from boggy locations, and use newts, turtles, tree frogs, snails, etc. for the animal life.

W. M. Welch Scientific Company
1515 Sedgwick Street
Chicago 10, Illinois

MAJOR GROUPINGS OF ANIMALS LIVING TODAY

PHYLUM	COMMON NAME	NUMBER OF DESCRIBED SPECIES	EXAMPLES
PROTOZOA	One-celled animals	30,000	Amoeba paramecium
PORIFERA	Sponges	3,000	Fresh-water and salt-water sponges
COELENTERATA	Two-layered bodies	9,000	Hydra, jellyfish, coral, sea anemone, sea fan
PLATHELMINTHES	Flatworms	6,000	Planaria, tapeworms
ASCHELMINTHES	Roundworms and wheel animals	13,000	Hookworm, trichina worm, pinworm and rotifers
BRYOZOA	Moss animals	2,500	Vulture-headed moss animals, comb moss animals
MOLLUSCA	Soft-bodied animals	40,000	Snails, devilfish, limpets, whelks,oysters, clams, mussels,scallops, squids, octopi, slugs
ANNELIDA	Segmented worms	6,000	Earthworms, leeches
ARTHROPODA	Joint-legged animals	722,000	Crayfish, shrimps, lobsters, crabs, centipedes, millipedes, crickets, grasshoppers, praying mantes, termites, dragonflies, bird lice, true bugs, cicadas, aphids, beetles, caddis flies, butterflies moths, mosquitoes, gnats, fleas, bees, wasps, ants, spiders, ticks, scorpions
ECHINODERMATA	Spiny-skinned animals	5,000	Starfish,brittle star, sea urchin, sea lily, cucumber.
OTHER INVERTEBRATE PHYLA	Comb jellies, ribbon worms, and so on.	900	Comb jellies, ribbon worms, spiny-headed worms, brachippods
CHORDATA	Spinal-chord animals	45,000	Sea squirts, lampreys, fish, amphibians, mammals, birds, reptiles

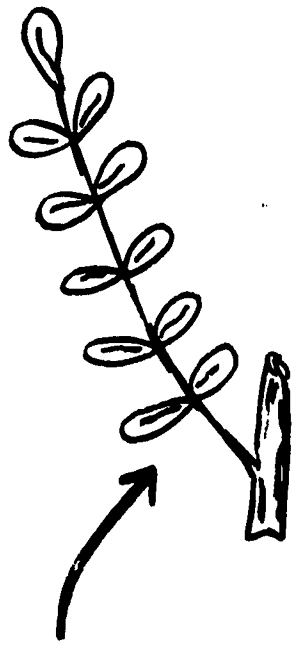
CLASSIFICATION OF ANIMALS AND PLANTS

The common house cat and man are classified here to demonstrate how the system really works.

	Cat	Man
KINGDOM	Animalia	Animalia
PHYLUM	Chordata	Chordata
SUB-PHYLUM	Vertebrata	Vertebrata
CLASS	Mammalia	Mammalia
ORDER	Carnivora	Primates
FAMILY	Felidae	Homindae
GENUS	Felis	Homo
SPECIES	Domestica	Sapiens

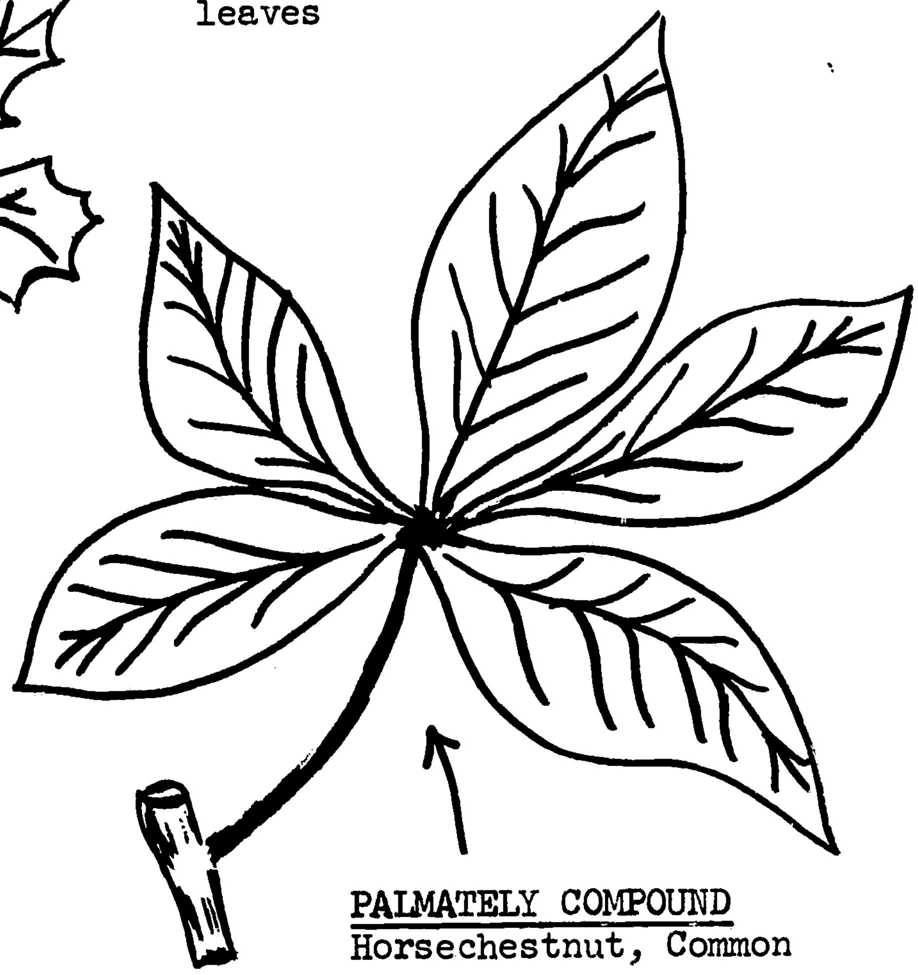
TYPES OF LEAVES

NON-EVERGREEN



SIMPLE

All species not listed on this page have simple leaves



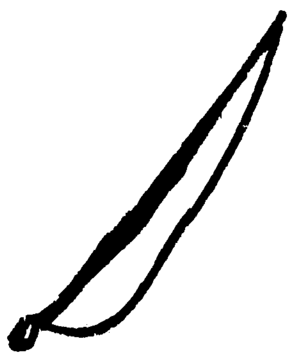
COMPOUND

Ash, Black
Ash, White
Butternut
Hickory, Bitternut
Hickory, Mockernut
Hickory, Pignut
Hickory, Shagbark
Honeylocust, Common
Locust, Black
Walnut, Eastern Black

