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ABSTRACT

The use of games to introduce elementary school children to some concepts about environmental factors is described in this group of five documents. Teaching procedures to investigate wind, shadows, liquids, colors, and color change, and aspects of sampling populations are outlined. Simple apparatus and experiments are suggested, and details of the construction and preparation of the materials are given. The following ideas are developed: the nature of different types of water pollutants depends upon physical properties of liquids; color change can be an index of other changes in organisms; shadows are predictable and related to movements of earth and sun; shade has effects on organisms; environmental factors have an effect on wind speed and direction; and factors influencing the validity of statistical samples are sample size, sample selection, and sample number. Opportunities for interdisciplinary activities are mentioned, particularly those using mathematical skills. Background information for the teacher is included in all units. This work was prepared under an ESEA Title III contract. (AL)

Revised 4/3/69

BUTTON BAGS

Environmental Science Center
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Introduction

Disraeli said there are three kinds of lies: lies, damned lies, and statistics!

Unfortunately, children and many adults are not as aware as Disraeli of the misuses of statistics.

This lesson is intended to initiate an understanding of the nature of statistics and the factors which influence their validity. Since statistics are the result of sampling, this is where we must start. The children sample a bag of beans and a bag of buttons and determine the proportions of the types of beans or buttons in the bag. Tools the children use in their determination of these proportions are graphing, estimation, and random sampling.

Independent investigations are provided at the conclusion of the lesson which utilize the skills the children learned in the class investigation and attempt to broade their understanding of sampling procedures. These independent investigations confront the children with such factors as size of sample, number of samples, and selection of sample. The materials used for the independent investigations are outdoor vegetation, the student population of the school, and the previously used button bags

The Environmental Science Center felt the need for this lesson when conducting outdoor studies with children. The class took samples to determine soil acidity, soil moisture, humidity, the density of a type of vegetation, etc. Many children seemed to have no understanding of the factors which determined the validity of their conclusions. For example, they might conclude the soil in a rather large area is very moist on the basis of one small sample.

Since much of science is concerned with sample tests, sample observations, etc we feel that the nature of statistics should become familiar to children early in their education. Our attempt to fill this requirement has resulted in the writing of three lessons: "Tubs of Tiles" (early elementary), "Button Bags" (upper elementary), and "Population Sampling" (upper elementary).

SAMPLING THE BEAN BAG

I. Sampling the Bean Bag

(See Appendix I for instructions to prepare this bag)

A. Mix the bean bag well and have each child take a few beans from the bag (15 to 20 or "a small handful").

B. They should separate these beans into a brown pile and a white pile.

ASK THE CHILDREN:

WHICH COLORS ARE THERE MORE OF IN THE BAG?

WHY DO YOU SAY THERE ARE MORE OF THE BROWN COLOR?

It should be easy for the children to answer this simple sampling question. Now they will try to see a numerical relationship and this may be more difficult.

C. Ask the children to group together in fours and make two rows of their beans, one white row and one brown row.

D. Put these figures on the board while the children work:

1. three white and one brown
2. two white and two brown
3. one white and three brown
4. four brown
5. four white

E. After the children have completed their two rows of beans, ask them to "predict" which of the above five statements would most likely fit four beans they would take from the bag with their eyes closed.

Looking at the relative heights of the two columns they made with their beans, they should see the brown column is about three times as long as the white, and therefore, most will choose Number 3.

F. Have the children replace their beans in the bag, mix the bag well, and choose four beans with their eyes closed. Record the number of children having the stated combination beside the statement on the board. Did Number 3 come out with the majority of the votes?

G. Divide the bag of beans among the class and have them count the total number of whites and the total number of browns. Have them calculate exactly how many browns there are for each white bean by dividing the number of brown by the number of white. They should arrive at approximately three browns for each white.

SAMPLING THE BUTTON BAG

I. Sampling the Button Bag (See Appendix II for instructions on preparing these bags.)

A. Divide the class into groups of four children each.

B. Give each group one bag of buttons.

C. Have each group divide into two teams of two children each.

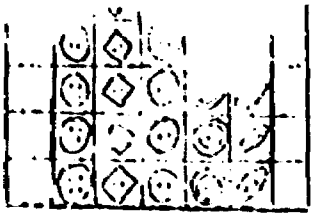
D. Give each team a pill cup to sample with (a larger sampling container might be used if your buttons are quite large).

E. Give each team several sheets of half inch graph paper. (You may have to make your own size to fit the largest button.)

F. Have one or two children mix the bag thoroughly (without opening it) by shaking, kneading, etc. (Shaking alone tends to sift the small, thin buttons from the others, so ask them to use other methods of mixing also.)

G. Each team should take one pill cup of buttons as a sample of the buttons. (Remember, two teams are sampling one bag.)

H. Graph the buttons from the pill cup by laying them in rows on the graph paper. (They may have to tape several sheets of graph paper together.)



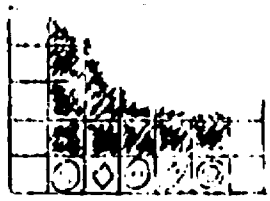
I. Have the teams from each group compare their graphs.

Conduct a class discussion when the teams have compared graphs and raise the following questions if the children don't. Are the graphs that were made from samples of the same bag similar at all? (Do they have the same longest columns? The same shortest columns?)

If they are similar, why are they similar? (When you eat a piece of cake, do you think another piece will taste similar to the piece you just ate? Why?)

If they do not think their graphs are similar, have each of the two teams mix the bags and graph a second sample. Remember, graphs of the samples will not be exactly alike, just similar.

J. They can make a permanent record of their graph by coloring in the columns of buttons, and gluing the button at the base of the column it represents. Return the buttons to the bag. This permanent graph will be used in the next activity.



K. Discovering which <u>model graph</u> is similar to theirs (see Appendix III for instructions on preparation of the model graphs).

1. Visually

   a. Hang the three model graphs you prepared earlier (see Appendix III) at the front of the room.

   b. Ask the children to take out the sample graph they prepared earlier. Have the <u>group</u> pick a model which is most similar to the collection of their sample graphs.

   c. When the group has picked a model, have them take a second sample with the pill cup and graph that sample, also. Is it similar to their first sample graph? Is it more or less similar to the model graph they chose? Do they still choose the same model graph after this second sample?

If they do not want to change their choice of model after taking a second sample, this will serve to reinforce their choice of model graph.

If any group decides to choose a different model graph after this second sample, have them graph a third sample. Have them keep taking samples until they have positively decided on one model graph.

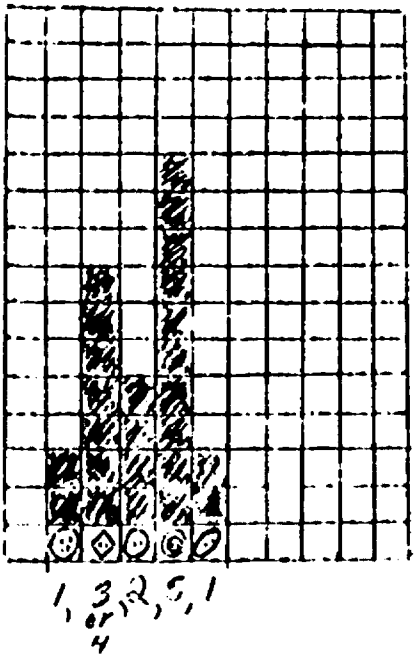
   d. Make permanent graphs of this sample, also.

2. Numerically

   a. Show the class how to find the <u>proportions</u> of buttons in their sample. You might use the following method. (Use a model graph to demonstrate.)

   Cut a strip of paper the same length as the shortest column. Hold this strip against each column of buttons and write below the column the number of times that strip fit on the column.

In the following example, the shortest strip would be two squares long. Can you see how the other numbers were arrived at?



Have the class repeat this procedure with the remaining two models.

Have the children do the same with their sample graphs.

They should compare the number below each of their columns with the number below that column on their chosen model graph. Did the numbers come close to being the same?

III. Independent Investigations

So far, the class has gained some feeling for sampling. The intention of the following series of independent investigations is to develop an understanding of the factors which influence the validity of a sample. These activities refine sampling procedures and expand their understanding. Investigation Card #1 introduces the idea that the size of the sample taken must be appropriate for the size of the population. Investigation Card #2 deals with the number of samples taken and its influence on sample validity. Investigation Card #3 causes the children to compare the graph they get when the buttons are well mixed with the graph they get when the buttons are not well mixed. This introduces the idea of random sampling of a population.

We suggest that three or four copies of each card be mimeographed, glued to individual pieces of poster board, and given to the teams to read through. They would then be allowed to choose and conduct any of the investigations on their own. They might design their own investigation. However, the investigations might be conducted by the class as a whole if you wish.

Display the model graphs throughout these investigations.

INVESTIGATION #1

Can you get a graph similar to the graph made in class using sampling containers of sizes other than the pill cup?

Materials:

your button bag

screw cap from liquid soap dish

pill cup

3 oz. dixie cup

graph paper

crayons

Procedure

1. Mix the bag well.
2. Take a sample with the soap cap.
3. Graph the sample.
4. Make a permanent graph using the crayons.
5. Put the buttons back in the bag.
6. Mix the bag well.
7. Take a sample with the pill cup.
8. Graph the sample.
9. Make a permanent graph using the crayons.
10. Put the buttons back in the bag.
11. Mix the bag well.
12. Take a sample with the dixie cup.
13. Graph the sample.
14. Make a permanent graph using the crayons.
15. Put the buttons back in the bag.
16. Mix the bag well.
17. Repeat any of the steps if you aren't sure of the results.
18. Write a short report telling how the size of the sample affected your results. Refer to your model graph and the graphs you made during this investigation, and include them in your report.

INVESTIGATION #2

Does the <u>number</u> of samples taken have any effect on your results?

Materials:

screw caps from liquid soap containers

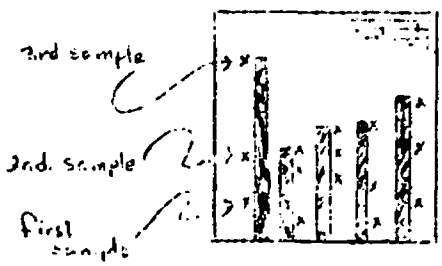
graph paper

crayons

your button bag

Procedure

1. Mix the bag well.
2. Take <u>a sample</u> with the screw cap.
3. Graph the sample.
4. Make a permanent graph and return the buttons to the bag.
5. Place an "x" beside the top of each column on your graph paper.
6. Compare this graph to the model graph you chose earlier. Is it similar?
7. Mix the bag well.
8. Take a <u>second sample</u> with the screw cap.
9. Put this second sample on top of the first on the graph.
10. Make it permanent by coloring it. Return the buttons to the bag.
11. Place an "x" beside the top of each column on your graph paper.
12. Compare this graph to the model graph you chose earlier. Is it similar?
13. Repeat procedure 7 through 12 for a <u>third sample</u>. The following graph shows how the "x"'s are placed on the graph.



14. Write a short report telling how you feel the number of samples affected the results. Include in your report the graph you made during this investigation.

INVESTIGATION #3

During your class sampling, you were very careful to mix the buttons before taking a sample. This is called random sampling because no spot has any different mixture of buttons than another spot.

Would the graph be much different if the buttons were not well mixed?

Materials:

your button bag

buttons of a type different from those in your bag (one cup)

pill cup

Procedure

1. Mix the button bag well.
2. Pour the cup of new buttons into the bag. Do not mix!
3. Take a sample with the pill cup.
4. Graph the sample and make a permanent graph with crayons.
5. Label the graph "unmixed" and dump the buttons back into the bag.
6. Mix the button bag well.
7. Take a sample with the pill cup.
8. Graph the sample and make a permanent graph with crayons.
9. Which graph do you think gives the most accurate picture of the number of new buttons?
10. Take several more samples to verify your choice.
11. Write a short report on your conclusions about random sampling. Include all graphs made during this investigation.

INVESTIGATION #4

By sampling the people in your school, can you determine about how many right-handed people there are for every left-handed person?

Materials:

graph paper

crayons

census forms, sample forms (see Appendix IV)

Procedure

1. Ask the office how many children are in your school. For this number of people, how many people would make a good sample size? How many people will you ask about handedness?
2. Determine where you will ask these people (lunchroom, drinking fountain, playground).
3. Ask your teacher for the "sample of left-handed and right-handed students" form.
4. Get your teacher's okay before starting to sample.
5. Take your sample by handing the form to each student to be sampled and have them fill it in.
6. Graph the results when all forms have been returned.
7. Check your results by conducting a census (a complete count of left and right handed students).
   - -- Get the form for "census of left-handed and right-handed students".
   - -- Go to each classroom and fill in a census form. Get the teacher's approval first.
   - -- Does this information agree with your conclusions when you took just a sample?
8. If the census results are not similar to the sampling results, try to improve the way you sampled. Did you take enough samples?

INVESTIGATION #5

During your sampling, you were very careful to mix the buttons before taking a sample. This is called random sampling because no spot has any different mixture of buttons than another spot.

Does random sampling work if the buttons are not well mixed?

Materials:

transparent round container

spoon

your button bag

water

graph paper

Procedure

1. Empty the button bag into the round container.
2. Fill the container within two inches from the top with water.
3. Stir the buttons strongly with the spoon.
4. Look down on the surface of the buttons. Look at the buttons through the side of the container. What do you observe?
5. Sample the buttons with the pill cup, carefully pouring the water back into the container.
6. Graph the sample.
7. Compare the graph you just made with the permanent graphs you made in the class activities. Are they similar? If they are not, why aren't they?
8. Repeat steps 3 and 5 if you aren't sure of your results.
9. Write a short report on your conclusions about random sampling. Include all graphs and observations needed to make your report clear.

INVESTIGATION #6

By sampling the people in your school, can you determine about how many people there are for each color of eye?

Materials:

graph paper

crayons

sample forms (Appendix form IV)

census forms (Appendix form IV)

Procedure

1. Determine how many people you will ask about eye color.
2. Determine where you will ask these people (lunchroom, drinking fountain, playground).
3. Ask your teacher for the "sample of eye color" form.
4. Get your teacher's okay before starting to sample.
5. Take your sample by handing the form to each student sampled and have them fill it in.
6. Graph the results when all forms have been returned.
7. Check your results by conducting a census (a complete count of the eye color of students).
   - -- Get the form for "census of eye color".
   - -- Go to each classroom and fill in a census form. Get the teacher's approval first.
   - -- Does this information agree with your conclusions when you took just a sample?
8. If the census results are not similar to the sampling results, try to improve the way you sampled. Did you take enough samples?

INVESTIGATION #7

By sampling the people in your school, can you determine about how many red-haired, blond-haired, and brown or black-haired students there are?

Materials:

graph paper

crayons

sample forms (Appendix IV)

census forms (Appendix IV)

Procedure

1. Determine how mahy people you will ask about hair color.
2. Determine where you will ask these people (lunchroom, drinking fountain, playground).
3. Ask your teacher for the "sample of hair color" form.
4. Get your teacher's okay before starting to sample.
5. Take your sample by handing the form to each student sampled and have them fill it in.
6. Graph the results when all forms have been returned.
7. Check your results by conducting a census (a complete count of hair color of the students).
   - -- Get the form for "census of hair color" from your teacher.
   - -- Go to each classroom and fill in a census form. Get approval first.
   - -- Does this information agree with your conclusions when you took just a sample?
8. If the census results are not similar to the sampling, try to improve the way you sampled. Did you take enough samples?

INVESTIGATION #8

Can you tell how many different kinds of plants there are on your lawn by taking samples?

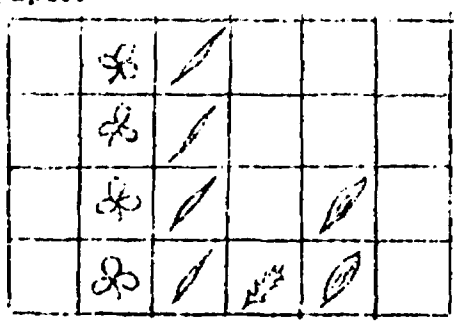
Materials:

hoola hoop

plastic sandwich bags

Procedure

1. Select a large area of school lawn from which to take your samples.
2. Stand in the middle of this area, close your eyes, and lightly toss the hoola hoop.
3. Examine the plants inside the hoola hoop carefully. Pick one plant of each different kind and put it in a sandwich bag. This is your first sample.
4. Decide how many more samples you should take by tossing the hoop. Consider how large the lawn is when you decide how many more times you toss the hoop.
5. Repeat steps two and three until you have taken as many samples as you think are necessary. Use separate plastic bags for each sample.
6. Ask your teacher for some two inch square graph paper.
7. Dump your samples into a pile. Graph the types of plants by taping them on the graph paper.



This sample graph was made from four samples. (The hoop was tossed four times.)

8. Decide what plant or plants are most abundant on your lawn; which are the least.
9. Write a short report telling how you took your samples and what conclusions you drew.
10. You might repeat this investigation in another area and compare the types of plants.

APPENDIX

I. Instructions for Preparing the Bean Bag

A. Purchase one bag of white beans and three bags of brown beans (all bags of same size).

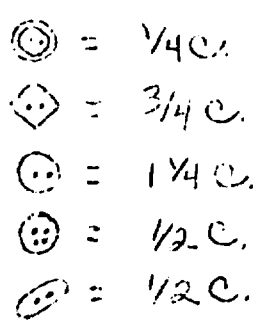
B. Mix the bags of beans together in another large bag. One quarter of the bag will be white beans while three quarters will be brown beans.

II. Instructions for Preparing a Button Population (teacher)

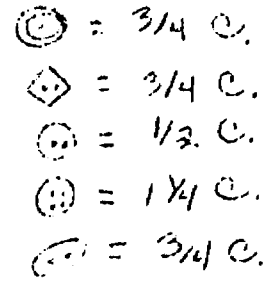
A. Obtain four cups each of five types of buttons. Try to get a variety of color and shape in the buttons. If the sizes of the five types are kept similar it will be easier to establish the proportions asked for in "B". This quantity of buttons can be obtained from a remnants store at a reasonable price (Munsingwear in Minneapolis). One cup of buttons is equal to approximately 500 shirt buttons.

