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ABSTRACT

Two of these three pamphlets describe methods of teaching young elementary school children the principles of sampling. Tiles of five colors are added to a tub and children sample these randomly; using the tiles as units for a graph, they draw a representation of the population. Pooling results leads to a more reliable sample. Practice is given in estimating population sizes by a capture-mark-release-recapture technique, first using colored beans, then with marked mealworms. The variation in estimates caused by sampling is indicated. The third pamphlet, for use with children in grades 4-6, depends upon some knowledge of sampling techniques. Its purpose is to introduce children to some possible explanations of biological diversity. Children study themselves and collect data on tongue-rolling ability, estimating its frequency in the population. Then a continuous variable--weight or length of seeds--is studied. Heredity patterns are developed and the idea of selection introduced. Practice in using histograms to record data is included. Each pamphlet contains background information and suggested teaching techniques. This work was prepared under an ESEA Title III contract. (AL)

POPULATION VARIATION

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Contents

Preface

This unit is an outgrowth of the combined efforts of the Environmental Science Center Staff and is an example of <u>but one</u> type of product to be developed within the curriculum operation of the Center. I's present form is preliminary and subject to further revision as a result of trials with children. It is hoped that those who teach it will offer comments and criticisms useful in its further refinement.

The unit materials are grouped into two categories denoted by the use of colored paper. The green section contains background information for the teacher, the white section is a teacher's guide to be used with children. In the future when a substantial sequence of units is developed, the Schematic Representation of Some Ecosystem Factors, found in the green section, will serve to place that sequence in proper perspective relative to a larger body of knowledge.

Introduction: TEACHING THE UNIT

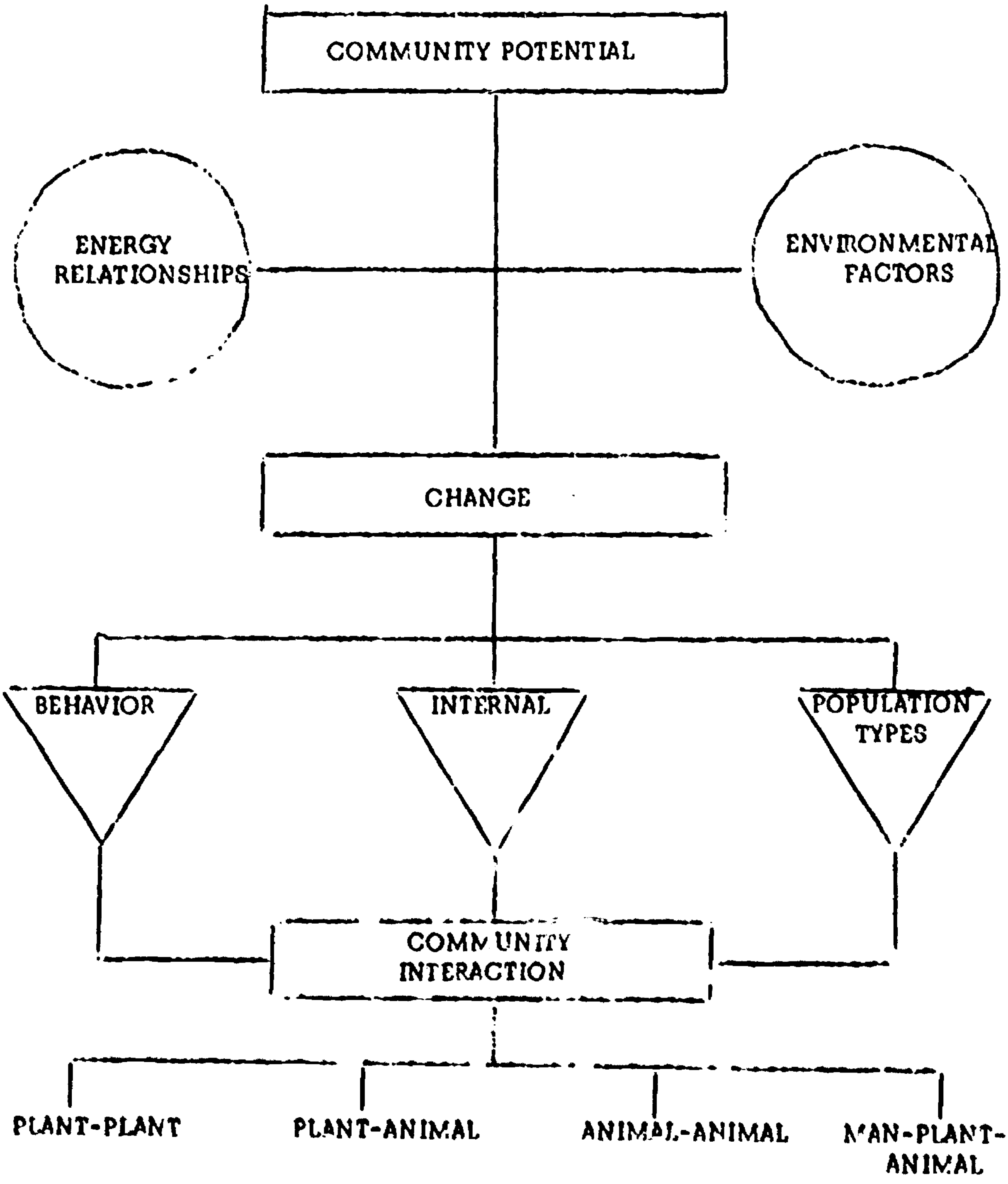
Population Variation is a unit of study designed to introduce children to some possible explanations of biological diversity. The children should be encouraged to develop their own explanations as a result of the activities they will experience in the course of the unit. Your role should be to guide their reasoning when necessary and to provide for a classroom climate within which the children are free to speculate. Speculation is given major emphasis in the unit because many of the questions with which the children deal have no answers satisfactory to all people in the scientific community.