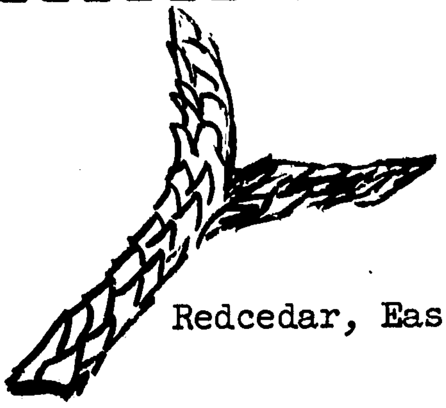
PALMATELY COMPOUND

Horsechestnut, Common

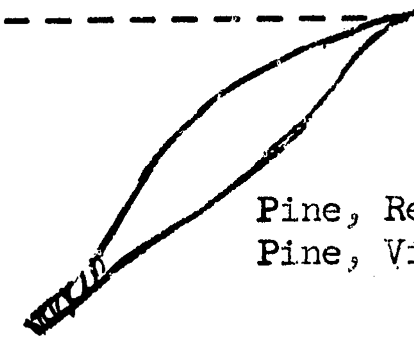
EVERGREEN



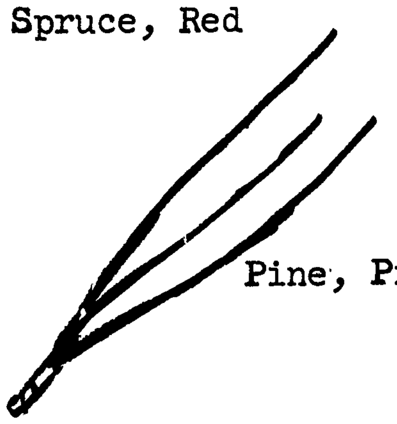
Hemlock, Eastern
Spruce, Norway
Spruce, Red



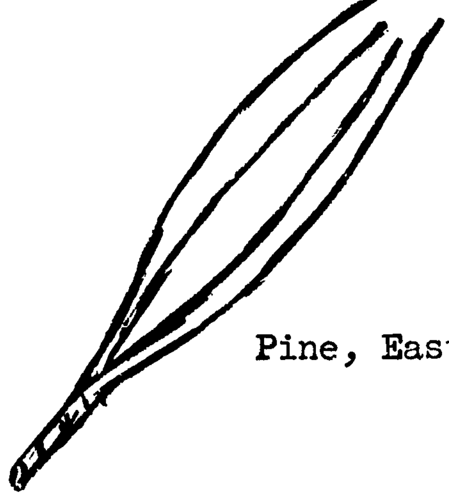
Redcedar, East



Pine, Red
Pine, Virginia



Pine, Pitch



Pine, Eastern White

IDENTIFICATION OF TREES

Tree identification can be a lot of fun. There are many things to look for when we are identifying trees. Below are listed some hints that will help you take a closer look at an unidentified tree.

1. The Leaf

    a. general shape

    b. veination

    c. margin of leaf

    d. placement on trees

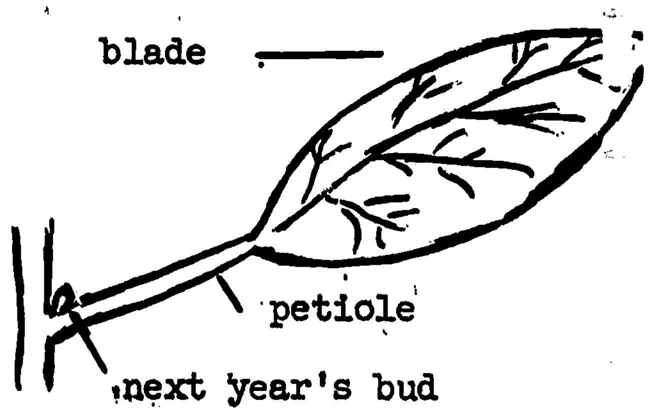
        (1.) opposite

        (2.) alternate

    e. color

    f. type of leaf

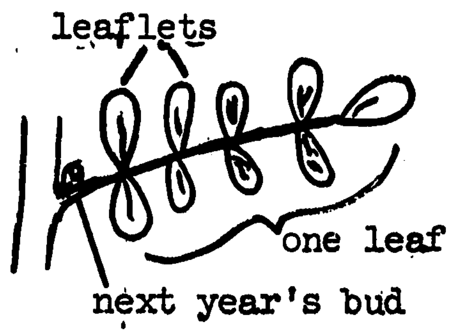
        (1.) simple
        all beyond bud is one leaf