B. Prepare six mixtures of these buttons in the proportions suggested below. Use six plastic bags. Notice each proportion was used twice.

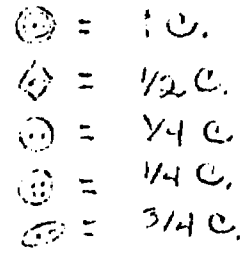
Two bags with proportions:



Two bags with proportions:



Two bags with proportions:

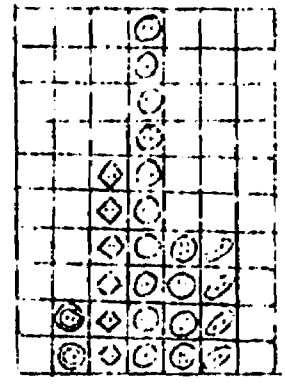


If you use the above method and there are buttons of greatly different size, you will have to change the number of cups. For example, if the button was about twice as large as all the others, you should add only two cups instead of four.

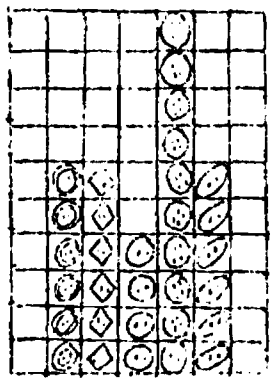
C. Tie the bags shut with bright ribbon or rubber bands.

III. Instructions for preparing graphs showing the proportions of each type of button in each bag.

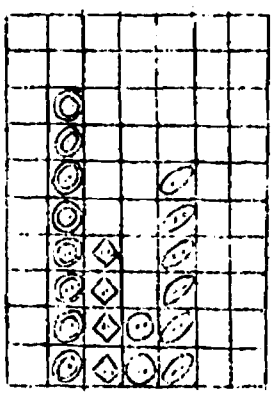
A. See the proportions for the first mixture on Page 16. Multiply the proportions by two and make a graph such as the following: (* 1 = 1/4 c.)



B. See the proportions for the second bag on Page 17. Multiply the proportions by two and make a graph such as the following:



C. See the proportion for the third bag on Page 17. Multiply the proportions by two and make a graph such as the following:



IV. Forms for Taking the Samples and Censuses of the Students

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SAMPLE OF LEFT-HANDED AND RIGHT-HANDED STUDENTS

Please fill out this form:

If you cannot fill the form out now, fill it in later and return it to room _____

Your Name _____ Grade _____

Put an "x" in the correct blank:

You are right-handed _____

You are left-handed _____

CENSUS OF LEFT-HANDED AND RIGHT-HANDED STUDENTS

Grade _____ Classroom Number _____

Number of right-handed students _____

Number of left-handed students _____

SAMPLE OF EYE COLOR

Please fill out this form:

If you cannot fill the form out now, fill it in later and return it to room _____

Your Name _____ Grade _____

Put an "x" in the correct blank:

You are blue-eyed _____

You are green-eyed _____

You are brown-eyed _____

You are black-eyed _____

CENSUS OF EYE COLOR

Grade _____ Classroom Number _____

Number of blue-eyed students _____
Number of green-eyed students _____
Number of brown-eyed students _____
Number of black-eyed students _____

SAMPLE OF HAIR COLOR

Please fill out this form:

If you cannot fill the form out now, fill it in later and return it to room _____

Your Name _____ Grade _____

Put an "x" in the correct blank:

You have red hair _____

You have brown hair _____

You have black hair _____

You have blond hair _____

CENSUS OF HAIR COLOR

Grade _____ Classroom Number _____

Number of red-haired students _____

Number of brown-haired students _____

Number of black-haired students _____

Number of blond-haired students _____

SHADOWS

Environmental Science Center
5400 Glenwood Avenue
Golden Valley, Minnesota 55422

SHADOWS

I have a little shadow that goes
in and out with me,
And what can be the use of him
is more than I can see.
He is very very like me from the heels
up to the head,
And I see him jump before me, when I
jump into my bed.
The funniest thing about him is
the way he likes to grow -
Not at all like proper children, which
is always very slow;
For he sometimes shoots up taller
like an india-rubber ball,
And he sometimes gets so little that there's
none of him at all.
One morning, very early, before the
sun was up,
I rose and found the shining dew
on every buttercup;
But my lazy little shadow, like an arrant
sleepy head,
Had stayed at home behind me and was
fast asleep in bed.

_____ ROBERT LOUIS STEVENSON

INTRODUCTION

The intent of the Environmental Science Center is to promote an understanding of our world's ecology (the interrelationships of living things with other living things and with non-living things). One might look at Shadows and wonder what implications it has for ecological education. The following statements explain the inclusion of Shadows in such a study.

The lesson begins with a series of play activities, some indoors, some outdoors. These play activities give the younger or less aware children an understanding of a nature of shadows. They find shadows are caused by a light source, and that the size and shape of the shadow depends on the orientation of the light source. This knowledge is essential background for a child before he can develop the more sophisticated understandings investigated in later activities.

For early primary children these activities provide an added learning experience. When children explore shadows they are experiementing with spatial relationships. Ability to discern spatial relationships is aided through the play activities in Part I of Shadows.

We also feel it is significant for children to discover that shadows are predictable. The children find they can predict the direction a shadow will point and even about how long the shadow will be at certain times of the day and at different times of the year. This not only gives them a feel for pattern in nature but starts them towards an understanding of earth and sun movement. For example, why is a noon shadow always shorter than any other shadow and why does a noon shadow always point north (in the northern hemisphere)? They must begin to relate the movement of the earth in relation to the sun to account for this occurence. To help make this association they make use of a globe and a lamp.

The lesson has a very direct application to ecology in that shade effects living things. The children will investigate this effect late in the lesson

by examining the difference in numbers and types of plants between shaded and sunny areas. They find that sun-caused shadows definitely help determine the ecology of an area.

Objectives

Early primary

1. Children explore shadows and experiment with spatial relationships.

2. Understand that shadows change depending on the orientation of the light source.

Late primary

1. Learn about sun and earth movement using shadows.

2. Understand the effects of shade on life (plants, animals).

Outline of Activities

PLAYFUL SHADOWS

I. Outdoors

A. Shadow tag
B. Shadow keep away
C. Shadow, how many shapes do you have?
D. Shadow people

II. Indoors

A. Your hands can make strange shadows
B. Stage a shadow play
C. Mystery objects

SHADOWS THAT ANSWER QUESTIONS

I. Shadow, what time is it?

A. Observing that a shadow from the sun changes position during the day
B. Marking the change of a shadows position over a period of time
C. Making a sun clock

II. Shadow, what direction am I pointing?

III. Shadow, how tall is the flag pole?

IV. Shadow, what time is it in England?

A. Preliminary activities
B. Determining the time in other countries

SHADOWS THAT AFFECT LIVING THINGS

I. Comparing the numbers of a vegetation type in shady areas as opposed to sunny areas.

II. Comparing the types of vegetation found in a shady area as opposed to a sunny area.

PLAYFUL SHADOWS

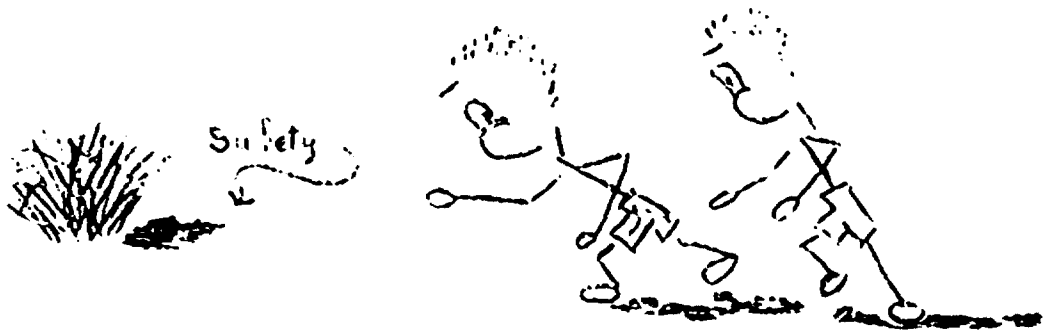
I. Outdoors

A. Shadow tag

1. "It" touches shadow to another's shadow.

2. "It" touches another's shadow with his foot.

3. Either version 'a' or 'b' using a stationary shadow (building, tree, etc.) as a safety place.



B. Shadow keep away

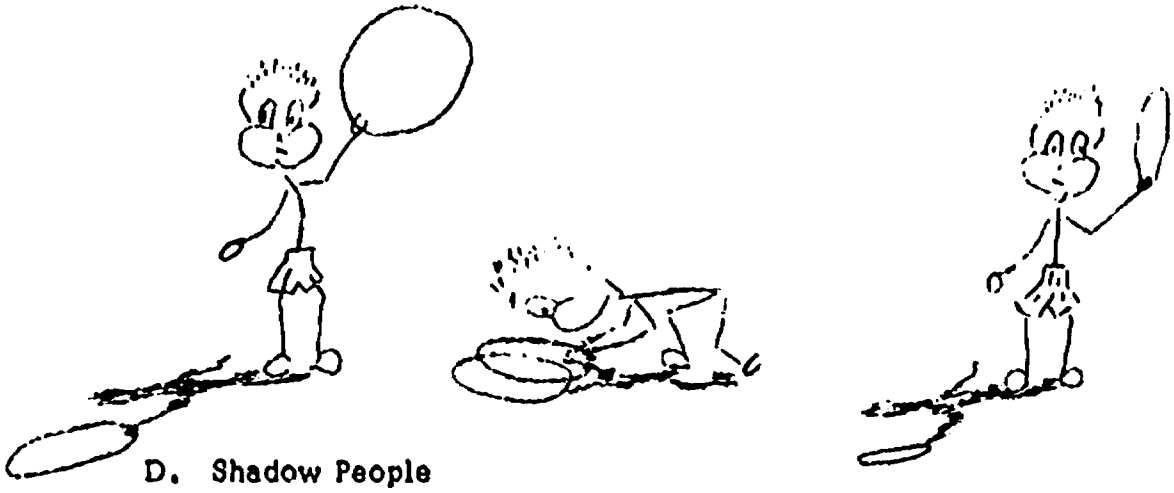
Ask the class to stay within a limited area (tennis court, etc.). Choose a partner and try to keep your partner from stopping on your shadow.

C. Shadow, how many shapes do you have?

1. Have each child bring to school a large, light object with a simple outline. For example, garbage can covers, hoola hoops, umbrellas, brooms, inner tubes, cardboard boxes, etc.
2. Divide the class into teams of two children each, give each team chalk, and have them spread out over a parking lot or some other paved area.
3. One child manipulates one of the objects and the other child sketches its outline on the pavement with chalk.
4. Ask the children how many different shapes they can make with the shadow of their object?

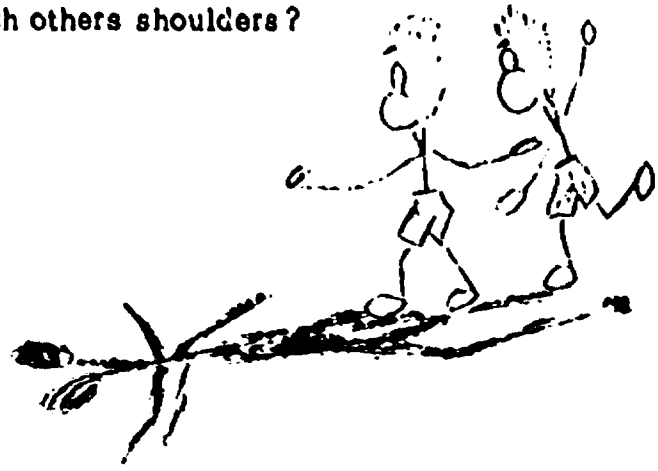
   a. How large can they make the object's shadow?
   b. How small can they make the object's shadow?
   c. How skinny can they make the object's shadow?
   d. How fat can they make the object's shadow?

e. How black and crisp can they make the object's shadow?
f. How faded and fuzzy can they make the object's shadow?



D. Shadow People

1. Have each team of two children make sketches of their own bodies in different positions. Take turns being the person who outlines the shadows with chalk. Can they make monster people? Can they make a shadow with their body which doesn't look like a person at all?
2. Combine every two teams into groups of four. Ask them to take turns being the person who outlines the shadows with chalk. The other three children should construct some design or picture using their shadows. Can they make an unusual design that doesn't look like three children? Can they make an animal like a giraffe or maybe an animal out of their imagination? Can they make a grouping of three people doing something like standing on each others shoulders?



II. Indoors

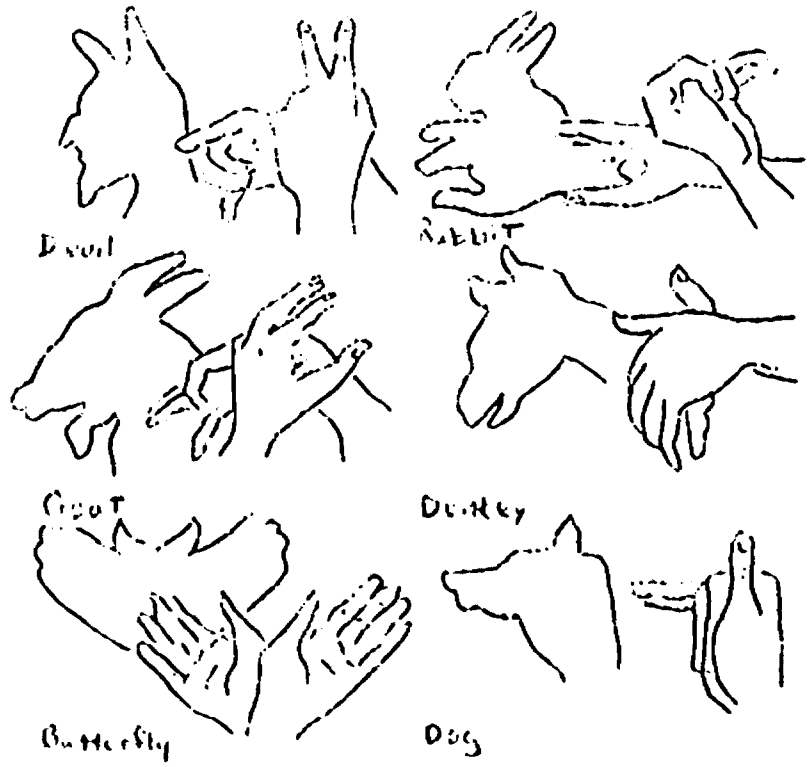
Materials needed: a sheet, a lamp with 150-200 watt clear light bulb

A. Your hands can make strange shadows

1. Set one 150-200 watt lamp without a shade in the center of the room. Have each team tape a 3' x 3' piece of white paper on the wall.

2. Shut off the lights and ask them to create designs, animals, etc. on the walls.

3. As each team member creates a new design, etc. the other member can sketch around the shadow on the paper.



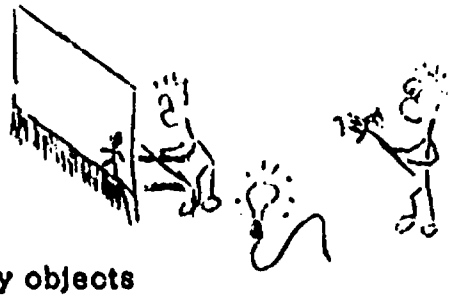
B. Stage a shadow play

1. Build a stage by hanging a sheet in a doorway or on a frame; put a strong light source behind it (slide projector or lamps).
2. Have each team think of some kind of activity they can perform behind the screen.

   i.e., boxing -- one stands closer to the sheet than the other, but when they box it looks like they are facing one another.

   i.e., an operation -- where the doctor removes books, pencils, etc., from the patient.
3. Put a table behind the screen and have the children create and perform their own plays of tales using cut out figures, or small figurines and play things from home. The figures could be taped or glued to handles made out of coat hangers. These plays might be taken from their reading book or relate to some other subject they are studying, such as social studies. Place the light source

to one side of the stage so the shadows of the childrens' bodies are less apt to show. Do they realize that the closer they hold their characters to the screen, the sharper and blacker are the shadows which their audiences see?



C. Mystery objects

1. Have the children bring a 'mystery object' from home concealed in a bag or box. It should be some common household object.
2. Each child used his mystery object to cast four different shadows on the sheet of the shadow stage. For example, one bottle might cast all the following shadows.

The rest of the class writes down the child's name and makes notes or drawings of the shadows.
3. Each child deposits his mystery object in a box taking care that the class cannot see it. The teacher holds a cloth over the box so he cannot see other mystery objects the box might contain.
4. The teacher gives each mystery object a number and displays them on a table.
5. The class looks at the objects and tries to match the object with the child who demonstrated it.
6. The person with the most correct matches wins the game.

Alternative: Teacher collects and numbers all mystery objects. One is provided for each child (advantage: teacher control over what objects are used). She could also limit the objects to one type such as all bottles.

SHADOWS THAT ANSWER QUESTIONS

I. Shadow, what time is it?

A. Observing that a shaodw from the sun changes position with the time of day:

1. Have each team select and study the shadow movement of one or two objects such as the following:

e.g. Using chalk, mark the movement of the shaodw of the school building once every two hours during the day.

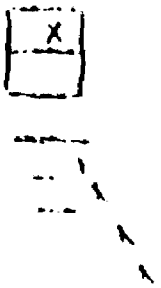
e.g. Mark the change in length of your shadow when standing in the same spot once every two hours during the day. Mark your feet positions by drawing around them with chalk.

e.g. Mark the change in length of the shadow of some small stationary object such as a twig.

2. Predicting where a shadow will fall. Have each team select and study the shadow of an object as in "1". Only after marking the shadow's position twice have them predict where it will fall in two hours. After two hours, who came the closest to their prediction?

B. Marking the change of shadow position over a period of time.

1. Does the shadow change positions from one day to the next?

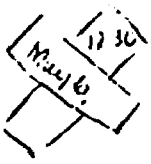


-Put a mark on the window with tape. You might use an "X". During the time of day that the sun shines on the window the "X" will cast a shadow on the floor.
-Assign each team a time of day to mark the shadow's position. Use tape to mark the shadow position on the floor. Perhaps they could check it every half hour. Remember the window will only be in the sun part of the day.
-Write the date and time of day on each "X" put on the floor.
-Check the <u>next day</u> to see if the shadow falls on the same spot at the same time. If not, put down more tape marks showing its new position.

2. Does the shadow change position from one week to the next?

a. A week later check the shadow position at the same time of day used the week before. (i.e. if the shadow was checked on Monday at 12:30, 1:00, 1:30, 2:00, 2:30, check the shadow at those times the next Monday)
b. If the shadow does not fall on the "X"'s taped to the floor the week before, make new "X"'s showing the shadow's new position for the time of day.

c. Write the time of day and date on each new 'X'.



3. Does the shadow change position from one month to the next?

   a. A month later check the shadow position at the same times of day used the month earlier.
   b. If the shadow does not fall on the 'X''s taped to the floor the month before, make new "X''s showing the shadow's new position for that time of day.
   c. Write the date and time of day on each taped 'X'.
   d. Keep a record of the tape position and date and time in a note book in case the tape is accidentally removed or is worn off.

4. Check each succeeding month in a similar way. (Give the class a chance to predict where the shadow will fall for each succeeding month. Perhaps you could keep account of the closest prediction for each month. Select just one hour, for example 1:00, for them to make their predictions on.)

5. At some time during the Shadows study, divide the class into group and have them attempt to account for the change in position of shadows over a period of time. To do this they will have to consider the earth's movement in relation to the sun. Such a discussi might be held during the following activity entitled, "Shadow, what time is it in England?", which deals with the same subject.

   Alternative: Line the class up outdoors and take a picture of them and their shadow each month. These pictures must be taken as close to one month apart as interfering weekends will allow. They also must be taken at the same time of day and in the same positio each month. Label the pictures with their date and tape them side by side on the bulletin board. Note: the difference in shadow length and direction from month to month.

C. Making a sun clock

1. Have one child from each team bring a large sheet of cardboard to school (approximately 3' x 3'). Provide each team with a stake approximately one and one half feet tall.
2. Lay the cardboard on the ground and drive the stake through the cardboard into the ground at the center of the cardboard. Leave about a foot of the stake above the ground. Fasten the corners down with small stakes.
3. Outline the shadow of the large stake on every hour of the day. You might assign each team an hour to put marks on all the sundial showing the ends of the shadows. When that hour arrives the team will go outside and mark the shadow for all the teams. They should label the mark with hour (11, 12, 1, etc.)
4. When the hours are all marked, ask the children if they can tell where the shadow will fall on the half hour. If so, they can make their marks and see if they were right. If not they could check to see where it falls on the half hour. Can they now make

marks on their sundial to show where the shadow falls every 15 minutes?

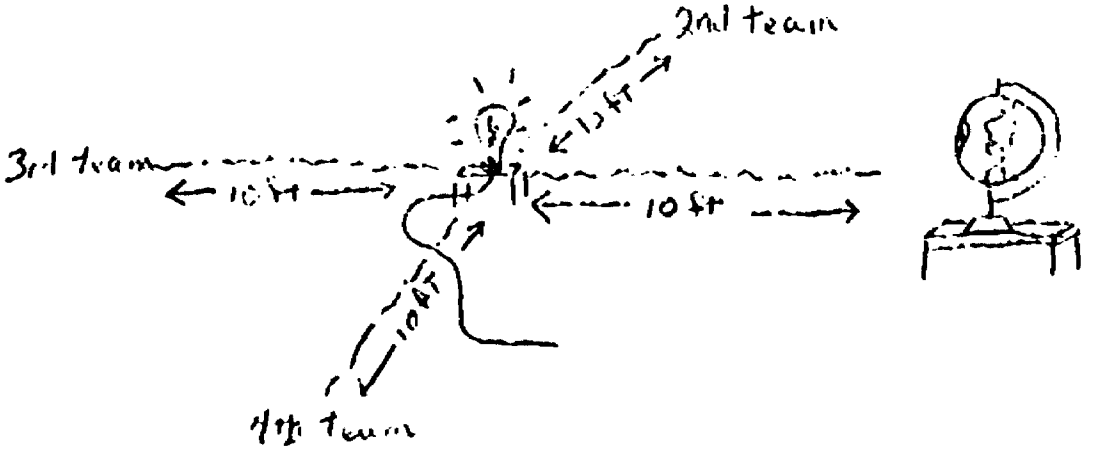
Ask them to make the mark for half hours of a different type from the mark for an hour. Also the 15 minute marks should be distinguishable from the others.

II. Shadow, what direction am I pointing?

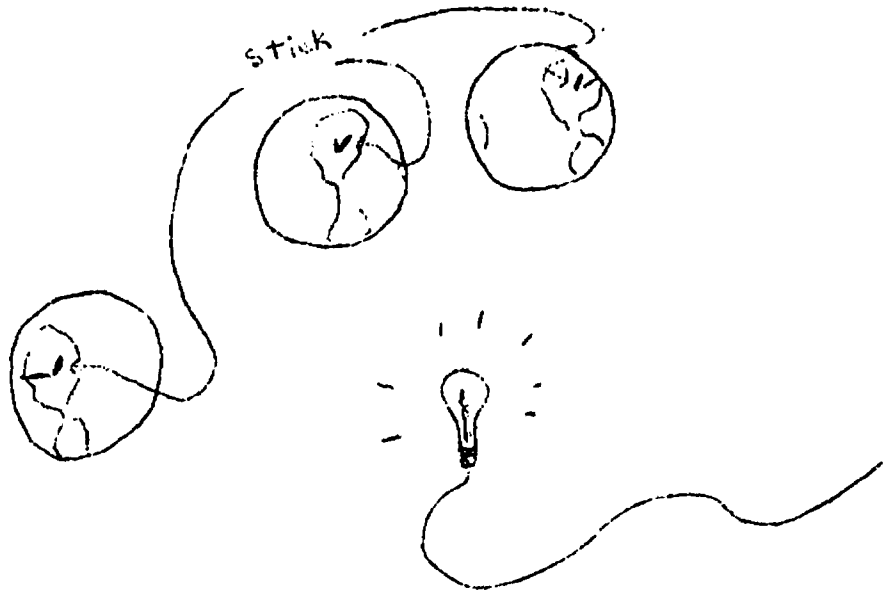
A. Provide each group of four teams with a lamp. For sharp shadows use a 150 watt clear bulb. Give each team a globe, one inch stick or cardboard figure, a lump of clay, and a 10 foot string.

B. Push the stick or figure into the clay lump and press this onto the globe in the area of your home.

C. Using the 10 foot string as a guide have teach team take a position around the globe maintaining 10 feet between the lamp and the globe. NOTE: Keep lamp at same level as equator of globe and keep the north pole up.



D. Rotate the globe so there is a shadow cast by the stick. Now imagine that the earth is spinning as it acutally does and turn it slowly in a west to east direction (counter clockwise as you look down at the globe). What happens to the shadow?



E. Have groups (about 4 students each) discuss the information gathered and relate the information to their previous studies about the changes of the suns shadows throughout the day. They might consider such paired questions as the following:

a. Where is the figure in relation to the lamp when its shadow is longest?
b. About what time is it when the sun shadows are longest?

a. Where is the figure in relation to the lamp when its shadow is shortest?
b. About what time is it when the sun shadows are shortest?

a. Where does the figure go into darkness (no shadow)?
b. About what time is it when sun shadows disappear?

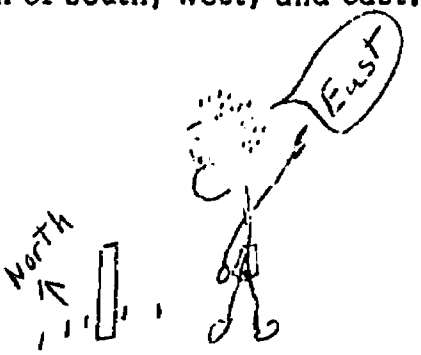
a. Where does the figure come into light (shadow begins)?
b. About what time is it when sun shadows appear again?

F. During the following class discussion the teacher should bring out the following questions if the class does not:

1. How many times does the earth spin around a day? (once) One turn of the globe moved their figure from light to dark.
2. About what time of the day is it when a shadow is its shortest? (Noon) (Relate these questions to set up of light and globe)

G. Return to the globe-lamp set up. What direction does the shadow point when it is shortest? (North, this would not be true in the Southern Hemisphere, but they probably do not know that the sun stays in one band around the equator of the earth and it may be too difficult a problem to tackle at this time.)

H. Try this activity outside. Put a stake in the ground and mark the length and direction of its shadow. Use small stakes at the end of the shadow, and put one in every 10 minutes from 11:30 to 12:30. Each team might be assigned a time at which they will be responsible for going outdoors and marking all the teams' shadow lengths. Based on this information which stake is closest to 12:00? Based on this information what direction is north? If possible, you might check north with a magnetic compass. They have now constructed an outdoor compass and from this should be able to tell the direction of south, west, and east.



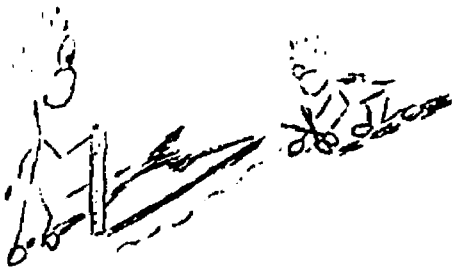
III. Shadow, how tall is the flag pole?

A. Provide each team with two yardsticks (or one yardstick and string) and clipboards.
B. Have each team select an object whose height it is possible to measure directly.
C. Using the yardstick, measure the length of the shadow of the object. (Do not measure the height of the object at this time)
D. Holding one yardstick straight up, measure the length of that yard sticks shadow using the other yardstick.....or.....
E. cut a length of string the same length as the shadow of the yard stick. How many times does the shadow string fit on the yardstick? If the shadow string is longer than the yardstick, how many times does the yardstick fit on the string?

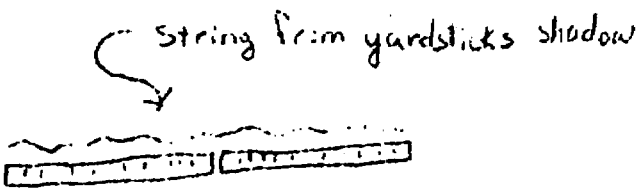
The shadow of the object measured earlier should fit on the object the same number of times as the shadow of the yardstick fit on the yard stick. For example, if the shadow string of the yardstick fits on the yardstick two times, the shadow of the object fits on the object two times. If the length of the object's shadow is one yardstick long, the height of the object is 2 x 1 yardsticks or two yardsticks tall. (Handle fractions in any manner your class is capable of. You might ignore fractions. You might consider 1/2 or more equal to "1" and less than 1/2 as "0")

F. Each team measures the height of the object and compares their calculated answer with the actual answer.

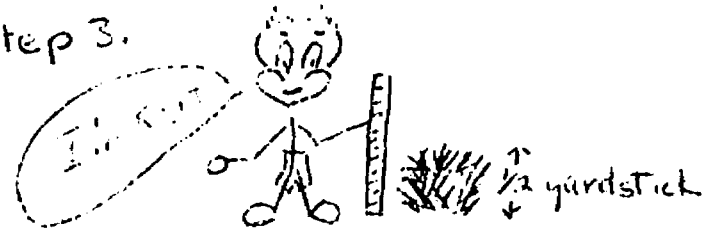
Step 1



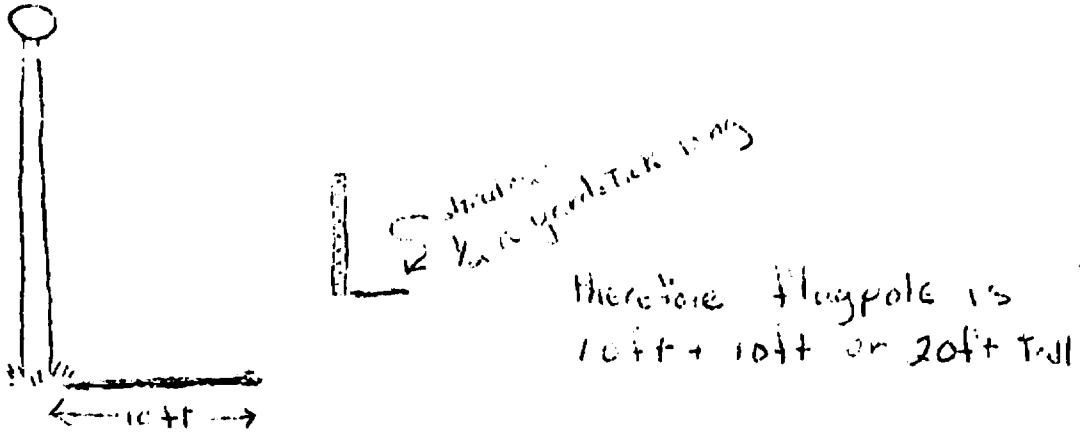
Step 2



Step 3.



G. Use this procedure to find height of objects to tall to measure directly, for example, buildings, flagpoles, etc.



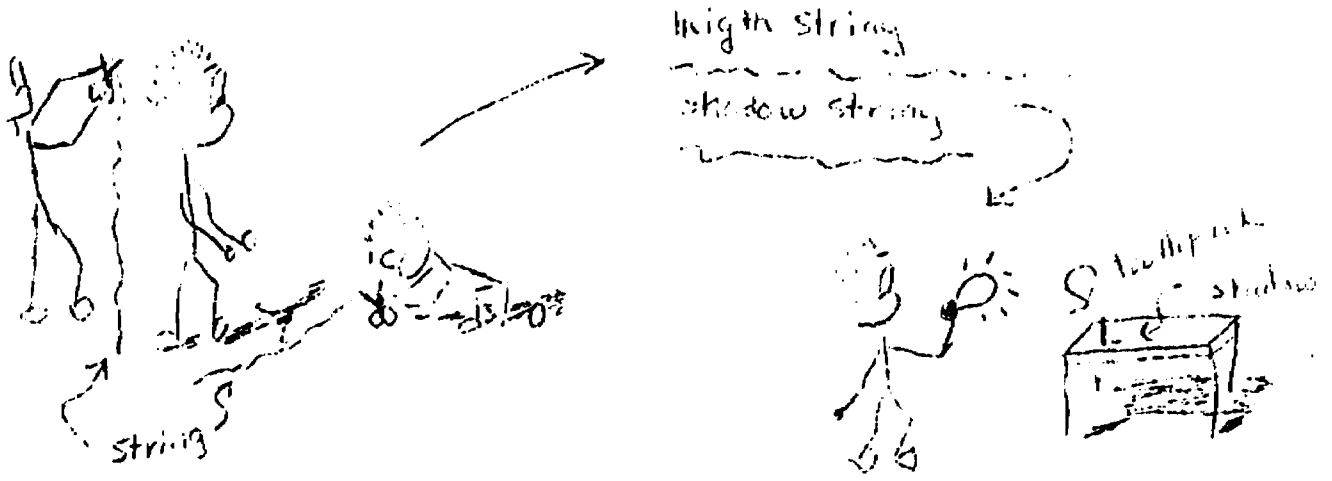
IV. Shadow, what time is it in England?

It will be necessary for the children to recognize the north and south poles on the globe. They will make use of the shadow compass they built earlier, and the technique of determining shadow proportions used in "shadow, how tall is the flagpole?"

A. Preliminary activities

1. Practice telling directions on the globe (east and west, U.S., north pole, south pole).
2. Practice using their shadow compass.
3. Measure the length of your shadow outdoors. Cut a piece of string the same length as your shadow. Measure your height. Cut a string of this length also. Compare the length of the string for your shadow to the length of your height. Depending on which is longer, how many times does the shadow string fit on your height string or how many times does the height string fit on the shadow string? If your class has not used fractions, count less than half of a length as "0" and more than half a length as "1".

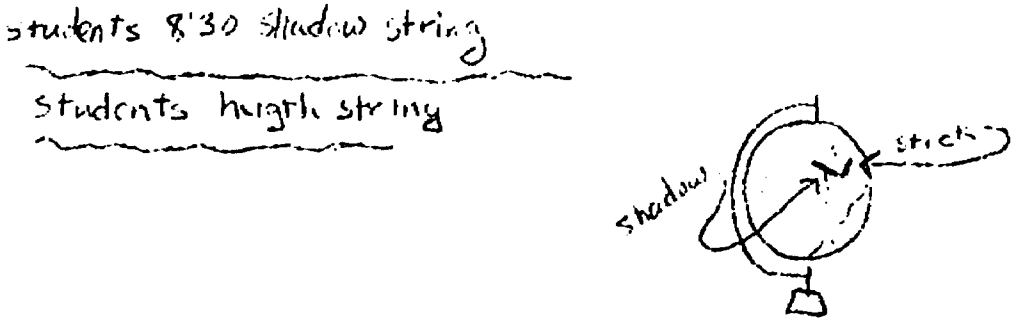
Using a toothpick stuck in clay and placed on a table top, move a lamp around until you can get the same relationship between the toothpick and its shadow and you did between yourself and your shadow. (Refer to their work in, "Shadow, how tall is the flagpole?") For example, if your shadow string is 2-1/2 times as long as your height string, make the toothpick shadow 2-1/2 times as long as the height of the toothpick by moving the lamp. Try this at several different times during the day (morning and afternoon), until everyone is capable of doing this.



The direction the shadow is pointing will be important in following activities. See if the children can orient the light source so the toothpick shadow is pointing in the same direction as your shadow was outside.