        (2.) compound

            (a.) alternate

            (b.) opposite



2. The Bark

    a. color

        (1.) outer

        (2.) inner

3. Buds

    a. shape

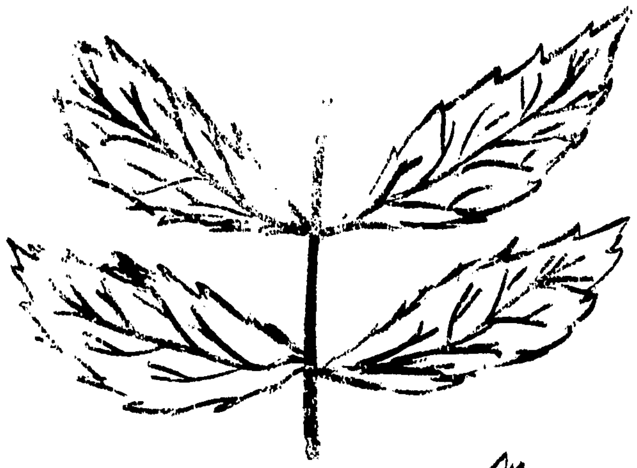
    b. color

    c. leaf scars

4. General confirmation of tree. (shape)

ARRANGEMENT OF LEAVES

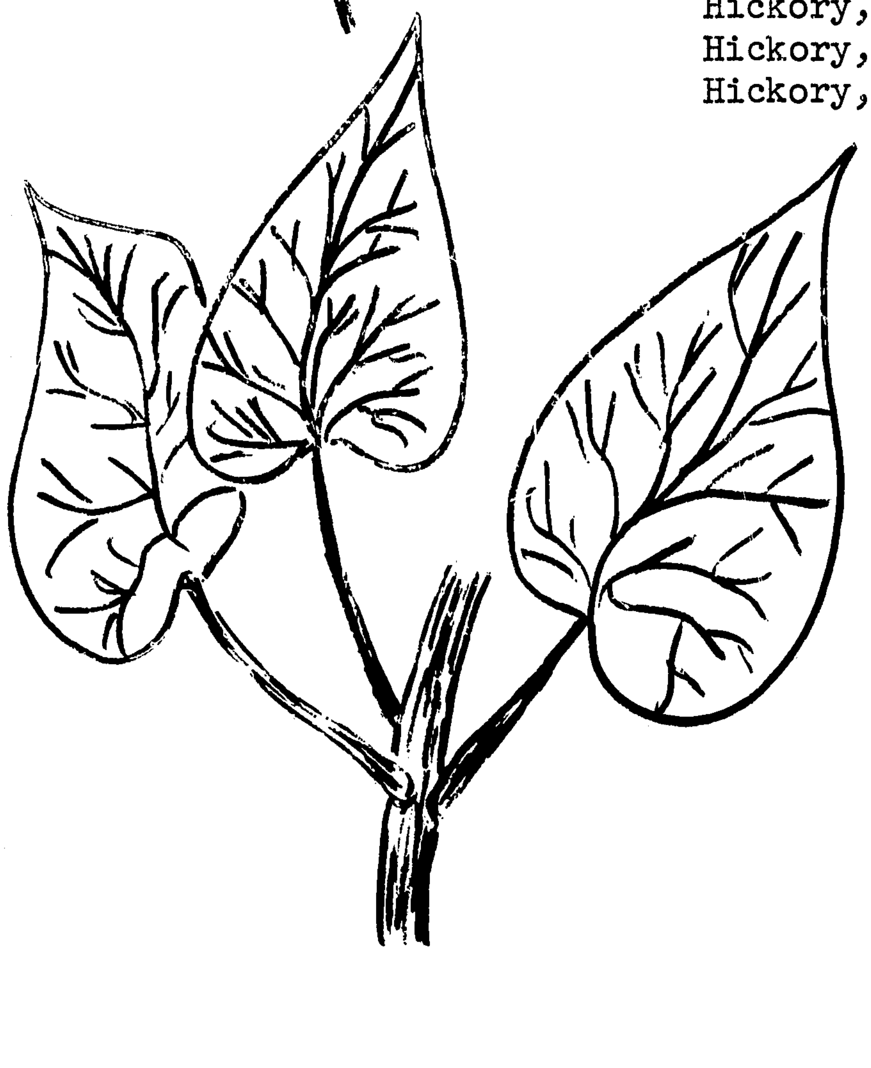
OPPOSITE



Ash, Black
Ash, White
Dogwood, Flowering
Horsechestnut, Common
Maple, Norway
Maple, Red
Maple, Silver
Maple, Sugar

ALTERNATE

Aspen, Bigtooth
Aspen, Quaking
Beech, American
Birch, Gray
Birch, Paper
Birch, River
Birch, Sweet
Birch, Yellow
Blackgum
Butternut
Cherry, Black
Elm, American
Elm, Slippery
Hackberry, Common
Hickory, Bitternut
Hickory, Mockernut
Hickory, Pignut
Hickory, Shagbark
Hickory, Shellbark
Honeylocust, Common
Linden, American
Locust, Black
Magnolia, Cumbertree
Oak, Black
Oak, Chestnut
Oak, Eastern Red
Oak, Pin
Oak, Scarlet
Oak, White
Papaw, Common
Persimmon, Common
Planetree, American
Sassafras, Common
Tuliptree
Walnut, Black
Willow, Black



WHORLED

Catalpa, Northern

GENERAL KEY TO TREE GROUPS

(Before using this key make certain that you do not have poison sumac, poison ivy, or poison oak; these are not included in the key.)

1a. Leaves, needles, or foliage, evergreen[1]. 2
1b. Leaves or foliage, deciduous (falling at the end of growing season). . 8

2a. Leaves, $\frac{1}{2}$" or more in width, broad . . Holly, Sweetbay, Rhododendron and Mountain Laurel
2b. Leaves, less than $\frac{1}{2}$" wide, needlelike, narrow, or small and scalelike 3

3a. Leaves, small and scalelike, close together, and overlapping . . Cedars
3b. Leaves, not scalelike, long and narrow 4

4a. Leaves, needlelike, in 2s, 3s, or 5s, united at the base to form bundles; when held together, the needles of each bundle form a cylinder . . . Pines
4b. Leaves or needles, not in bundles, but occur singly 5

5a. Needles, paired or in 3s around the twig . . Eastern Redcedar and Pasture Juniper
5b. Needles or leaves, alternate, in spirals, not opposite each other. 6

6a. Leaves, needlelike, 4-sided (in one species diamond-shaped) in cross section (roll between thumb and finger to feel edges . . Spruces
6b. Leaves, blunt, with essentially parallel sides flat in cross section 7

7a. Twigs, stout; buds, sticky; older twigs show small circular scars where leaves have fallen off; top of tree, stiff and spiral-like . . Balsam Fir
7b. Twigs, slender; buds, not sticky; top of tree, flexible, bends over . . Hemlock

8a. Leaves, narrow, almost needlelike, many times longer than wide, on old twigs occur in tufts on woody spurs . . Tamrack
8b. Leaves, broader, not at all needlelike. 9

9a. Leaves, opposite or in 3s. 10
9b. Leaves, alternate (look on normally fast-growing twigs; on dwarfed growth, the crowded leaves may appear opposite when really alternate). 17

10a. Leaves, simple 11
10b. Leaves, compound 16

[1]In summer look for both old, unusually leathery leaves or needles, and new ones on the same twig.

GENERAL KEY TO TREE GROUPS (continued)

11a. Leaves, lobed palmately like fingers on a hand . . . Maples
11b. Leaves, not lobed 12

12a. Leaf margin, smooth, not toothed. 13
12b. Leaf margin, toothed (serrate). 15

13a. Side veins parallel margin. . . . . .Dogwoods
13b. Side veins do not parallel margin 14

14a. Leaves, heart-shaped, usually in whorls of 3 . . . Catalpa
14b. Leaves, elliptical, paired. . . . . Fringetree

15a. Side veins parallel margin. . . . . Buckthron
15b. Side veins do not parallel margin . . . . Viburnums

16a. Leaves, palmately compound . . . . Ohio Buckeye or Horse Chestnut
16b. Leaves, pinnately compound . . . . Boxelder Ashes

17a. Leaves, simple. 18
17b. Leaves, compound 50

18a. Leaves, lobed 19
18b. Leaves, unlobed 26

19a. Undersurface of leaf, covered with silvery wool . . . . White Poplar
19b. Undersurface, not silvery-wooly 20

20a. Ends of lobes each bear a bristly or hair tip . . Red Oaks
20b. End of lobes, not bristly-tipped. 21

21a. Leaves and twigs have a spicy odor and flavor, some leaves lobed, some not lobed. . . . . Sassafras
21b. Leaves and twigs, not spicy, but may be tangy 22

22a. Outline of leaf, elliptical or broadest above the middle . . White Oaks
22b. Outline of leaf, circular or nearly so 23

23a. Base of leaf stem, hollow, enclosing the next year's bud. . Sycamores
23b. Base of leaf stem, solid. 24

24a. Sap of broken leaves and twigs, milky (cloudy). .Mulberries
24b. Sap, clear, not cloudy. 25

25a. Leaves, mostly 4-lobed, the apex "chopped off" or indented with a wide notch . . . .Tuliptree
25b. Leaves, 5 or 7 lobed, star-shaped . . . . .Sweetgum

26a. Leaf stem, flattened so that the leaf trembles in the slightest breeze. . . . . . .Poplars, Aspens
26b. Leaf stem, circular or grooved in cross section. 27

GENERAL KEY TO TREE GROUPS (continued)

27a. Leaf margin, entire, not toothed in any way. 28
27b. Leaf margin, serrate or with rounded teeth 33

28a. Leaves, tipped with a bristle or hair . . . Shingle and Willow Oaks
28b. Leaves, lacking a bristly at the end 29

29a. Sap, milky (break leaf stem); twigs, armed with sharp thorns . . . Osageorange
29b. Sap, clear; twigs, unarmed 30

30a. Leaves and twigs, with a spicy odor and flavor . . Sassafras
30b. Leaves and twigs, not spicy. 31

31a. Leaves, heart or kidney-shaped. . . . . Redbud
31b. Leaves, elliptical to oval or widest above the middle 32

32a. Pith, when sectioned lengthwise, shows faint cross bands of darker tissue. . . . . Black tupelo
32b. Pith, either chambered or, if solid, without cross bands . . . Cucumbertree, Pawpaw, Persimmon, Alternate-leaved Dogwood

33a. Leaf margin, with course wavy or rounded "teeth" . . . . Swamp white Oak, Chestnut Oak, Whitchhazel
33b. Leaf margin, with sharp teeth; or if these are rounded, they are very small 34

34a. Sap, milky or cloudy . . . . Mulberries
34b. Sap, clear 35
(From here to No. 50 the trees get "taller and closer together" and the trail is dimmer; only the alert will not get lost!)

35a. Leaves, average 4" or more in diameter, nearly circular, somewhat heart-shaped at the base 36

36a. Leaves, with medium-sized to large definitely single teeth on margin. 37
36b. Leaves with double teeth or such small ones that it is difficult to see whether they are single or double 40

37a. Leaves, lopsided and more or less heart-shaped at the base; fruit, a large pitted drupe, the thin flesh tasting like a date . Hackberry
37b. Leaves, more or less equal at the base, not heart-shaped; fruit, a nut. 38

38a. Teeth, ending in a hair or bristle . . . . Chestnuts
38b. Teeth, without bristles. 39

39a. Teeth, sharp; leaf, with a papery rattle; buds, long and lance shaped Beech
39b. Teeth, slightly rounded like a nipple; buds, short and egg-shaped Chinquapin Oak

GENERAL KEY TO TREE GROUPS (continued)

40a. Twigs, armed with long thorns . . . Thornapple, Wild Pear, Flowering Crab

40b. Twigs, without thorns or spines 41

41a. Leaves, with conspicuous medium-sized to large double teeth . . . Elms

41b. Leaves, with small single or double teeth 42

42a. Twigs, stout; pith, 5 angled in cross section; leaves, broadly egg-shaped to almost circular . . . . Balsam

42b. Twigs, slender; pith, triangular, circular, or so small as not to be easily seen; leaves, narrowly egg-shaped, lance-shaped, or elliptical to oval. 43

43a. Pith, conspicuously triangular when sliced crosswise (make several sections) . . . . Alders

43b. Pith, circular or so small as not to be easily seen 44

44a. Twigs, with an intensely bitter quinine taste or bitter-almond flavor. 45

44b. Twigs, not as above 46

45a. Twigs, bitter; bud, covered by a single scale; seeds, very small, silky haired. . . . . Willows

45b. Twigs, with a faint to strong bitter almond flavor; bud, with 2 or more scales; seeds, not silky haired, enclosed in a fleshy fruit . . . . . . Cherries, Plums, Peach, Shadbush

46a. Veins parallel margin; fruit, fleshy. . . . . .Buckthorn

46b. Veins do not parallel margin; fruit, dry or fleshy. 47

47a. Twigs have a peculiar sweetish taste (not wintergreen); leaf crinkled, more or less hairy; fruit, an apple . . . . .Wild Apple

47b. Tree without the preceding combination. 48

48a. Bark, papery; short, dwarfed twigs (spur shoots) bearing tufted leaves common on older growth; fruit, a very small, 2-winged nutlet ("seed") borne in a cone. . . . . .Birches

48b. Bark, smooth and blue-gray or finely shreddy; spur shoots, lacking; seed, unwinged 49

49a. Bark, smooth and blue-gray; trunk, "muscular" appearing; nutlet, backed by a 3 lobed leafy bract . . . . American Hornbeam

49b. Bark, shreddy; nutlet, enclosed in a papery envelope. . . . . . .Hornbeam

50a. Leaves, more than once compound 51

50b. Leaves, once compound 53

51a. Leaves, large, 1-3 ft. long 52

51b. Leaves, smaller, less than 1 ft. in length; twigs, with long, sharp, usually 2 to 3 branched thorns. . . . . Honeylocust

52a. Leaflets, entire; fruit, a thick short pod . . . . . Coffeetree
52b. Leaflets, serrate; fruit a small drupe; the stout twigs with numerous short sharp spines . . . . .Devil's Walking Stick

53a. Leaves or twigs, when broken, release a milky sap. . . . . Sumacs
53b. Sap, clear 54

54a. Leaflets, 3 in number; when crushed, with a rank somewhat orange-peel odor .Hoptree
54b. Leaflets, 5 or more. 55

55a. Twigs, armed with spines or thorns 56
55b. Twigs, unarmed 58

56a. Twigs, with long, branched thorns; leaflet margins, finely toothed; fruit, a mahogany-colored, twisted pod. . . Honeylocust
56b. Without the preceding combination; paired spines usually present. 57

57a. Crushed leaves, with a strong orange odor; small spines, on the leaf stem . . . . Prickly Ash
57b. Leaves, without orange odor; spines on woody twig only . . Locusts

58a. Crushed leaves, with a peculiar, disagreeable odor like popcorn with rancid butter or, as a student once said, "like a zoo"
58b. Leaves, fragrant, or odorless, margins, entire or toothed all the way along. 59

59a. Leaflets, entire; base of leaf stem, hollow, enclosing next year's bud, fruit, a beanlike pod . . . . Yellow-wood
59b. Leaflets, serrate; buds, visible; fruit, a nut, or small red "apple". 60

60a. Second year's pith shown chambers when sliced lengthwise . . . Walnuts
60b. Pith, solid. 61

61a. Leaves, more or less fragrant when crushed; leaflets, large, mostly 3" or more in length; fruit, a nut . . . . Hickories
61b. Leaves, not fragrant; leaflets, small, mostly about 2" long, Fruit, a small red apple. Mountain Asnes

GUIDE TO BIRD STUDY

OBJECTIVES

1. To cause you to think of birds as living, working, helpful beings, with each kind of bird having its own preference for habitats, food, nests, etc.
2. To help you to identify the common birds by coloring, size, song, etc.
3. To arouse your desire to protect birds.
4. To add to your knowledge of birds and their habits, and to their relationship to other animals.