B. Determining the time in other countries

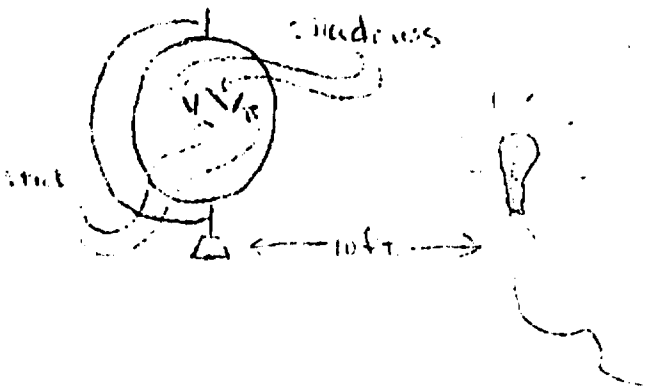
1. Set up a lamp and a globe with 10 foot distance between them and the lamp at the same level as the equator on the globe.
2. Go outside. Have one member of each team stand while the other member measures the length of his shadow, and determines the direction the shadow is pointing, using the shadow compass. Make determinations at 8:30, 10:30, 12:30 and 2:30.
3. Compare the length of the shadow to the height of the student as in preceding illustration.
4. Assign each team a time when they can use the globe and light to work steps 5-11.
5. Using a one inch figure, stick it on a globe with clay in your home location.
6. Move the globe so the shadow cast by the one inch figure is in the same proportion and direction as yours was at 8:30. Fix the globe in that position.



7. Place a second one inch figure on the globe. Position it on a line which runs from east to west through the 8:30 figure.
8. Look at the shadow length and direction of the second figure. Judging from the information you have on your shadow, what is the approximate time of day in the spot where this second figure is located? Can you move it around so it is about 10:30?

Students 10:30 shadow string

Students height string



9. Using a third figure locate it on a line extending from 10:30 figure to the east. Judging from the information you have gathered on your shadow, what is the approximate time of day in the spot where the third shadow is located? Can you move the figure so it is exactly 12:30?
10. Go through the same procedure with a fourth figure and locate it at a 2:30 position.
11. Rotate the globe from west to east (counter clockwise) until the figure with the 10:30 shadow has an 8:30 shadow. What happened to the figure which originally had the 8:30 shadow? What time do you think it is where your first figure is now? What happened to the other figures?
12. Have each team write down where they located the sticks on the globe for each of the times. Obtain a map of the time zones and have them check to see how close they came.

SHADOWS THAT AFFECT LIVING THINGS

I. The children will compare the number of a vegetation type in an area that is shaded most of the day with the number of that vegetation type found in a sunny area.

A. Provide each team with a yardstick, four stakes, and about 4 feet of twine. With this material they will rope off one foot square plots. (Or, use a wire hoop tossed on the ground to delineate an area.)

B. Take the class outdoors to a part of the lawn which is not shaded by the building or trees. Ask them to pick an unshaded spot for their study area.

C. Have each team use the stakes and string to rope off a plot one foot on each side.

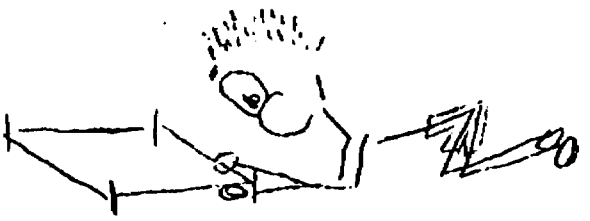
D. Each team may now examine their plots for different types of plants. Have each team pick one plant each of the three most abundant types of plant in their plot and pin them to a centrally located piece of cardboard.

E. From this collection select a plant type which is found in all the plots or in most of them. Have each team count the number of the plant in their plot.

F. Have the teams move their plot to an area which is shaded most of the day. (Next to a building?) Carefully count and record the number of the selected plants found in their plots in this shaded area.

G. Return to the classroom and have each group of two or more teams combine data. Can they see any significant differences? Take an average for the class of the number of the selected plant per plot in the shade and compare it with the average number per plot in sunlight. (You could compare the total number if your class cannot do averages) Is there a significant difference? Does shade seem to have a good or a bad affect on this plant's growth?

Warning! Don't change the type of area when changing from the sunny plot to the shaded plot. Otherwise you may introduce variables other than amount of sunlight. For example, the type of soil may be different. If you are studying sunny plots on the school lawn, try to stay on the school lawn to study shady plots.



COLOR AND CHANGE

Environmental Science Center
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CONTENTS

Introduction: TEACHING THE UNIT

"Color and Change" is designed to introduce children to the notion that color is an important property of natural materials and color change in these materials is often an indication that something of significance has taken place within them. Color recognition skills are an important part of the early elementary curriculum, but they may not often be taught in a science context. This unit will serve the dual purpose of providing experiences for development of these skills through involvoing children in science activities wherein these skills may be practiced.

It is strongly recommended that the unit be initiated in early fall soon after the children begin school. One activity draws upon seasonal changes for illustration and it would be well to begin before the leaves turn color. An alternative to fall teaching would be to begin in spring as leaves and flowers emerge. It is desirable to spread the lessons or parts of them over the entire year; thus, it would be difficult to estimate the time involved in completing them.

The material in the unit has been designed for grades K-3. Some of it may be more appropriate for one level than another, therefore, you should read through the entire unit prior to teaching it and make decisions about what part or parts you will use. Lesson I is definitely for kindergarten children. No doubt you will wish to include related activities you have found to be successful in the past. Be encouraged to use anything you believe will be effective in teaching the colors or other parts of the unit.

Children are naturally curious, but before the child can become an "inquirer" he must have acquired other capabilities. Perhaps most essential for early development of inquiry in the very young is the skill of observation. Children spend a great deal of their time exploring their environment, watching, listening, and touching those things which attract their attention. One needs to guide this attention to begin fostering intelligent observation. While it may seem a fairly easy task to show children things of interest, in reality getting them to observe what they are shown demands more than a passive glance on their part. In these lessons observation is accompanied by description of one physical property of that object — color.

These lessons and activities have been drawn from both Science — A Process Approach,[1] an elementary science curriculum developed by the American Association for the Advancement of Science, and the MINNEMAST[2] Elementary Science and Mathematics project.

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[1] Science — A Process Approach

[2] MINNEMAST, Minnesota Mathematics and Science Teaching Project

BACKGROUND INFORMATION

Change is a dramatic example that Nature is a dynamic system in a constant state of flux. The phenomenon is very apparent in North Temperate regions where one observes color appearance and disappearance, the growth and death of leaves and grasses, or mass migrations of life forms in response to the seasons.

Consider, for example, the deciduous trees in your community. Leaves develop from buds on branches which have been in a resting state during the winter. The breaking of bud dormancy is dependent upon change — day-length increases, making more "sun energy" available to the buds and temperature becomes favorable for water movement within the plant. A series of rather sophisticated chemical changes occurs due to the combined influence of energy relationships and environmental factors, eliciting further change, the end result of which is the production of leaves.

Many shades and color combinations occur in plant structures with green, yellow, red, and blue most common. The predominance of one or another pigment is subject to change in response to the interaction of numerous factors such as those related to seasonal changes. A panorama of particolored landscapes reflects this phenomenon which has great aesthetic appeal to Sunday drivers and many an artist.

Contrary to popular belief, chlorophyll is not the only pigment found in green leaves. The autumnal shift in color is not a mystical chemical process. In most instances it is the result of alterations in pigment predominance. Chlorophyll is lost as the day-length changes and the "unmasking" of other pigments occurs.

Red, blue, and violet hues are attributed to another pigment. This pigment is found in crystal form in the cell sap and is water soluble. Interestingly enough, the color is dependent upon the relative alkalinity or acidity of the water medium. In Lesson II, this property is put to work and a "mystery" is provided about which the children can speculate.

Color change may also be used as an index of interaction in other instances. Bruised apples or bananas are evidence of injury; ripening of fruit indicates maturation.

Lesson I

PERCEPTION OF COLORS

This lesson may be omitted for first and second graders, however, you may wish to review their knowledge of colors before they become involved in other activities.

At the conclusion of this lesson the children should be able to recognize the primary (red, blue, yellow) and secondary (purple, green, orange) colors, and their tints and shades, sometimes spoken of as color lightness and darkness.

Materials

Item	Quantity	Source
Construction paper	as great a variety as possible of colors, their tints and shades	school
Shoe boxes	approximately 12	home

Procedure

Assemble the children seated in a circle on the floor, and place three shoe boxes in the center. On one shoe box tape a piece of red construction paper, on a second tape a piece of blue construction paper, and on the third a piece of yellow. Cut about 50 pieces of 2 x 2 construction paper in these same three colors. Scatter them around the circle at the feet of the children. Ask the children to place the pieces in the shoe box which has the matching color. When this has been completed produce another bag full of 2 x 2 pieces of construction paper. This bag should contain not only the three primary colors but also the three secondary colors plus tints and shades of all six. Scatter these about the circle and ask the children to select one piece at a time and place it in one of the three shoe boxes which comes most close to the color of that piece. For instance, a green piece might be placed in the blue box, while an orange piece might most closely approximate yellow. (A variation of this game would be to hide the pieces around the room and have the children hunt for them.)

When the pieces have all been placed in the three boxes, examine them with the children. Discuss and vote on the placement of "questionable" pieces.

Children are almost certain to remark about the orange, green, and purple pieces. Since these colors are so common, perhaps the children will suggest making three more shoe boxes in which to place these colors. Produce three more shoe boxes and ask the class which of the various shades and tints is the most "true green"? "True orange"? "True purple"? When one color has been decided upon for each of the three, tape this piece to a shoe box. After the new boxes have been thus marked, groups of children may re-sort the pieces into the appropriate boxes (red, yellow, blue, green, orange, purple).

The children should have gradually become aware of an order or "grouping off" of the colors they have been working with. Perhaps they could now order the boxes in a circle. Through discussion, it may be decided that orange belongs between yellow and red, purple between red and blue, and green between blue and yellow.

(They may still not realize that the secondary colors result from combinations of the primary colors. This is not important at this time.) When the boxes have been arranged in the circle, encourage the children to walk around the circle and name the colors.

Extend the activity by showing the children how to make their own color charts. Have the children paste pieces of each of the six colors on a strip of tagboard. They will each have their own color chart, and may walk around the room identifying the color of different objects through comparisons to their chart. They will also see that objects come in many colors which are not on their chart. And some may begin (if they have not already) to notice that brown, black, and white are not included on their charts, yet many objects are of these colors. These colors may be added to the charts.

Lesson II

COLOR AND CHANGE IN NATURAL OBJECTS - INDOORS

Natural objects appear in a variety of colors. In this lesson the children will describe and reproduce the colors of a collection of fruits and vegetables. They will then observe the the change that naturally occurs in these fruits and vegetables over a period of time. Finally, they will work with natural pigments which were extracted from familiar materials.

Materials

Item	Quantity	Source
Paint	a jar of yellow, red, blue, and white for every two students	school
Shoe boxes from Lesson I		
Drawing paper	one or two per student	school
Red cabbage	one	grocery
Vinegar	one quart	grocery
Clear ammonia	one quart	grocery
Hot plate	one	school
Pyrex or Corningware dish (any transparent container)	six	home or school
Babyfood jars	six per student	home or school
Paper towels	one roll	school

Procedure

I. Description of Fruits and Vegetables by Color

Display the fruits and vegetables on a table before the class. Ask them to identify the various types by name. Perhaps there will be some they do not recognize. Name them for the class, and then have them assign color descriptions to the objects.

Multicolored fruit (i.e. not quite ripe, etc.) might tend to confuse the children, but suggest that they assign a description on the basis of the predominate color. If some are still unidentifiable, make up another shoe box with a question mark on it so that the confusingly colored objects may be categorized along with the rest. Have the children place the various fruits and vegetables into the shoe boxes according to the color match.

II. Observation of Color in the Fruits and Vegetables

Lay large sheets of paper on the floor and provide every two children with red, yellow, white, and blue paint (colored chalk could also be used if paint is not available). Pass out one piece of fruit or vegetable to each child. Ask them to paint a picture of their piece of fruit or vegetable on the paper. Since they have received only primary colored paint they will encounter some difficulty in reproducing, for example, the color of an orange. They will find it necessary to mix two colors to produce other colors (i.e. orange), and to produce shades and tints of colors. When they have reproduced the shape and color of their piece of fruit or vegetable as closely as possible, they might exchange pieces with someone. They should find that differences of color and shape not only exist <u>between</u> types of fruits and vegetables, but also <u>within</u> a type of fruit or vegetable. For example, one orange might be entirely green in color while another is entirely orange. The purpose of the activity is twofold: 1. Colors may be mixed to produce others, and, 2. Fruits vary in color and shape not only between types, but also within types.

III. Observation of Change in the Fruits and Vegetables

Give each child a transparent container which can be tightly sealed (plastic refrigerator dish, glass jar, plastic bag tied shut). Ask them to put the piece of fruit they last painted on their paper into the container. They should seal the container and put their name on it. Either mark the wall calendar on the day this was done and call their attention to this date, or have them put the date on the container. Ask that they put an "X" beside their painting of that particular piece of fruit. Collect and save the paintings or display them near the containers of fruit. Place containers someplace where they are easily observed by the children. Ask them to "keep an eye on" their piece of fruit or vegetable. Obvious changes in the fruit or vegetable may not occur until they have been sitting for over a week. From then on they will change rapidly. Some will develop very interesting and beautiful molds. They will decompose completely in approximately six weeks. The children might make one or two further paintings as a record of the color and shape of their fruits or vegetables as the decomposition continues. It might be interesting for them to compare the different kinds of molds which will occur (E. S. S. unit <u>Mold Gardening</u> would fit here very well).

IV. Pigment Magic

INTRODUCTION

The children work with several solutions which have very definite and obvious reactions when mixed. This reaction is the production of different colors, tints, and shades. These colors, tints, and shades depend upon which solutions are mixed together, what quantities of these solutions are mixed, and in what order the solutions are mixed.

If the children are to reproduce a certain color they must keep records of which solutions, what quantities, and what order was used for the original solution. They also must overcome the problem of contamination of their solutions when performing these activities.

OUTLINE

A. Red Cabbage Experiments
   1. Preparation of:
      a. cabbage water
      b. ammonia water
      c. vinegar
      d. mixing containers and tools
   2. First day activity:
      a. discovering colors and their shades and tints using solutions "a", "b", and "c"
      b. recognizing the problems involved in reproducing a color
   3. Second day's activity:
      a. eliminating contamination of solutions
      b. keeping records
      c. preparing a collection of colors, their shades, and tints
   4. Third day's activity — reproduction of colors from their collection of colors

B. Other Pigments
   1. Collection and preparation of pigments from other plants
   2. Examination of these pigments

A. Red Cabbage

1. Preparation — teacher

Boil a broken up head of red cabbage in a generous amount of water for about ten minutes. Pour the resulting colored water into containers of approximately one cup in volume. You will need enough solution and containers so each team of two children can have a cup of the liquid.

Pour two inches of household ammonia (non-sudsy kind) into a gallon bottle. Fill the remainder of the bottle with warm water. Provide each team with a babyfood jar full of the ammonia solution. This dilute solution of ammonia is not very dangerous, but the children should still be warned to be careful when working with it. If it gets into a child's eyes, it will irritate and should be quickly rinsed out with clear water.

Fill a second set of babyfood jars with vinegar. Again there should be a sufficient number of jars so each team of two children may have a supply of this solution also.

Mark the three solutions (cabbage water, ammonia, vinegar) so they may be differentiated from each other. For example, they might be marked A, B, and C.

Besides the three marked jars of solutions, each team of children should be supplied with six eyedroppers and as many small transparent containers as the class can possibly gather together (i.e. babyfood jars, juice glasses, etc.)

2. First Day -- Introduction to Solutions

Ask the children to use the empty containers to mix portions of solutions A, B, and C in any combination and any order they wish. They will see many brilliant colors appear as they mix the three solutions.

As a child discovers a color he might put part of that color in a jar and place it on a table. Each time a new color is discovered it would be added to this grouping. Encourage the class to begin adding various shades and tints of colors to the collection on the table. The resulting group of colored solutions may include shades and tints of green, pink, lavendar, yellow, brown and blue.

The children will uncover two problems while doing this activity. When they discover a new color, they or possibly their neighbor may want to reproduce that color. This will only be possible if they have not contaminated solutions "A", "B", and "C". For example, they may produce a green color by using an amount of "A" with an amount of "B". However, they might not change eyedroppers when they take solution from "B". Solution "B" is now contaminated by "A" and they will not be able to reproduce that color green. They will need to get fresh solutions. Sometimes they will see their solutions A, B, and C have been contaminated because they will turn color. Allow the students to discover these problems for themselves.

A second problem they will encounter while trying to reproduce a color is "forgetting" how each solution was used to produce a color. Which solutions did they use to produce a color? How much of each solution was used? In what order did they mix the solutions?

3. Second Day — Contamination and Record Keeping

Ask the class how they might overcome the problem of contamination. Might they use a particular eyedropper in a particular solution? They could mark the eyedropper corresponding to its solution.

Ask the class how they might overcome the problem of forgetting. Can they think of a means of recording kinds of, amounts of, and order of solutions? They might record kinds by using the letter of a solution. They might record amounts as the number of eyedroppers full of a particular solution used to produce a color. And the order of their addition might correspond to the order of their addition might correspond to the order in which they are written down. For example, a green might have been produced by adding three eyedroppers of "A" to two eyedroppers of "B". This may be shortened to "2B + 3A" and is termed a formula.

Ask the children to again produce as many different colors and their shades and tints as they can discover. This time they must take care not to contaminate the solutions. They also must keep a record of their formulas. Each time a new color, shade, or tint is added to the collection, the formula should be written on the cover of the jar or on a piece of tape which is stuck to the jar.