IDENTIFICATION

1. Begin by observing birds near your home or school. Then take field trips.
2. Equipment needed:
   a. An eye that is aware of birds. Study living birds.
   b. A pair of good field glasses.
   c. A notebook and pencil.
   d. A bird book to help identify. (See bibliography below)
   e. A local checklist if available.
3. Keep daily and yearly list.
   a. Keep list of species seen.
   b. Keep number seen. (Single, pair, flock, abundant, common, rare, etc.)
   c. Note time seen. (Hour afield, month, season, etc.)
   d. Note weather conditions.
   e. Note locality and habitat.
   f. Date.
4. What to look for:
   a. What is its size? (The robin, sparrow, pigeon or crow are often used as a reference point for comparison.)
   b. What is its shape? (Is it chunky, is it slender? What are its wings like? Is it a long-legged bird? Does it have a crest? What is its tail like? Does it pull legs up when flying or drag them?)
   c. How does it act? (Does it wag its tail? Does it climb trees? Does it hover or glide in the air?)
   d. How does it fly? (Does it undulate, fly straight, erratically, soar, slowly, rapidly, etc.?)
   e. What are its "Field Marks"? (Is it all one color, white or black? Does it have color in certain spots? Does it have patterns?)
   f. What is its voice like?
   g. Where is it found?
   h. When is it found?

BASIC STUDIES

1. Learn the structures and anatomy of birds.
2. Learn the classification of birds. (Family, genus, species, variety, race, etc.)
3. Learn the distribution of birds.
4. Learn the nests of birds. (Habitat, site, materials and construction, number and size, etc., of eggs.)
5. Learn the food preference of birds.
6. Learn the life cycle of birds.

SPECIAL STUDIES

Bird Banding, Photography, Nesting Studies, Life History Studies, Population. Studies, Ecological Associations, Local Lists, Economic Value, etc.)

BEGINNING BIBLIOGRAPHY

A Field Guide to the Birds, Roger Tory Peterson. Houghton & Mifflin Co. $3.95

How to Know the Birds, Roger Tory Peterson. Mentor Book. .35¢

The Pocket Guide to Birds, Allan Cruickshank. Cardinal Giant Book. .50¢

Birds, A Golden Nature Guide. Zim and Gabrielson. Paper - $1.00 Cloth - $2.50

Birds'Nests of the East, Richard Headstrom. Washburg, Inc., N. Y. $3.00

Beginner's Guide to Attracting Birds, Leon Hausman. G.P. Putnam's Sons, N.Y.

THE INCUBATOR

1. If a commercial incubator is used, carefully read the directions that accompany it, particularly those regarding regulation of temperature.

2. Keep water in the moisture pan at all times. Insufficient humidity is one of the main reasons for a poor hatch. If the air surrounding the egg is dry, the water present in the albumen evaporates through the egg shell causing the albumen and embryo to dry up.

3. Do not place the incubator in direct sunlight or in a draft.

4. Be sure that the incubator is level.

THE EGGS

1. Keep the eggs as clean as possible; perspiration or grease may stop up the pores of the shell.

2. Do not use fertile eggs that are over seven days old. If the eggs are kept a few days before incubating, do not chill them; turn them twice a day.

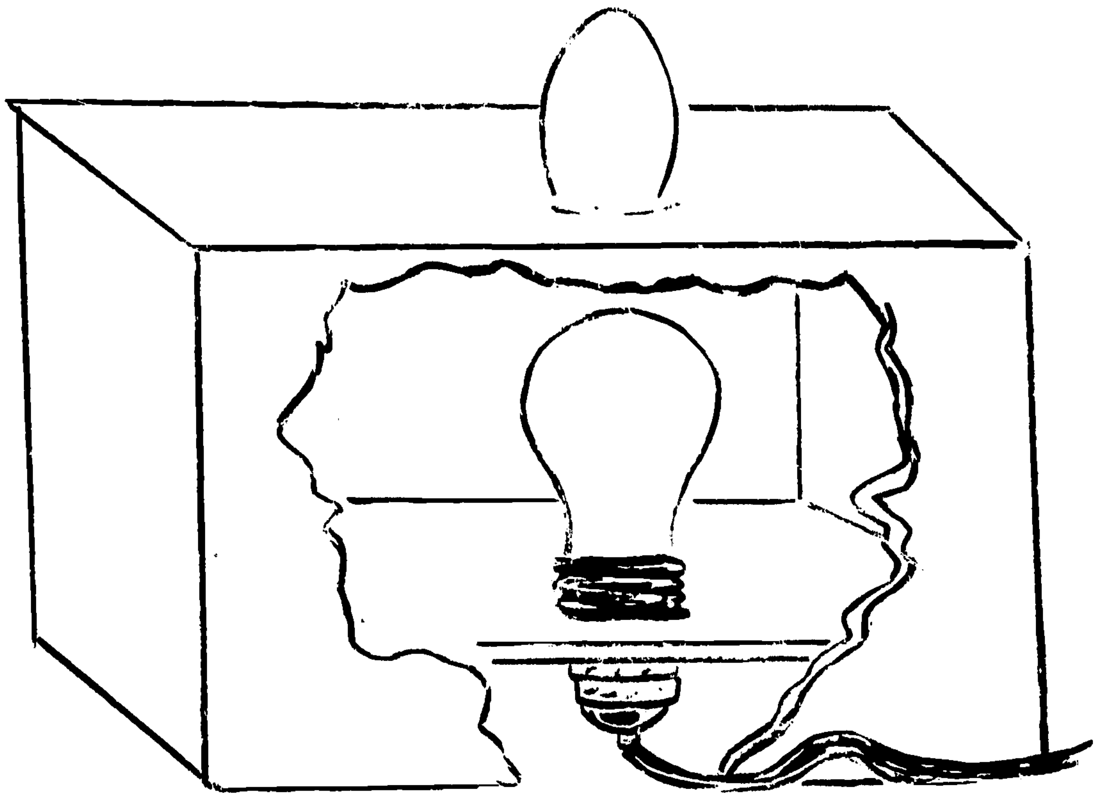
3. Before placing the eggs in the incubator, mark them a.m. on one side, p.m. on the other. Eggs must be turned twice a day, until the 18th day. This prevents the embryo from adhering to the shell. The hen turns the eggs with her beak. Since one side of an egg looks very much like the other, marking them is an easy way to make certain each one is turned regularly. (Any kind of marking you wish may be used; a.m. and p.m. fit in nicely for classes studying time.)

4. Turning the eggs when school begins in the morning and just before dismissal in the afternoon works well. When turning the eggs, roll them gently; don't jar or move them suddenly.

5. Candling the eggs: Some embryos may not develop or will have arrested development. They may be separated from the developing embryos by candling the eggs. Eggs showing no development or arrested development should be removed from the incubator. Eggs may be candled on the 8th day and again on the 14th day.

   A small cardboard box with a light bulb on a drop cord makes a good candling box. Cut a small hole in one end of the box, just large enough to support an egg. Place the large end of the egg against the hole. Light will show into the egg. Handle the eggs with care. Remove them one at a time from the incubator and after candling return them immediately if the embryos are developing.

CANDLING AN EGG



An eighth day fertile egg will show a small, dark spot with many little blood vessels extending in all directions suspended inside the egg. A fourteenth day fertile egg will show a large portion of the egg occupied by the now rapidly growing chick.

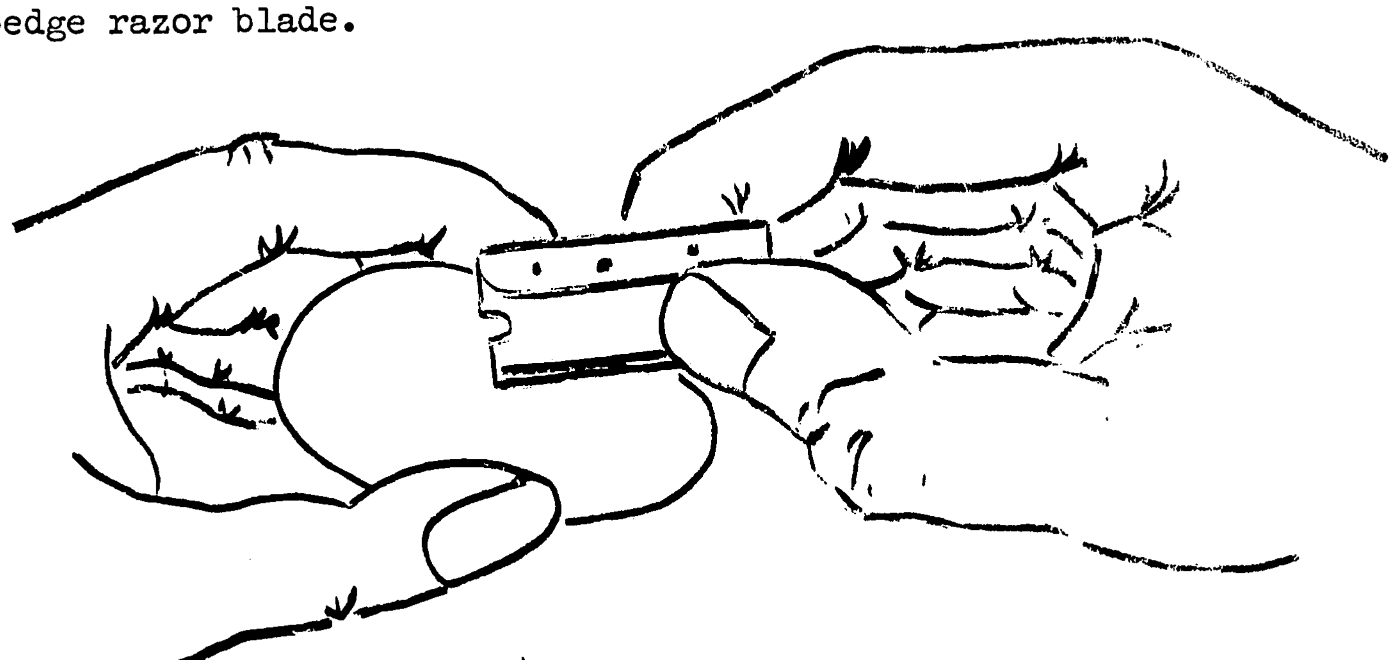
Opening the Eggs and Preserving the Embryos

1. Opening an egg every three days is a good time interval. The progressing development is readily seen with approximately this spacing: 3rd, 6th, 9th, 12th, 15th, and 18th days.

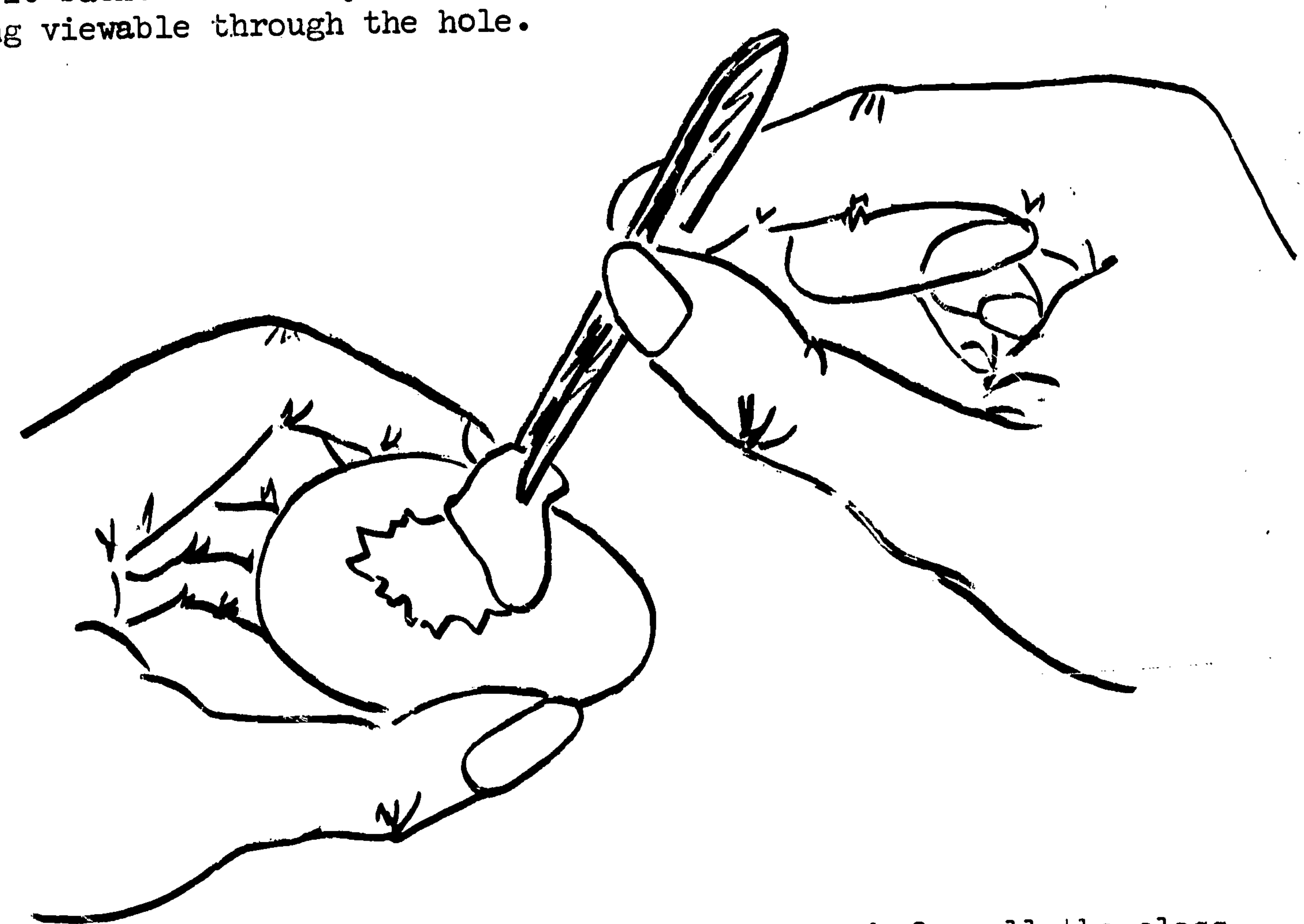
2. Do not be dismayed to open eggs and find no development. In a group of quaranteed fertile eggs only 80 to 90 per cent of the eggs may be fertile.