4. Third Day — Reproducing Colors

Ask the children to work in pairs. Each pair may select one of the colors from yesterday's collection, and try to reproduce that color by using the formula written on the cover. Each child in the pair may work independently to reproduce the color. They might hold the colors against a white sheet of paper to compare them. When each member of the pair has closely reproduced a color they could exchange with another pair. If neither member of the pair can reproduce the color, they should examine their technique. Are they following the formula carefully? Are they sure they have not contaminated their solutions? If they still cannot reproduce the color, they may assume the formula is incorrect. They could then experiment to find what the correct formula would be.

B. Other Pigment

When the children have finished working with the cabbage water, tell them how you obtained the water by boiling the cabbage. What came out of the cabbage when it was boiled was the color pigment of the cabbage. Tell them there are some pigments which will not come out when boiled in water (i.e. chlorophyll will only come out when boiled in alcohol; this might be demonstrated). Ask them if they think they could find other plants which might have pigments which would come out when boiled in water.

The children might bring in such things as flower petals, plant leaves, vegetable rinds, and fruit rinds. These can be boiled and the resulting solution investigated to see if it also will change color similarly to the cabbage water.

Lesson III

COLOR AND CHANGE IN NATURAL OBJECTS - OUTDOORS

Color and changes in the natural world are often observed by children, especially when the seasonal difference in foliage becomes apparent to them. But leaf change is only one example of a natural color to be studied as a part of this lesson.

Materials

Item	Quantity	Source
Lunch bags	one per child (1)	grocery
White paper	several large sheets	school
Scotch tape	two rolls (2)	school
Insect pins	one box (1)	school
Styrofoam coffee cups	one dozen (12)	grocery
Plant tags	fifty (50)	garden store
Notebooks	one per child (1)	school
Crayons or paint	one set per child (1)	school

I. Color as a Distinguishing Characteristic of Natural Objects

Give each child a lunch bag and take them out to the school grounds. Ask them to bring back as many different colors as they can by selecting objects they find around the school grounds. These objects should be natural. Tin cans, balls, and anything that is manmade is therefore excluded. If they wish to bring back part of a living plant, ask them to bring only a small part. When the children return to the classroom they could dump the articles on a table and compare their bag of colors with their neighbors' bag of colors.

Make a list of all the different colors they have found. Who found the most different colors?

Make a list of all the different kinds of objects brought back. Such a list might include: flowers, leaves, branches, grass, rocks, soil, and bugs. They might now make a more complete study of the different colors each of these items may exhibit. To do this each child might collect two or three more examples of each of the items. They might find and bring these items from their own home area.

You could divide a couple of large tables into sections. One section would be designated for all the different leaves brought in. This section might be covered with white paper for a background and scotch tape provided for taping their leaves to the table. A child might keep his leaves separate from the others on the paper by circling them with pencil and writing his name inside the circle. Leaves should be collected and studied for color within two days or they become dry and crumbled. The children might consider the following questions: Are all leaves green? Are all green leaves the same shades and tints of green? If you have leaves which have come from the same plant, do they have the same color? Does a small and

possibly young leaf have the same color as a larger and possibly older leaf from the same plant?

You might reserve another section of a table for branches and concentrate on a study of bark color. Is all bark the same color? If each child brings a couple of small twigs from trees and bushes around his home, you should have examples of red, orange, yellow, brown, black, and even green barks. This is usually quite an amazing revelation to children who may tend to think of all bark as being brown.

A section for soils can be interesting. A collection of dirt samples from the children's home areas may result in soils which tend to be red; others which tend to be yellow, and a range in shades of browns and blacks. This, as with the bark, is not commonly realized until the comparison can be seen in one spot at one time.

Flowers, rocks, and "bugs" may also be studied in a similar manner. The variety of colors to be found in these three items is almost unlimited. Flowers might be kept in jars of water for the study. Rocks should be displayed on a white background and might be observed with hand lenses. Bugs might be pinned with insect pins to styrofoam coffee cups and observed with hand lenses.

II. Color and Change over the Year

Prepare the class for a field trip around the school grounds, and give each child a plant tag upon which they will write their name and a baggie. When outdoors, instruct each child to choose a plant for study. (It is interesting if an evergreen is chosen as one of the study plants, as this provides a contrasting example.) They can fasten their tag to the plant they have selected. To protect the paper tag from rain and snow, they should slip the baggie over it and close the top tightly by tying or fastening with a rubber band.

Tell the children that during the next several weeks they will be observing their choice of plants and must relate to the class whether or not it changes during that period of time. This part of the observation should be continued over the <u>entire</u> school year so that the complete color cycle can be noted. Perhaps you can arrange monthly observations and reports so that the children remain involved.

You might have the children make drawings of their objects using crayons or paints. This activity could be easily correlated with their art work and is a good outdoor activity for fall. However, if bringing art materials outdoors presents too much of a problem, the drawings can be made upon their return to class. Try to get the children to predict, either while they are making their drawings or afterwards, what they expect is going to happen to their plants as the year progresses. Do they anticipate any change in color? If so, those who can might be encouraged to make a drawing of what they expect. Mount the childrens' drawings so the entire class may view the results. As the year progresses, mount additional drawings of each study plant side by side.

Suggested Activities

Will green leaves change color by placing them in a cold environment?	Collect some maple or aspen leaves before they begin to change color or show signs of drying. Place them in a plastic bag in the refrigerator. Observe for color changes.
Will a banana ripen as rapidly if it is placed in a cool place?	Acquire four bananas. Place two of them somewhere in the room and two in the refrigerator. Note the date and observe the color changes daily. Record observations.
Will evergreen branches change color if they are brought inside?	Clip some branches from fir or pine trees and bring them to school. Provide the branches with a sugar water solution such as is used with Christmas trees. Observe the change.
What changes occur in people as they grow older?	Have the children bring in several snapshots of themselves taken at various ages. Discuss the changes which have occurred since the pictures were taken.
Hidden colors in washable black ink. (Analogous to the hidden colors in green leaves which appear as the chlorophyll is lost.)	Obtain a quantity of washable black ink for use by the entire class (two bottles). Place a single drop on a piece of moist filter paper or white paper towelling. All of the colors which make up black ink will be revealed in rings spreading out from the initial drop. The color rings will be the same on all papers. Have the children compare their rings and name the revealed colors.

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LIQUIDS AND MORE LIQUIDS

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WHAT'S IN A NAME?

A Study of Liquids

CONTENTS

I. INTRODUCTION

Introduction: Water pollution is a very immediate concern to scientists and laymen alike. The scientist understands pollution in terms of soluble and insoluble pollutants, how they affect water life, how they gain entrance to our water systems, and how the pollutants can be controlled. The layman understands pollution in terms of lakes and rivers that are not safe for his children to swim in, game fish replaced by rough fish, and destruction of the aesthetically pleasing character of water bodies. However, a solution to the problem will probably not take place until the layman gains a few more of the scientists understandings.

E.S.C. is attempting to increase understanding of pollution problems by bringing the study of ecology into the elementary school classroom. This lesson could be a child's first step towards the scientists ecological understanding of water pollution. The activity of the lesson causes the children to mix together liquids such as water, alcohol, oil, and syrup. Using food coloring they discover how these liquids mechanically mix together.

They find answers to the questions: what liquids are soluble in each other? What liquids will not mix together? (Why, for example, are we so concerned about leaking oil wells off the California coast? What might the children suggest would break up the oil?) After this investigation of liquids the children add different solids to their liquids. They discover that some solids float and others sink, that some solids completely disappear in a liquid while others mix in but are still visible. (Why, for example, do we worry about fertilizer washing off our fields and into the water when it seems to just disappear?) These and other activities pave the way to more sophisticated understandings of water pollutants.

II. PURPOSE

One purpose of this series of activities is to dramatize the need to examine a substance for its characteristics rather than "feel" one "knows" all about a substance because one is able to <u>name</u> it. (the liquids suggested for use in this lesson are labeled in modified Russian)

A far more important purpose is to initiate an understanding of pollution problems in young children.

The germ of ideas of further studies of liquids are introduced (i.e. bacteria content, density and specific gravity)

"What's in a Name"

Materials:
Distilled Water - labeled "Coynthbacra"
Water - labeled "Boda"
Clear Syrup (Karo) - labeled "Cipon"
Clear oil (mineral) - labeled "Miclo"
Alcohol - labeled "Akotomb"
White Vinegar - labeled "Ykcy"
Diluted ammonia - labeled "Amnak" WARNING: There are very strong fumes from ammonia, you may want to eliminate this liquid with your group.
Food Coloring - four colors
14 small containers, lab. equipment or pill bottles for each participant
2 tall pill bottles for each participant
7 eye droppers per table - one for each liquid
1 plastic pail for waste
1 hot plate
6 thermometers per class

Procedure

- Place 7 bottles of the above listed clear liquids in front of each participan
- Ask them to examine the liquids in the closed containers.
- Use prepared sheet with Russian names of liquids. List all the properties of the 7 liquids that can be determined by sight. They may manipulate the closed containers, shake, tip, etc.
- Open the containers and carefully smell the contents. Add English names from knowledge gained.
- Taste contents of other containers. Add remaining English names. Don't taste alcohol or ammonia.
- Discuss, "Does knowing the name of a substance help or hinder the study of its properties."
- Examine drops of each substance, not characteristics.
- Weigh specific amounts of each substance in a container (weigh the empty containers ahead of time.)
- Heat the liquids to their boiling points and record. (Establish safety rules)
- Place drops of different food coloring in the water, syrup, vinegar, and alcohol (i.e. water-red; syrup-blue, etc.)
- Stack the liquids in layers in a test tube or a tall pill bottle. Trial & error method. This will take one, two or more class sessions.
- Into a babyfood jar or tall pill bottle place oil, water, syrup and alcohol in that order. Take care pouring the alcohol. What is on the bottom, second, third, fourth layer? Drop 1 drop of food coloring in the center - watch - what happens? Why?
- Ask the children to bring in other liquids to examine.
- Ask them to bring in any powder such as flour, sugar, salt, etc., mix them with the various liquids and see what happens.
- Continue examining the liquids and solids as long as interest continues.
- Permit individuals to conduct their own experiments as much as possible (Establish safety rules)

- Weigh specific amounts of each liquid. (10 cc., 1/2 babyfood jar, one quart) continue until you can detect a difference in weight. Be sure to account for the weight of the container.
- Discuss comparisons between the weight and the stacking in layers.

IV. WATER

Materials:
Natural water sources

pond	rain
lake	snow
creek	standing
river	

Transparent containers, babyfood jars or five or more pill bottles - per participant
Hand Lens - one per participant
Filter cloth, handkerchief, rag, five or more per participant
Scale
Microscope
Well slides - one per participant
Metholine blue in 0.10 g. solution in 100 ml. of distilled water

Procedure
- Collect samples of water from natural sources
  - pond
  - creek
  - river
  - standing
  - snow
  - rain water
- Place in transparent containers, babyfood jars.
- Examine for:
  - clarity
  - odor
  - purity - filter and examine cloth
  - weight
  - pollution

Methylene Blue test -
Prepare a solution of methylene blue 0.10 g. in 100 ml. of distilled water. Place five parts water (pond, creek, etc.) in a transparent container, with two parts methylene blue solution. If the methylene blue becomes transparent it indicates the presence of bacteria. Methylene blue is an organic compound, an aniline dye, that can be used as an indicator. It is always dark blue when it is in the oxidized condition, but when reduced (requiring one atom of hydrogen per molecule of methylene blue) the color disappears. The time required to change the color in the various waters could be recorded and discussed.

WIND

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INTRODUCTION

What's Important About Wind?

We rather dislike making wind "important to know about because". Wind can really be fun to find out about in its own right. And if we say, "Wind is important to know about because wind brings the clouds that give us rain", the kids know we are speaking in 3000 year old cliches, or if we say, "Wind is important to know about because it dries our mother's wash when she hangs it out on the line, or pumps the water in Holland", they know we are not up with the technological age or we are out of our tree. If we say, "Wind is important to know about because it carries pollutants or it affects the trade routes at sea", they know we are talking about the adult world of all abstractions and no action.

But then, there are some teachers and principals who might want to know if we have anything in mind besides fun and games. We will try to be formal about this, but don't tell the students.

Wind is important to know about because we live with it.

Any air movement is a factor in the whole complex of physical events which we call weather. We have written lessons on temperature, humidity, light, snow, rain, soil, and other environmental phenomena. Wind either affects or is affected by each one of these. In fact, none of these phenomena can truthfully be separated out of the environment and said to exist alone. All are intertwined and we cannot really know about one without knowing about all the rest.

We are a part of the environment and so is the wind. We must live with each other. If we can know how the wind will behave perhaps we can better know how to behave while living with it.

Some Philosophy:

We think weather is interesting. Most students in later grades don't agree with us.

We have a theory that these students never had any fun with weather, or maybe never got acquainted with it at all. Or maybe they heard (were told) a lot about the weather, but never did anything with it.

This lesson about wind was written in the belief that if kids can do fun things related to problems we want them to know about, they will learn and they will retain a favorable attitude toward the problem. If they are favorably disposed toward the problem (i.e. not turned off) they will be more willing to learn more about the problem at a later time.

Fun and games in science is not the main objective of the Environmental Science Center. Our purpose is to get everybody to be more aware of the environment in which they live so they can solve their living problems more capably.

We don't suppose that solving major problems, such as air pollution or population is the job of grade school children. But they will have to solve them some day. We hope they will do a better job than we have.

What we do suppose is, that to know enough to solve such major problems, children will need to be interested enough to learn a great deal about them.

We would like to get this whole process started, not by throwing a lot of facts or burdensome problems at grade school kids, but by helping to get them interested through doing fun things.

Therefore, we hope that you, as the leader of this adventure, will take up this spirit with us. We think that the spirit of fun adventure for the kids and the leader is most valuable for getting across the importance of the subject we are finding out about. We like adventure so much that in this lesson there is no one right answer for anything and no one right way to do anything, and each time the lesson is led it may take a different turn.

See what activities and materials from this lesson are most interesting for your students. Then see what appeals to you. Rearrange it. Be adventuresome. Make your own lesson. We hope a lot of our stuff is appealing enough to steal.

OBTAINING MILKWEED COMA

The fluff of milkweed seeds is called cōma. The word comes from a Greek rootword, Kome, meaning hair, and here refers to the tuft of plant hairs at the end of the seed. The term coma would also apply to the fluff of other wind dispersed seeds such as dandelion and cattail.

Coma is also a word for unconsciousness, but this meaning derives from a different Greek root, Koma, meaning deep sleep.

The plural form of coma, referring to tufts of plant hair, is "comae." We have incorrectly used the plural form "comas" in this lesson, as we thought that this would be more intelligable to children. You may feel that it is important to use the proper plural form, and we leave it to your discretion to correct us when necessary.

Milkweed coma is by far the best for the activities we propose in the first part of this lesson, but other plant coma, down feathers, or even fluffed cotton or lint will work.

Milkweed coma is collected by breaking the milkweed seed pod from the plant, in late summer or fall, when it is almost ripe but not yet split open. Place each pod into a plastic bag so that when it dries and splits the seeds and comae will be contained. The bags of coma can be kept for years. One pod supplies more than enough comae for a class, as each child uses only one coma at a time.

Cattails can be gathered in the late fall or sometimes all winter. If they are gathered too early they will not ripen and fluff out.

Cottonwood trees supply coma tufted seeds in late spring and early summer. Dandelions bloom most profusely in spring and fall. Thistles may also provide usable coma.

ORIENTING ACTIVITIES

These orienting activities are designed to provide an immediate, fun activity, and to give a basic "feel" for how the wind behaves and how the milkweed seed parachutes, called cō'ma, behave in the wind.

Materials:

milkweed coma (see preceding page)

plastic bag

box

Activities:

--- Place milkweed pod inside of a large plastic bag.

--- Carefully remove five or six comas from the bag and break off the seed.

--- Place these comas in a medium size box, deep enough to keep them enclosed.

--- Select an individual to begin the activities.

--- Have this individual take a piece of coma from the box and release it.

--- Follow its movement until it settles.

--- Have the first individual remain with his coma to keep track of it.

--- Have a second individual follow the same procedure in a different part of the room.

--- All class members watch the action of the milkweed coma.

--- Notice similar or distinctive actions between first and second.

--- Have two or three individuals get a coma each and repeat the procedure — each individual remaining with his coma where it falls.

--- Remove enough coma from the box to accommodate the rest of the class.

Usually some wind pattern strong enough to move the comas exists in a school room. This may be detected by the students. If not, O.K., other things may be noted, e.g., movements of people cause breezes which move the comas. The one by one involvement of students in this coma activity will impress them that there is a purpose to watching the comas behavior. It will avoid a free for all of "large muscle" activity.

--- Have the members of the class come up in small groups to get their coma and follow it until it falls.

--- Each child will now mark the spot of the first fall.

--- Note any clustering of children.

--- Have a portion of the children (girls or boys, a reading group, those wearing red, etc.) get up, toss their coma into the air and follow on a second float through the room.

--- Repeat until all have had a second turn.

--- Note any directional trends.

--- Discuss — what is carrying the "down"?

Game Activities:

--- Divide the class into several teams.

--- Have one team go to one side of the room (i.e. north).

--- See how far each child can blow his coma in one minute.

--- Measure longest distance and record.

--- Have a second team go to another side of the room (i.e. west).

--- Repeat blowing contest in one minute.

--- Measure and record results.

--- Repeat until all teams have had a turn.

--- Determine winner and discuss influences in results — why did the winner win?

Some Problem Solving

Ask the class, "If you were given two or three pieces of coma what test could you or your group devise to supply the class with more information about the way coma behaves?"

The following suggestions may come from the group. If not, ask one of the group to initiate one or all of them.

--- Twist two comas together and test any differences in action with a single "down".

--- Twist three or more comas together and test any differences.

--- Permit a few children to follow their comas around, out of the room and down the halls to trace air currents.

A possible course of action follows:

Your planning may include some or all of the following activities:

--- One period of time for free examination.

--- One or probably more periods of time for controlled experiments. These experiments will come from the dialogue groups and will involve one group or the whole class.

--- As many sessions as is necessary to exhaust the suggestions and do any comparative experiments.

Planning Outside Activities

The idea of going outside to test air currents will probably come from the class. If not, do it anyhow. By this time each child should have had enough experience in handling the coma to be well aware of some of the techniques for keeping track of their coma. A planning session for the outside activities is essential to establish:

general rules

where to go

what to do in case of loss

free examination

controlled experimentation

etc.

Coma Races

When the children take their coma outside, they find that it floats much faster and farther than it does in the classroom. Our first objective will be to focus their attention on wind direction and wind speed.

I. Preliminary Activities
(Select a flat open area such as a baseball field.)

1. Establishing the starting line and finish line will be the first consideration of the children.

   a. Divide the class in groups of five children each and give each group two five foot lengths of string to mark the start and finish line.

   b. Each group chooses a spot and marks the start and finish line. One child can find the distance between start and finish by putting down the starting line; taking 50 steps, and putting the finish line down.

   c. Each group races their pieces of coma. Tell them this is a practice run. If the coma falls before the finish line they may throw it in the air.

   d. Have the groups rearrange their start and finish lines so their coma will float correctly in the race. They will have to consider wind direction to do this.

Discuss any problems they may have had during the race. Did their coma go the wrong way? Did their coma go the right direction? Did it end far to the right or left of the finish line? How might they place their start and finish lines so the coma will float fairly straight from start to finish?

II. Game Activities

A. Find the person with the fastest coma racer.

1. Select one child from each group (four children each) to be the finish line judge. The judge may later race against the winner, and one of the losers becomes the finish line judge.

2. The winner from each of the groups races in the championship race.

3. Championship race is held on one of the race tracks already set up.

B. Have a race with the entire class.

1. Keeping wind direction in mind, ask the class where the start and finish lines should be.

2. Set up a starting line long enough so the entire class can line up on it.

3. Have a child step off 150 steps and place the finish line there. Make the finish line only ten feet long.

4. Have the children race to the finish line. There is only one rule: the coma must cross directly over the finish line. (This will require that the children fight the wind by blowing the coma with their breath or throwing it in <u>another direction</u> when it drops to the ground.) This may make the class more aware of wind strength and direction.

Discuss how the coma race can best be won. What are the "facts" that must be known in order to win the race?

The next race will confront the children with up drafts, down drafts, and eddies created by the buildings, walls, and corners. Solving these problems will provide the class with a number of "facts" and questions about wind to add to the data sheets.

Discuss what facts must be learned to win this race. How can one predict how the wind will behave so as to carry the coma in the best direction to win the race?

C. Have the class race coma from a point on one side of the building to a point opposite it on the other side of the building. This means going around corners.

1. Make the finish line in the shape of a square about 10 feet across and place it close to the building wall.

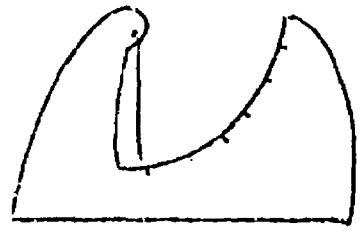
2. The winner must make his coma racer cross over or fall within this square. This should encourage the children to stay close to the school building.

Students may come up with other types of races or other areas to race in. The students may suggest that more information is needed to make better predictions about how to win a race, or better predictions about how the wind behaves. This is a good time to introduce a wind measuring device. Whether the students suggest it or not, go on to measuring.

Measuring Wind

Through the coma activities the children become aware of wind direction and wind speed. However, they probably found the coma an ineffective and unruly measure of wind direction and speed. The following activities will acquaint them with a measuring device, while introducing them to the notion that slow and fast wind may be caused by physical objects in the environment.

Start with the measuring device which uses a thread to detect air movement.



These measuring devices were designed to be functional, yet inexpensive, in the hope that children would be allowed to take them home when the lesson was over. We would therefore suggest that each child have each of the devices as his own. He should put his name on his own measuring device and be responsible for its construction and care.

WIND GAUGES

The wind gauges should be made from cardboard. The cardboard back from an 8-1/2 x 11 inch tablet of writing paper is ideal.

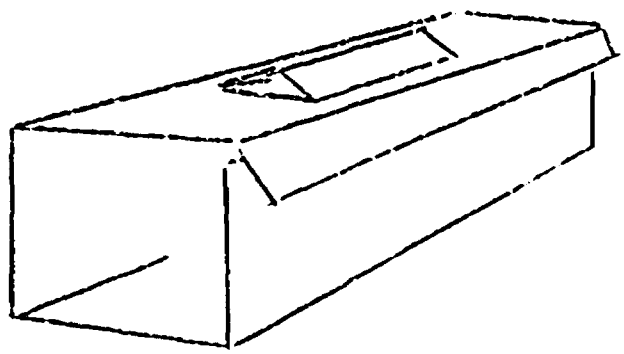
Trace the pattern of the gauge onto the cardboard. (For classroom use, duplicate a pattern for each student.) With a ruler and the point of a knife score all the lines which are marked "score". Scoring means to cut into the cardboard only a little way so that it will fold easily along the line of the score. The scoring cut should be on the outside of the fold. Note that two short scores are to be done on the reverse side.

Cut completely through the cardboard along the lines marked "cut". Tape the folded flaps where they are marked.

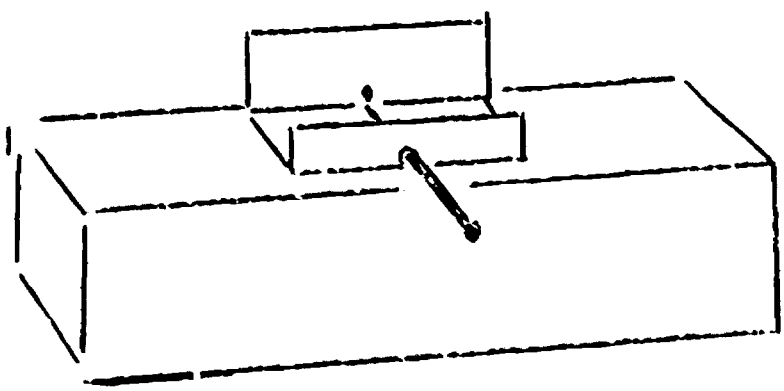
Assembly:

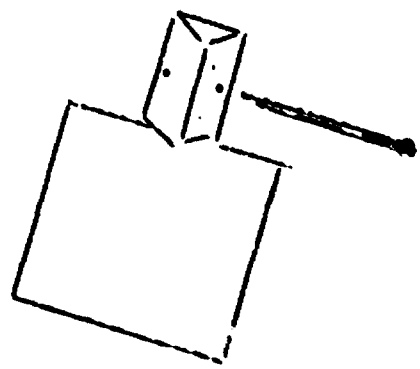
1. Tunnel wind gauge

Fold along scored lines to make a box with open ends. Tape the long side — flap down to the side of the box.

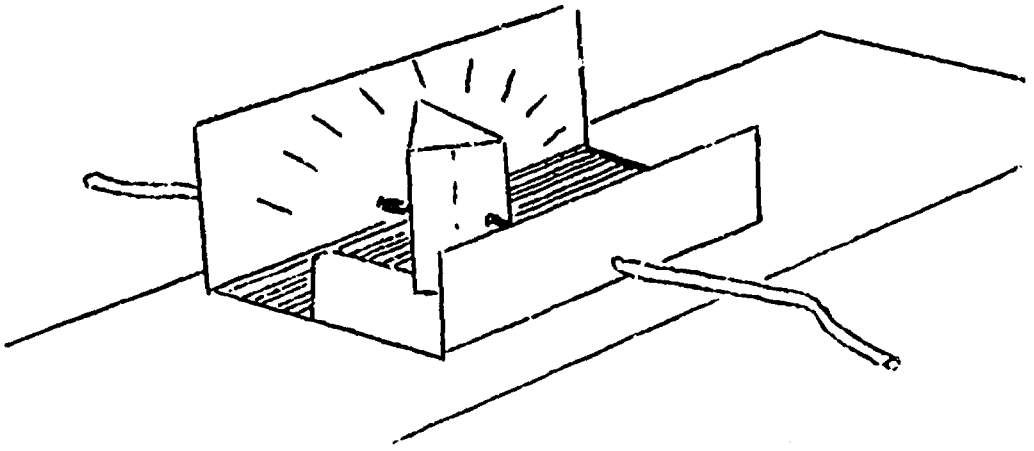


Open the small flaps so that they point up. Use a large pin or other sharp metal point to make holes at the dots. Also make holes at the dots on the handle of the wind vane after it has been folded and taped.





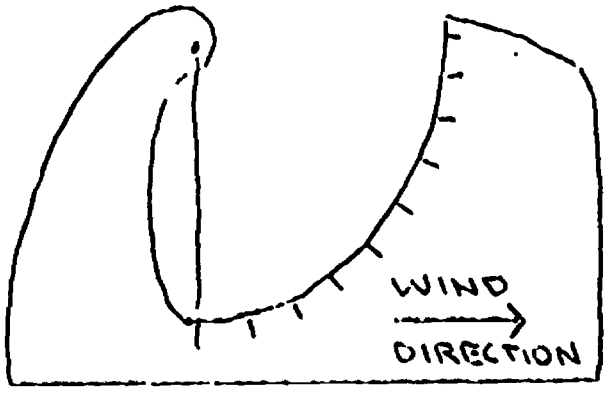
Put the wind vane inside the tunnel so that the handle points up through the hole. Shove a straightened paper clip or other wire through all four holes to support the vane. Marks can be made on the flap next to the handle of the vane to indicate wind speed when the tunnel is pointed at the wind.



2. Wind direction finder and speed indicator

Cut out of stiff cardboard. Make a small hole at the dot. Tie a thread through the hole. Cut the thread off so that it just reaches the inside of the curve of the indicator.

If the thread does not hang straight down (if it is curly) rub some light-weight oil into it (corn oil, mineral oil, or three-in-one lubricating oil).

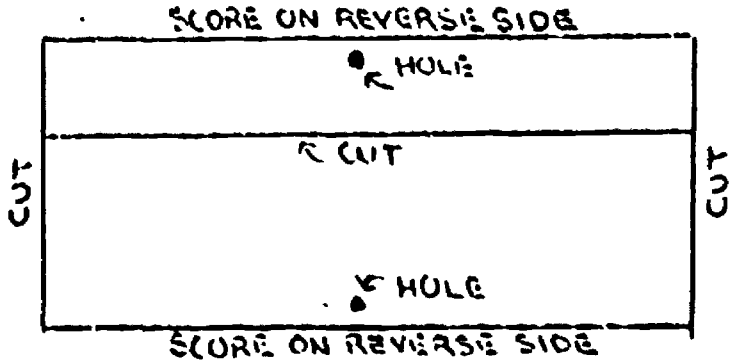


When the indicator is aimed into the wind, the thread blows back directly over the curve. How far the thread blows back is an indication of the wind speed. Mark equal divisions along the curve for easy reading. This device is more sensitive than the tunnel wind speed indicator and can be used for very slight breezes.

SCORE

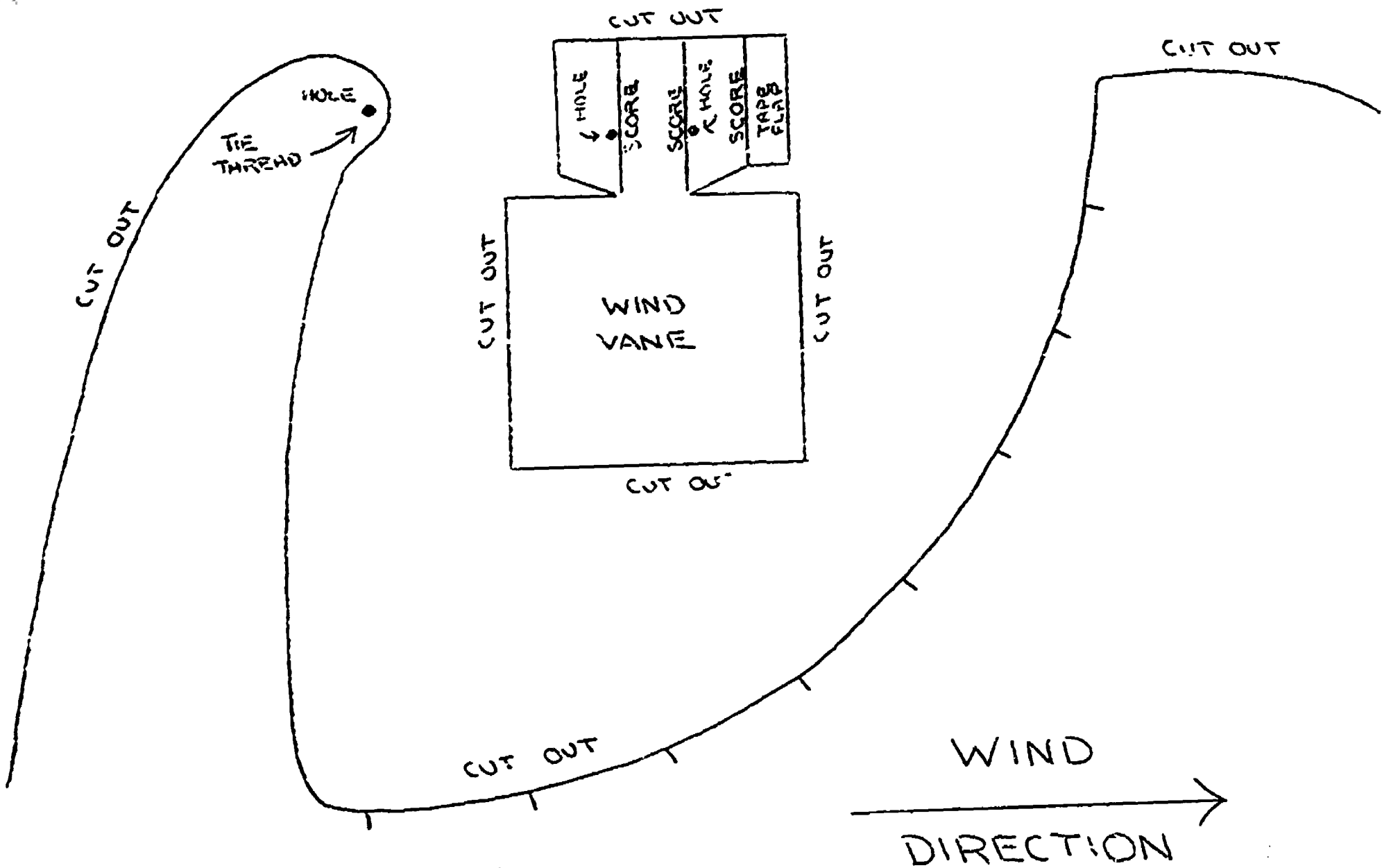
SCORE

SCORE



SCORE

TAPE FLAP


CUT OUT
HOLE
TIE THREAD
CUT OUT
CUT OUT
HOLE
SCORE
SCORE
HOLE
SCORE
TAPE FLAP
CUT OUT
WIND VANE
CUT OUT
CUT OUT
CUT OUT
WIND
DIRECTION

Calibrating the Measuring Devices

If comparative measurements are to be made with the variously made wind gauges built by the children, the gauges will have to be calibrated. Otherwise they will not read the same under similar conditions.

1. Use a fan to calibrate. A window fan, table fan, or the air vent of a ventilator can be used.
2. Mark off distances along the floor at one foot intervals -- starting at 30 near the fan and numbering down. This will give the strongest wind the highest reading.
3. Have the children place their measuring device at each interval, starting at least ten feet away from the fan, and mark a line and the interval number on the scale of their device.
4. The string gauge is supposed to be quite sensitive to slight breezes. If the tunnel gauge is too sensitive, the vane inside the tunnel can be weighted with a paper clip or two.

Making and Using the Measuring Devices

Wind-Speed Indicator, Direction Finder

1. Pass out flat cardboard wind indicator stencils, stand pieces, and thread.
2. Complete the construction according to the instructions on page 14. If the thread does not hang straight down, if it curls, rub some light-weight oil into it (corn oil, mineral oil, or three-in-one lubricating oil).

Reading this device

1. Point out all parts of the gauge.
2. Discuss each part's possible use and what it indicates.
3. Answer questions asked by the children.

Pre-Activities

1. Aim the indicator into the wind, the thread blows back directly over the curve. How far the thread blows back indicates the wind speed. This device can pick up very slight breezes. Practice reading the wind speed in the classroom with the door open or a window and door open.

2. Read the wind speed by noting which number the end of the string is pointing at. The string may flutter a bit, but make the best guess you can of the center of the flutter. The device must be level and upright for a correct reading to be made.

3. If you have a blower or fan in your room test the wind speed at several places around it.

4. Compare reading of all the children.

5. Discuss wind patterns in the room.

6. Measure the wind speed elsewhere inside the school building — record findings.

7. Hold the device directly into the wind so that the string falls or swings directly against the marked edge of the device.

8. Now you have determined the wind direction. The wind is coming from the direction you are pointing the device. It is going in the direction the string is fluttering.

Wind tunnel gauge construction

1. Pass out flat cardboard and wind tunnel patterns.

2. Discuss problems, answer questions children have.

3. Construct tunnel.

Reading the gauge

1. Point out parts of the gauge.

2. Discuss their possible use and what they indicate.

3. Answer children's questions.

Pre-Activities

1. Plan ways to test the reading of the device. (You could have them blow through the tunnel — who can blow the hardest?)

2. Measure air actively inside the building, by open door, in halls, etc.

3. Record these speeds.

4. Discuss any difference and causes.

Effects of Obstacles on Wind

Have the class take their devices outside to see if they can detect the wind. When you are sure all can use the instrument, ask them to work on the following problems:

1. Who can find the weakest measurable wind and where did you find it?

2. Who can find the strongest wind and where did you find it?

There probably will be more than one spot located for slowest and fastest wind. Each member of the class should see the locations of the slowest and fastest winds. Possibly each member could recheck the wind in these locations. You might divide the class and send one part to each location and then rotate the groups as they finish their measurement. What is the average speed in the two locations?