3. There are various ways to open the eggs. Three are listed below. You may discover even better ways.

   a. Carefully tap the shell to crack it. Then open it into a saucer as you would a breakfast egg.
   b. Rest the egg in a saucer on its side and hold it steady with one hand. Bore a small hole in the shell with a sharp instrument, such as a single-edge razor blade.



then using tweezers peel the shell away from the membrane, making a hole about the size of a quarter. Gently puncture the membrane and lift it back. The embryo usually rolls to the top of the egg, becoming viewable through the hole.



This permits the embryo to remain alive long enough for all the class to see the beating heart. A hand lens and bright side lighting improve the observation. A study or gooseneck lamp works well. The embryo may then be emptied into a saucer for better viewing and preservation. This method works best during the first six days of development.

c. Tap the air sac end of the egg (the large rounded end); peel away the shell almost to the membrane of the air sac. Pull the membrane back with tweezers. This provides a good "peek hole" through which the children may observe the chick. The egg then may be completely opened into a saucer. This procedure is especially effective from the tenth to the eighteenth days, when the chick is large enough to fill most of the sac.

4. Preserving the embryos and listing the developed parts of each embryo on the side of the preserving jar is an optional activity. Formaldehyde is used to preserve the specimens; however, formaldehyde hardens and clouds the yolk and white of the egg after a day or two, making the embryo difficult to view. If you preserve the embryos, it is suggested that the sac and accessories be cut away from the embryo, using small scissors and tweezers, preserving the embryo alone.

After the embryo has been separated from its sac, use a tablespoon to lift the embryo and carefully place it in a wide-mouth jar which has been previously filled with enough formaldehyde to cover the embryo. It is better to put the embryo into the formaldehyde. Pouring the formaldehyde on the embryo may cause damage to the embryo. Then cover the jar. Label the jar with development day (3rd, 6th, etc.) and list the developed parts of the chick.

5. From the 18th day until hatching is complete the incubator should not be opened. Be sure there is ample water in the moisture pan to last through the last four days when the incubator is not opened.

HATCHING

1. The eggs will hatch on the 20th to 22nd days. Choose the day to begin incubation so that hatching will occur on a school day, not a weekend. If the incubator has maintained a temperature slightly lower than the recommended temperature, the eggs may take a day or two longer to hatch.

2. The chicks should be left in the incubator for 24 hours after hatching. They need the warmth of the incubator during these hours. They have a good internal supply of food and do not need to be fed until 48 hours after hatching.

3. After 24 hours place chicks in brooder. Add chick food and water. A rock in the food and water pans prevents tipping and spilling. Aluminum foil tins make good food and water pans.

4. Make arrangements to give the chicks to a local poultry farm or animal park. Do not send the chicks home with the children. This eliminates the problem of not having enough chicks to go around. It also lessens the problem of children developing personal feelings toward an egg which contains "my chick" and resulting sadness if that egg is opened during the twenty-one days or fails to hatch. The chicks in this unit are used as food for the mind, just as those that hatch may eventually be used as food for the body. They shouldn't be viewed as eventual pets for the children.

W O R K I N G

W I T H

G R A P H S

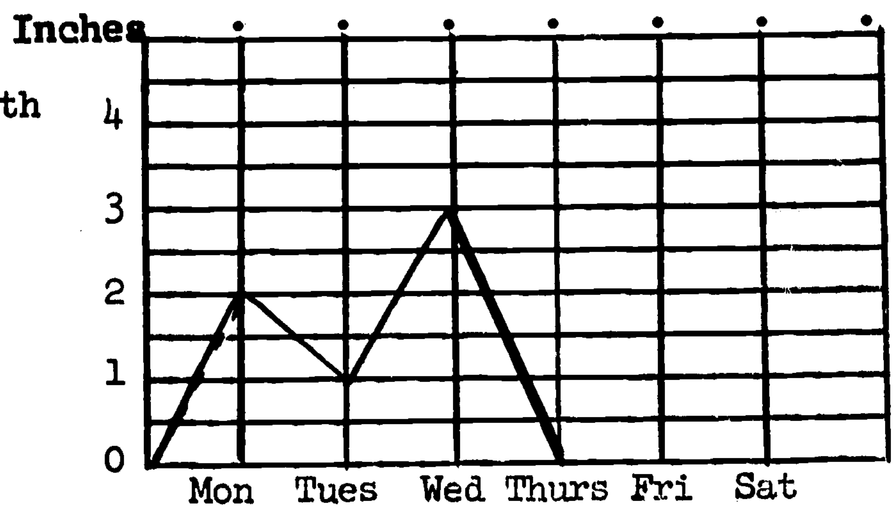
GRAPHS

Two of the simplest types of graphs are the bar graph and the line graph. Always use graph paper when making a graph.