3. What direction was the wind moving toward at each place?

As yet, understanding wind direction may be vague as compass directions have not been considered in relation to the school site. This will be taken up somewhat intuitively, while considering mapping. If children have had no background on this, a lesson on mapping, scaling, and orientation may be in order.

To avoid confusion when making maps, we suggest that a term such as "south wind" not be used. Such a wind is moving north. So we would speak of its direction as north and would indicate it as an arrow pointing in the same direction as the air movement. The arrow on the wind measuring device points in the direction the air moves.

Discuss how the locations of the slowest winds were different from the locations of the fastest winds. If there was more than one location for the fastest wind, how are the locations similar? If there was more than one location for the slowest wind, how are the locations similar? Was wind direction always the same? Each group may now contribute to a class discussion. See if they can make two lists of opposing characteristics for fast and slow wind locations.

MAPPING WIND MEASUREMENTS

Draw a large map of your school and grounds on a large piece of paper at least 3 ft. x 3 ft. Include on the map all major landmarks such as the building, swing sets, etc. It's not necessary that the map be very accurate.

I. Preparation Activities

Display a map of the school grounds in the room. Divide the class into teams of two children each. Give each team several sticks or tongue depressors, 6" squares of colored construction paper, and a smaller dittoed copy of the wall map. Put an "x" on the wall map in the middle of an open location such as a baseball field. This is where the class will begin their wind direction study.

II. Outdoor Activities

A. Have each team determine wind direction around the location marked with an "x". They can record this on their small map using an arrow to show the direction that the wind is going.

B. Each team should now locate spots where the wind direction is the same as the direction at "x" and spots where the wind direction is different from the direction at "x". Each time they find a spot they should record it on their map using arrows to show what direction the wind is going. (Distortion of area will occur.) If it is near some landmark which is not sketched on their map they should sketch this in. To mark each location so they can return to it they could put a square of construction paper on the ground and anchor it by pushing a tongue depressor through it and into the ground.

III. Interpreting Data

A. Return to the classroom and have the teams transfer their information from small map to the large class map using a piece of colored chalk. Number the locations on the wall map and individual maps.

B. Send a team out to place numerals on the tongue depressors or paper to correspond to the wall map.

C. Have each team return their own to its location for the next day's activities.

Divide the class into discussion groups of four people each. Split up team members so they are in different groups. Have them consider their results by examining each member's small maps for:

1. Number of times they found wind direction similar to that at point "x".
2. Number of times they found wind direction different from the direction at point "x". (Were there any locations where the wind was in an opposite direction from point "x"?)
3. Can they find any similarities between areas where the wind was going in the same direction?
4. What possible conclusions can they draw from this data?

Each group may now contribute to a class discussion. Refer to the class wall map during this. What do they think is the "general" wind direction? Why do all these other wind directions occur?

<u>Comparing data between two days</u>

1. Have the class repeat the same procedure the next day by checking the wind at "x" and returning to their test spots (marked with construction paper and tongue depressors).
2. On a new small map they again show wind direction at these locations. Using another color of chalk this information is transferred to the large class map.

3. Have the class discuss how the wind directions are the same as yesterday and how they are different. Is it blowing in the same "general" direction as yesterday?

4. If conditions vary, continue to run the tests for the next two days and discuss the results.

INDIVIDUAL INVESTIGATIONS

Pages giving complete directions on how to perform the activities and how to present the resulting data, are included at the back of this booklet. Duplicate the activities and give the child a copy to take home. Several children may choose one investigation, but they should conduct the experiments independently. Children who complete their activity early may choose another.

Most activities are designed for out-of-class or after school. The children might best view these activities as "science projects" or "investigations." These activities serve two main functions:

1. They provide an opportunity for the children to practice the several techniques which have been presented to them (measuring, mapping, etc.).

2. They put these techniques into a sequence that provides the child with recorded information. Then the child is asked to make a decision which gives him an answer to his investigation. The answer does not need to be definitive, in fact the more insightful the student, the less definitively he may see his results. The main objective is that the child be able to follow through with an investigation and have some idea of what he has done and what it might mean to him.

Have each child select one of the following activities that appeals to him:

1. Map the wind direction around the corner or end of a board fence.

2. Map wind speed as the wind goes up one side and down the other.

3. Map the wind speed and the wind direction all the way around a running fan

4. Map the wind speed and direction around your house.

5. Measure wind speed by timing how long it takes milkweed coma to travel a measured distance.

6. Measure wind speed on both sides of a window screen that has been taken off a house.

7. Measure and record wind speed in locations where there is a different growth of plants.

8. Map the wind speed and direction around an air register or air conditioner in your house.

9. Trace and map the air currents in a room with milkweed coma.

10. Use a paper helix to detect up and down air currents in a room.

11. How many ways can a child move a milkweed coma without touching it with fingers, pencil, or any solid object.

12. Try to map the air currents in a one foot cube of space in a room by watching dust moats, floating in a sunbeam or in the beam from a slide projector.

13. Make a wind speed measuring device of your own.

14. Determine with your wind tunnel how fast the wind must blow to move a leaf, handkerchief, twig, etc.

15. To determine how far odors are carried on the air currents in the school, pop several containers of popcorn with the classroom door open. Map the results using time and distance measure.

Winds Beyond the Schoolyard

The children have been investigating winds on a small scale. Now they will attempt to relate what they learned in their schoolyard to the vast movements of air masses in our atmosphere. To make such a study they will have to avoid all the turbulences and eddies they have found around ground obstacles and study high above where the wind blows free and unobstructed.

Materials	Amount
heavy 9" balloons	2 per student
heavy 11" balloons	1 per student
postcards	1 per student
grocery or kite string	2 balls
helium cylinder	small "E" cylinder fills 40 balloons, $18.00 prox. large "E" cylinder fills 500 balloons, $30.00 prox.
plastic bags	

I. Preparation for balloon launch

1. Put a large map of the U.S. on a bulletin board and mark the location of your city on it.

2. Purchase helium cylinder to fill the balloons with. Provide each child with two 10" balloons and one 12" balloon, a six foot piece of string, baggie, and a postcard.

3. Get someone to help. This is a good project for one or several parents. Fill the balloons about a half hour before launch time. Tie each set of three balloons (two 10" and one 12") together and let it rise to the ceiling. The long string can be used to pull it back down with. Fill the 12" balloon so it is no larger than the 10" and tie the ends of the balloon (a balloon filler attachment may be purchased but it is not necessary). (The 12" balloon partially inflated will expand with the decreased air pressure as the balloon rises, and will be less likely to break than the fully inflated 10" balloons which are needed to get the whole device quickly off the ground.)

II. Preliminary balloon launch

1. Tell them they will now try to find out where the wind is blowing high above the schoolyard. Give each team of two children one helium filled balloon, and the map of the school grounds. Have each team locate a spot on the school grounds away from tall obstacles such as trees, telephone poles, wires, etc. At a signal such as the blowing of a whistle, each team releases their balloon and marks the direction it takes on their maps.

2. Discussion — identifying the problem, suggesting solutions, suggesting activities.

During this discussion the important point to be brought out is that all balloons disappeared in the same general direction, even though they may have first risen in different directions.

Raise the following question if the class has not already done so. "Does the wind continue in the same direction it was going when it passed over our schoolyard? How can we find out?"

If we chase the balloon, it might fly too high or too fast, or if we could find it after it landed we might be able to tell what direction the wind took after leaving the schoolyard. How might we accomplish this? Someone will probably suggest putting a note in the balloon asking the finder to contact them. Suggest postcards enclosed in plastic bags and suspended from the balloons. Have groups plan what should be included on the postcard. They should think of questions which would give them the most possible information about the wind. When each group has made a list of questions have them write it on the board. The class may then discuss these questions and decide as a whole what should be included on the card. (A sample card is included.)

The plan might be similar to the following:

<u>Information telling the finder about the class project</u>

1. Date and hour found (might give some idea of wind speed).

2. Direction of wind (the finder could determine this).

3. Where it was found _____.

4. Condition of the balloon _____.

5. Your name and address (a thank you note might be sent).

6. Any other comments _____.
   Return name and address

The children put their name and the school address as a return address on the cards. These are tied shut and attached securely to the three balloons about a foot down the cord. Cut off the remainder of the string. The class should release the balloons in an area without telephone poles, trees, or other objects in which the balloons might become hung up. Select a day that is clear and mild, if possible.

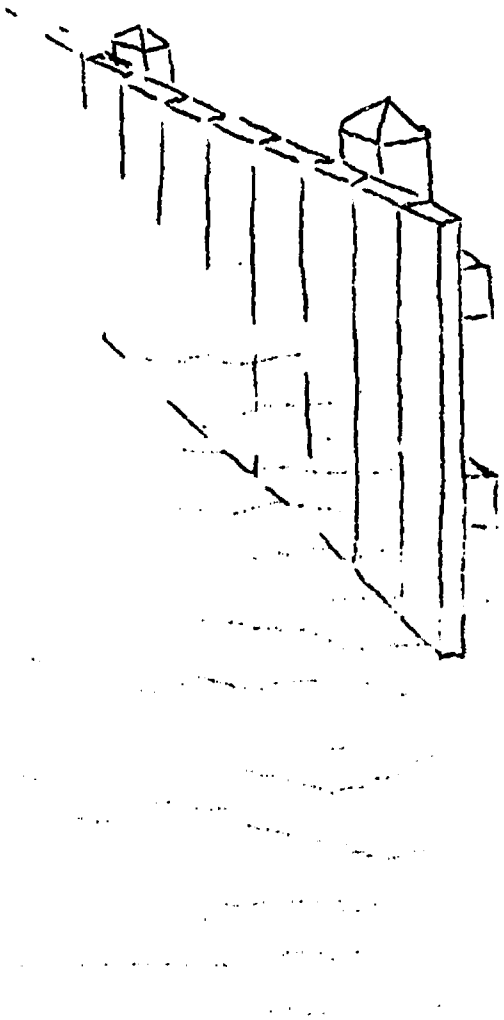
Watch the balloons until they are out of sight. Note the direction in which they leave. Return to class and mark this direction with an arrow on the map next to the mark designating your city.

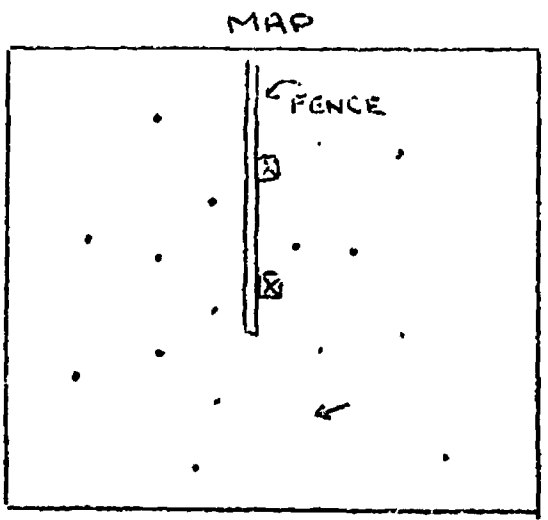
Have the children predict where they think the balloons might go. They could mark their prediction on the map using a common pin and a small name tag. What did the children base their predictions on?

Of course, not all of the cards will be returned. Have the class consider the many things which might happen to them. But if a dozen cards are launched at least two or three should come back. As the cards return mark the spots they were returned from on the map. Use pins and name tags the same as the prediction tags but make these name tags out of a bright color so they can be differentiated from the prediction tags.

When two weeks have elapsed have the class discuss the results. How close were their predictions? Did the balloons change from the direction they started out? What are some possible reasons they came down? Did all the returned cards come from the same general direction?

1. Map the wind direction around the corner or end of a wall or board fence. Make a map which shows what the fence would look like from above.



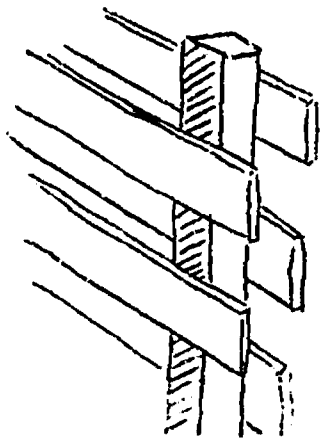


(USE GRAPH PAPER)

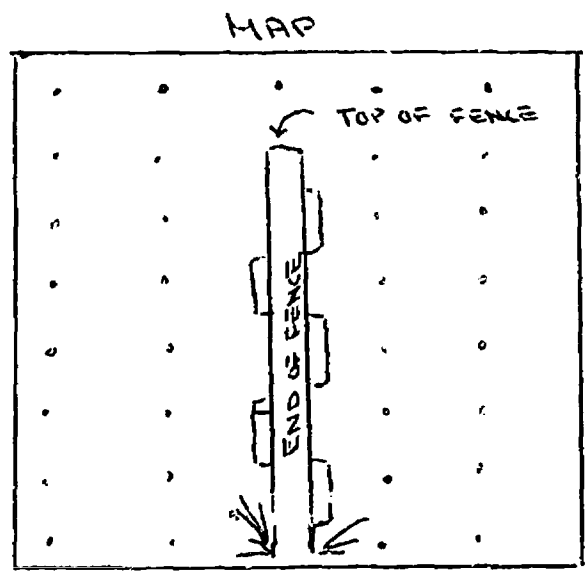
Make wind direction measurements at many places around the fence. Measure the distance from the fence to the place where you take the wind measurement. Put a dot on your map to show where you took your wind measurement. Draw an arrow through the dot showing wind direction.

After making many measurements and recording them with arrows on the map, see if you can come to some conclusions about wind directions around the end of fences or walls.

2. Map wind speed as the wind goes up one side of a board fence and down the other. Make a map of what the fence would look like from the end.



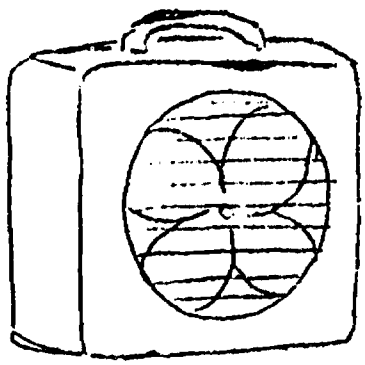
ANY KIND OF FENCE THAT BREAKS THE WIND WILL DO

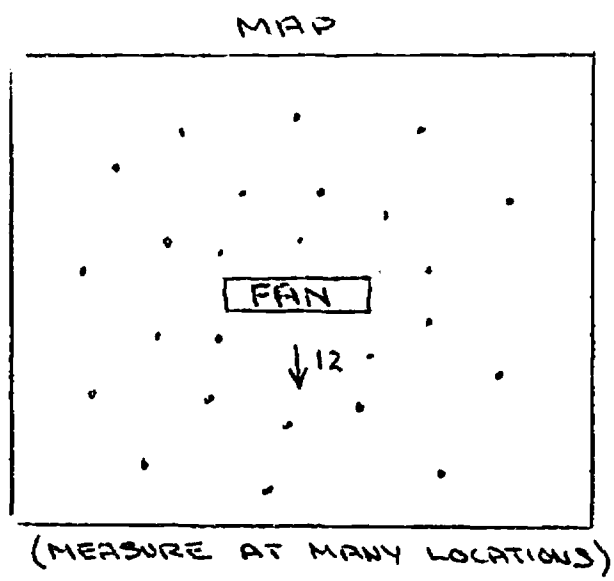


(MEASURE AT THE DOT LOCATIONS)

Make your windspeed measurements away from the end of the fence, somewhere in the middle and in a place away from bushes and trees. Use a wind <u>direction</u> indicator so that the wind <u>speed</u> indicator can be aimed in the proper direction. Measure windspeed both up and down the fence and at several distances from the fence. Measure the distance from the fence and from the ground where you make your wind measurements. Put dots and windspeed on the map to show where you made each measurement. Can you decide anything about how the wind behaves when blowing past a fence by looking at the information recorded on your map?

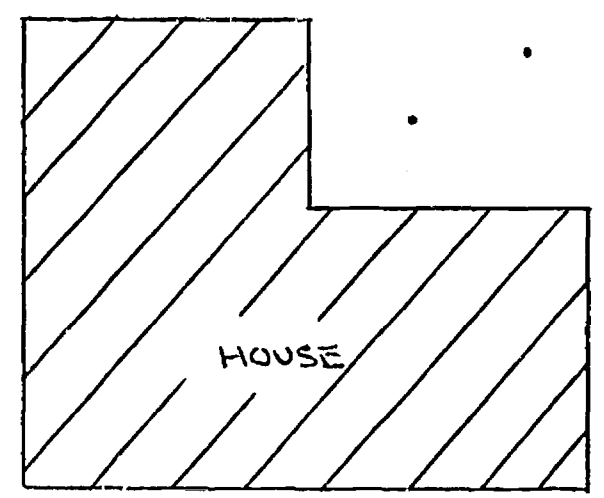
3. Map the windspeed and the wind direction all the way around a running fan.





Draw a map of what the fan would look like from the top. Measure windspeed and wind direction in all directions from the fan. Measure the <u>distance</u> from the fan where each wind direction and windspeed is made. Put a small arrow on the map to show the wind direction at each place you took a measurement. Write in the windspeed by each arrow. Can you come to some conclusions about how the air behaves around a fan by looking at the information recorded on your map?

4. Map the windspeed and direction around your house. Make a map of the air movement around your house on one particular day. Draw an outline of your house with space around it to record information about the wind.



(MEASURE AT MANY LOCATIONS)

Make wind direction and windspeed measurements in many places all around your house. Measure the distance from the house to the place you make each wind measurement so that you can mark a dot and measurement readings in the proper location on your map. Draw arrows at each dot to show wind direction and write numerals to show windspeed. After making wind measurements and recording them, can you make some conclusions about how the wind behaved around your house on the day you measured it?