LINE GRAPHS:

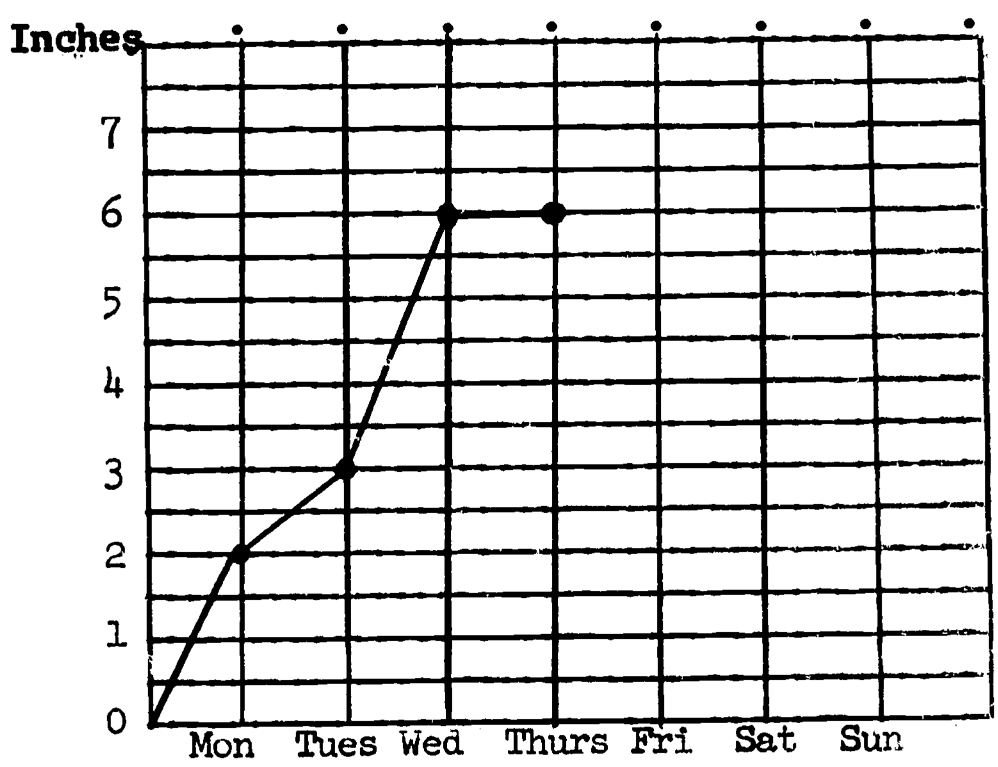
The line graph can be used to show pattern of growth, for instance. This would show how much a plant grew each day, not a total growth accumulation.

PATTERN OF GROWTH



The line graph can also be used to show total accumulation of this growth data.

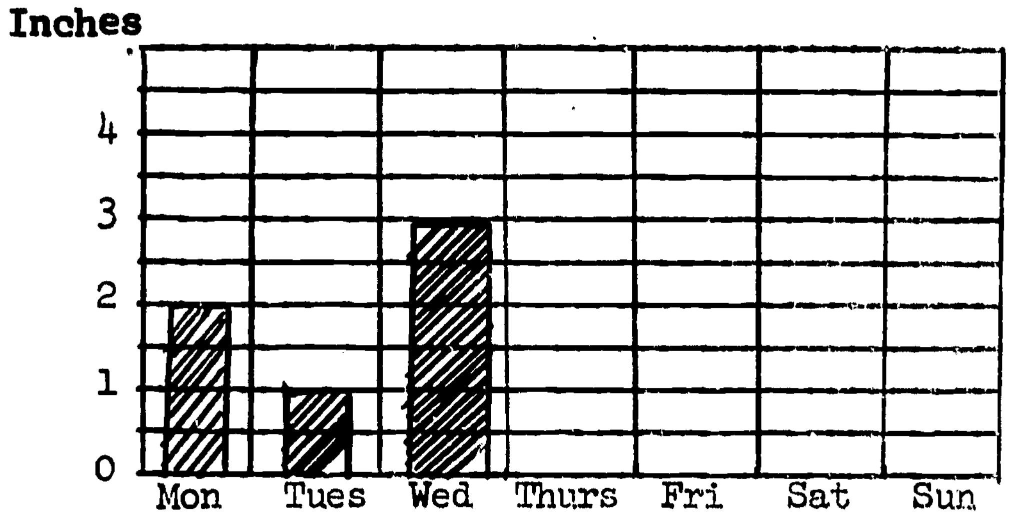
ACCUMULATION OF GROWTH



BAR GRAPHS:

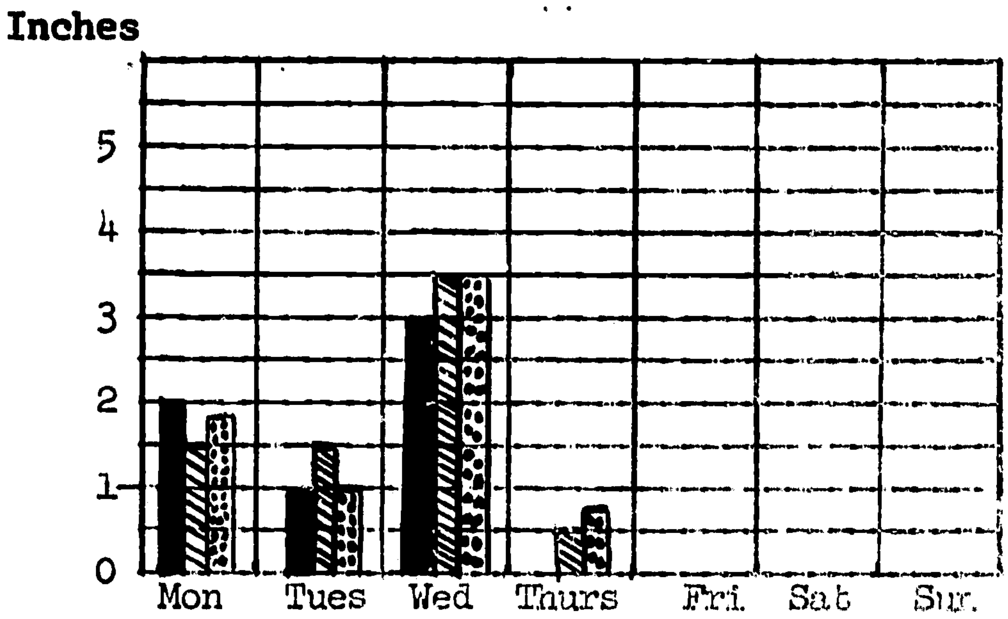
Bar graphs can give you similar information as a line graph but in a different form.

PATTERN OF GROWTH



One might also use a bar graph to show comparisons of growth.

COMPARATIVE GROWTH



These graphs may be used for many visual representations: temperatures, growth of plants, rate of child growth, scores of teams in games, depth of the ocean, heights of mountains, distances to cities, etc.