5. Measure windspeed by timing how long it takes milkweed coma to travel a measured distance. Get a piece of string or clothesline 20 feet long. Tie a piece of cloth exactly at the middle or ten feet from the ends.

In an open place, measure the wind direction. String out the measuring line in the direction the wind is blowing.

Use a clock or watch with a second hand for timing. Or you can also count out loud MISSISSIPPI-ONE, MISSISSIPPI-TWO, etc., as fast as you can to count seconds. It works best if you get a friend to help. You time after he lets the coma go.

Have your friend stand at the up wind end of the measuring line and you stand at the down wind end. You say, "Ready, get set, go, MISSISSIPPI-ONE, MISSISSIPPI-TWO", etc., until the down gets to you.

Record five windspeed measurements at a time each afternoon for one week. Compare your results with the weather report.

How many feet did your down travel in how many seconds?

If the wind is not strong enough to carry the down 20 feet what can you do for a measurement?

Are all five measurements for one day the same? Why might they differ?

If someone asked you what the windspeed was on one day what would you tell him?

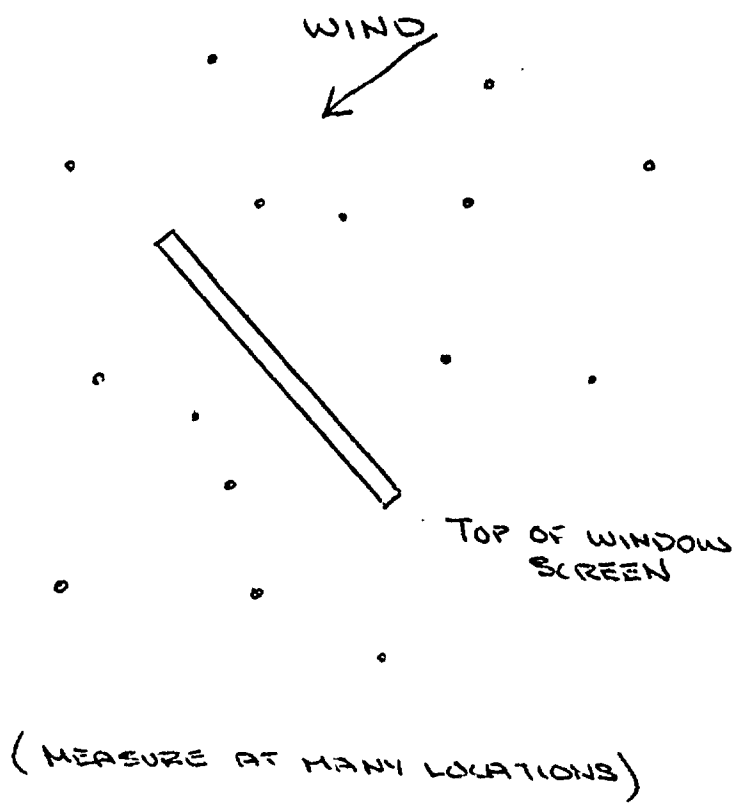
Can you make a chart of the windspeed for the whole week?

6. Measure windspeed on both sides of a window screen which has been taken off of a house.

Set the screen across the direction of the wind in an open space. Prop up the screen with a long stick or have a friend hold it up for you.

Measure the windspeed in several places all around the screen. Is there any difference in windspeeds. Where is the least windspeed.

Make a map of the windspeeds around the screen.



Measure how far away each measurement is taken from the screen so that you can write it in the proper place on your maps.

Does the screen have any effect on the wind's speed?

Try other kinds of material to measure their effect on windspeed.

7. Measure windspeed in locations where there is a different growth of plants. Measure windspeed:

   1. On an open area like a playground.
   2. In the middle of some bushes that are away from buildings.
   3. Under some trees.
   4. In the middle of a big bunch of weeds.
   5. Some other places you choose.

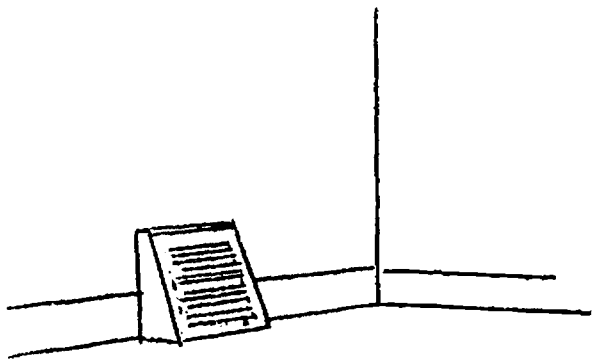
   All on the same afternoon.

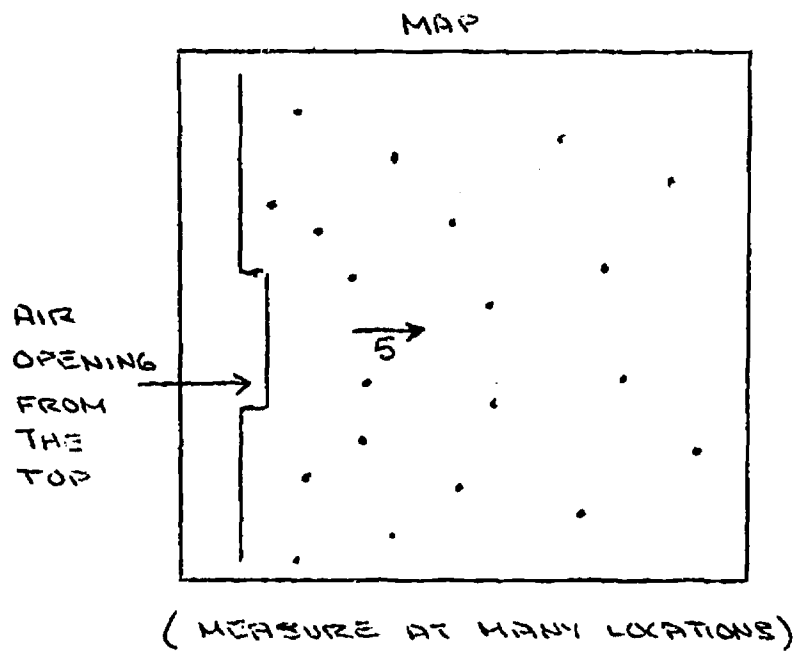
   Make a record of your measurements. Measure windspeed in these same places on five different days. And keep a record.

   Can you make a chart of your information?

   What conclusions can you make about the wind's behavior from the information you have collected?

8. Map the windspeed and direction around an air register or air conditioner in your house. (Same directions as around a fan.)

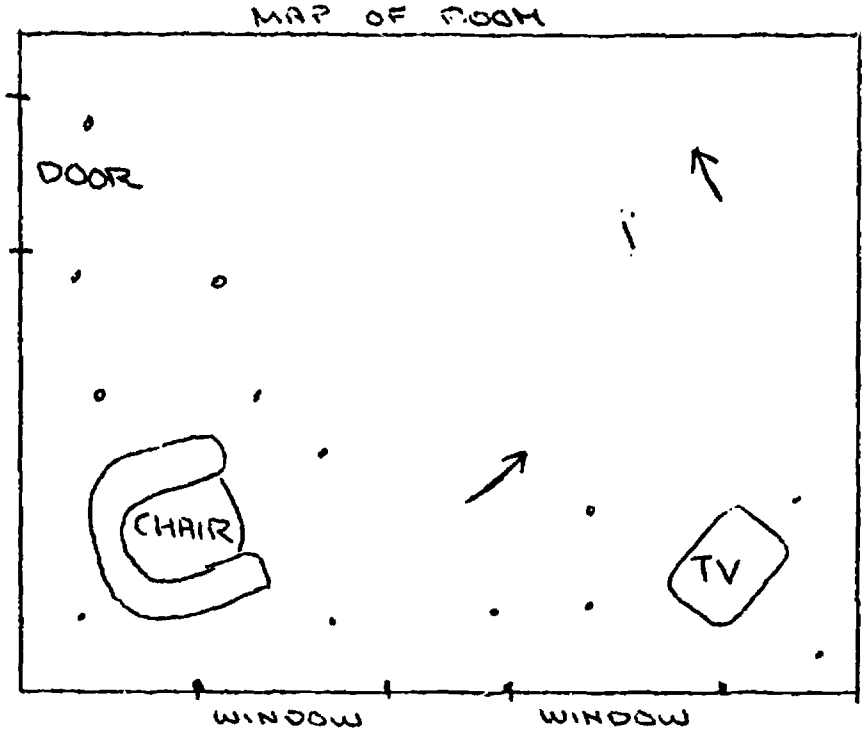




Measure the distance from the air opening where each wind direction and windspeed reading is made. Put a small arrow on the map to show the wind direction at each place you took a reading. Write in the windspeed by each arrow.

Can you come to some conclusion about how the air behaves around an air opening by looking at the information recorded on your map?

9. Trace the air currents in a room with milkweed coma. Make a map of the room and show how the air moves with arrows. In the map show the size and location of large or important items. An important item would be something which your measurements show affects the movement of the air.



(MEASURE AT MANY LOCATIONS)

If the air in the room does not seem to move in any place, what could you do to cause the air to move? Can you keep the air moving so that you can map its movement?

After you have mapped air movement in the room, can you make any conclusions about how the air behaves in this room?

10. Use a paper helix to detect up and down air currents in a room. Cut out the helix pattern which is on a separate page. Study the helix and how it works to discover which way it turns when the air is moving up and which way it turns when the air is moving down. Knot a three foot thread and string it through the center of the helix. The thread which holds the helix must be kept long and must be taped to the ceiling or some object for the helix to work right. The helix is very sensitive to air movement. It will be jiggled too much if it is held by hand. Also, it takes a few minutes to adjust to the new conditions each time it is moved.

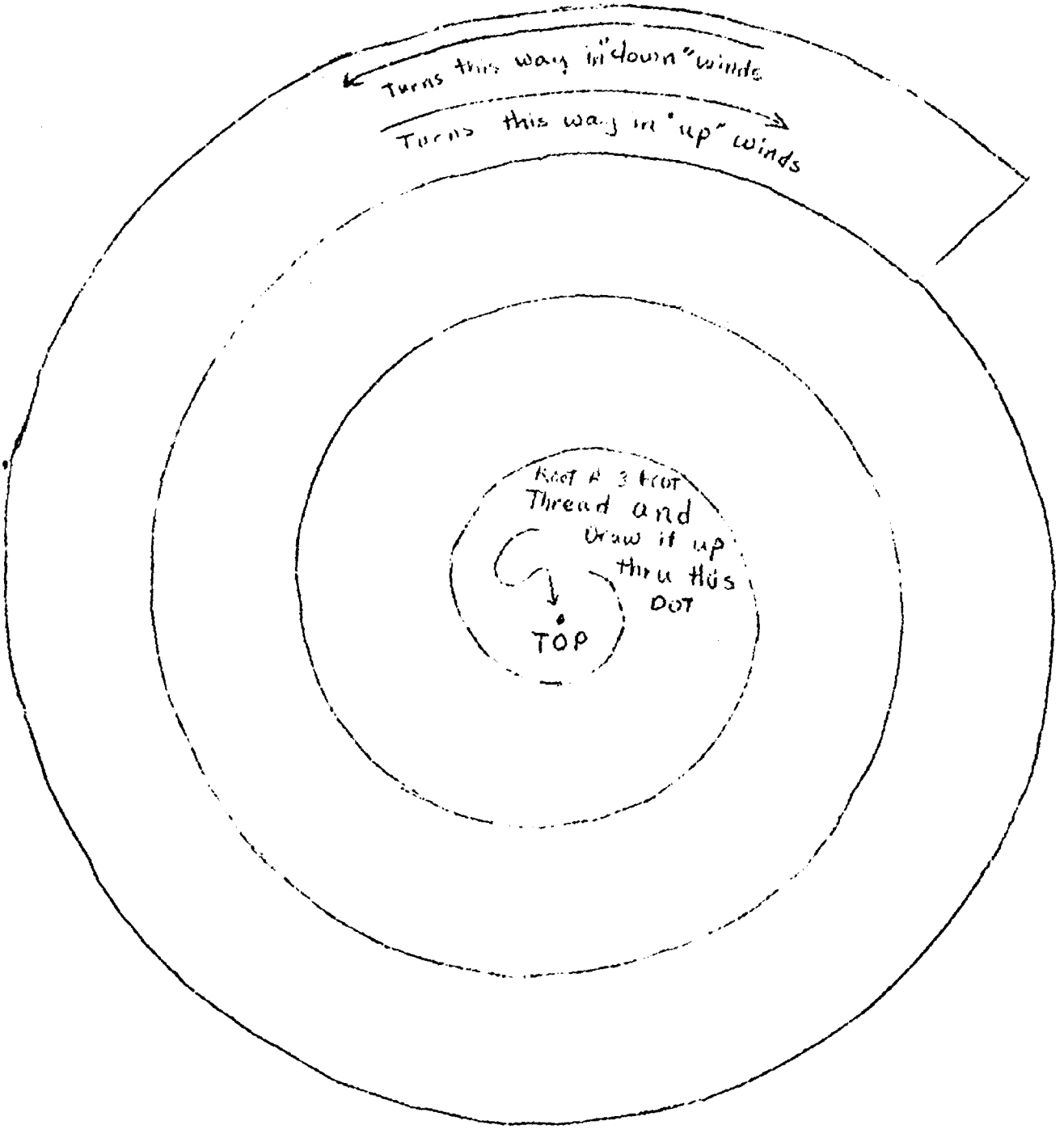
New thread is tightly twisted and will untwist causing the helix to turn. To prevent this from happening run the thread through your fingers and against your thumb-nail several times. This will untwist the thread before you start.

You have to be very slow and patient to take measurements with this device. Make a map of up and down currents in the room. Make an "x" for the location of down currents and an "o" for the location of up currents After you have collected information on your map, can you make any conclusions about the up and down behavior of air?

Can you predict what conditions make "up" air currents?

Test out your predictions. Can you make "up" air currents? How many ways can you make "up" air currents? Can <u>you</u> make any conclusions about what can cause air to move up on the basis of your experiments?

What might cause "down" air currents?


Turns this way in "down" winds
Turns this way in "up" winds
Knot # 3 Knot
Thread and
Draw it up
thru this
DOT
TOP

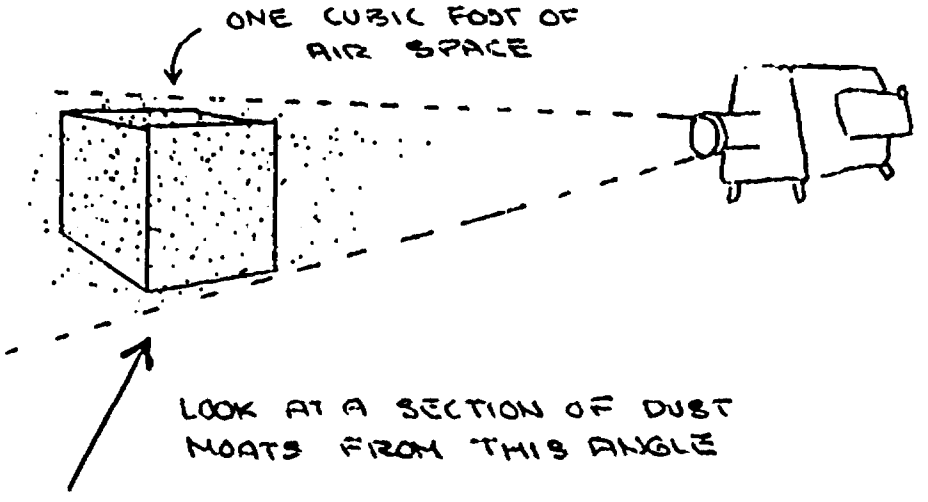
11. How many ways can you move a milkweed coma without touching it with your finger, pencil, or any other solid objects?

Keep a written record of the different ways.

Can you classify the ways that the coma can be moved?

Can you conclude anything about air movement from the information you have collected and organized?

12. Try to map the air currents in a one foot cube of space in a room by watching dust moats floating in a sunbeam or in the beam from a slide projector.



The dust moats can be seen best by looking at an angle toward the light source with a dark wall in the background. Turn down the lights in the room.

If you can't find enough dust in the air, sprinkle a little talcum powder on a piece of paper and then blow the powder off the paper into the beam, or hit two chalk erasers together. Wait until the strong air currents from your breath or movement die down before trying to trace smaller air currents.

Another way to make dust moats is to rub two pieces of cloth together very briskly in the beam of light. Tiny pieces of lint rub off the cloth. Also, a larger piece of cloth or a towel can be shaken violently to produce dust.

How would you map these air currents? What can you observe that can be recorded? Can you conclude anything about air movement from the records you have made?

13. Make a windspeed measuring device of your own. Test it. Compare it with the windspeed measuring device from class. How can yours be made to give the same reading as the one from class?

14. Determine with your two wind measuring devices how fast the wind must blow to move a

coma

leaf

handkerchief

twig

small rock

many other things you choose

This will extend over several days of different wind conditions. You may have to make measurements on several different days to get all the different wind speeds you need.

15. To determine how far odors are carried on the air currents in the school, pop several containers of popcorn with the classroom door open. Ask your teacher how to get started.

You may select any one or all of the following suggestions to determine how far the pleasing odor travels.

Post classmates down the hall and have them indicate by noting the time or telling you exactly when they detected the odor. If you are going to measure accurately you will have to be completely ready with helpers in place before you start popping the corn. Note the exact time when you begin, as well as the times when the odor is detected.

Arrange with other teachers to have them inform you when this pleasing odor reaches their rooms. You will want to reward them by giving each class, that wishes to cooperate in this test, a large bowl of popcorn, enough for everyone in each room. Be sure you arrange this carefully with other teachers.

Record your findings in time and distance measurement.

Map the air currents in the building, down halls, into rooms. Indicate the time it took the odor to travel.