In Lessons I, II, and III, the children will study themselves and their peers as they collect data on a single population variable — tongue-rolling ability. Lessons IV and V deal with variation in the physical properties of several seed populations. The interrelatedness of unit activities is revealed in Lesson VI as the children begin to generalize about their previous experiences. It would probably be best to permit the children to arrive at their own conclusions at their own pace, rather than attempt to tie the many ideas together with a summary statement. A final opportunity for speculation is provided by the story "Johannson and the Bean Seeds." Although written in a light tone, the story is intended to offer real data for discussion in an understandable context.

Population Variation has been written for grades four through six. Your experience in teaching other material to children of those ages will serve as a guide for pacing this unit. You might think in terms of spending a minimum of three weeks to cover the material. Since the amount of time spent in science varies from school to school, a three weeks minimum estimate is based upon an average time of ninety minutes per week. Schedules notwithstanding, the most important determinant of planning time is your insight and knowledge of the children's learning pace and capacity.

Although Population Variation is a science unit, you will find that many of the activities relate to problems in social studies, while others would be appropriate for use in a mathematics curriculum. The intent of the Environmental Science Center is to develop materials with cross-discipline application. It is recognized that the lines often drawn between the various areas of a school program are usually for purposes of expediency and are, therefore, arbitrary. A teacher can do much to erase these lines by indicating to children the overlapping areas of concern among the disciplines. As you read through this unit try to envision some cross-curriculum applications of the activities, and note where it might be appropriate to point these out to the children.

SCHEMATIC REPRESENTATION OF SOME ECOSYSTEM FACTORS



BACKGROUND INFORMATION

Think of the children in your class. Each one of them is different from every other one. They have different personalities, they vary in intelligence, and they present physical traits distributed over a wide range of values. It probably does not make sense to speak of a typical child. But it does make sense, you will agree, to speak of a typical group of children.

This possibility raises an interesting question: How does one describe a group of dissimilar individuals? Scientists have been concerned with this question for a long time, because no two specimens they find and no two measurements they make are completely alike. The scientist says they exhibit variation. Of course, if the differences are very small, such as among grains of rice in a bowl, it is easy to ignore the differences altogether and to pretend that the grains are really alike. To the children in your class, however, you will not want to apply this technique; and even small differences can be examined closely. The variation that is found may reveal unsuspected information if studied carefully.

When one selects a group of dissimilar individuals for study, one usually has in mind some ways in which they are alike. All the pupils in your class are at the same grade level, and all the grains in the bowl are rice. Once this is recognized, one can turn to the differences, the traits which show variation. Here the description is extremely simple. If the children's height is of interest, just give the height measurement of each one; if the weight of the grains of rice is of interest, give the weight of each one. In other words, to describe one trait of a group, just give the measure or other characterizations of that trait for each individual in the group. Since the group consists of individuals, the description of the group is just the description of all the individuals in it.

That is a lot of information! Here for instance is a table of data for a first grade class:

	Sex	No. Children in Family	Height (inches)	Weight (pounds)	Birth (month)
John	M	2	46	48	April
Mary F.	F	1	40	41	June
James	M	3	45	46	October
Richard	M	2	44	48	June
Joan	F	2	41	40	March
Alice	F	1	51	54	August
Frances	F	3	46	49	February
Kevin	M	6	47	42	March
Tom S.	M	2	49	47	October
Linda	F	1	42	40	April

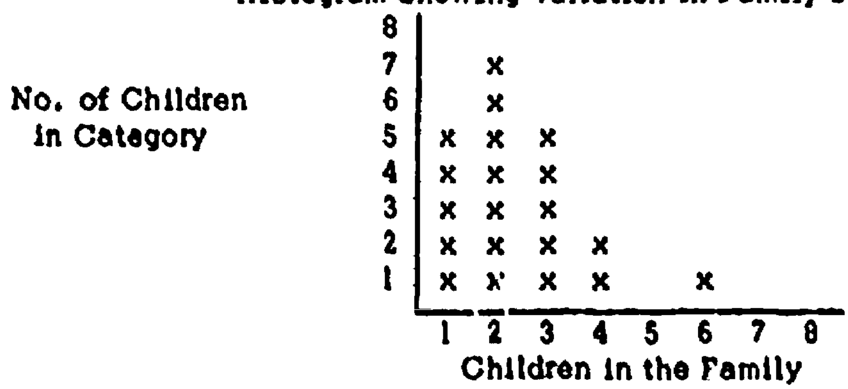
Continued:

Barbara	F	4	42	46	January
Ruth	F	3	50	53	July
David	M	1	41	41	February
Mary P.	F	2	50	51	April
Tom A.	M	2	46	48	December
Robert	M	3	43	45	April
Michael	M	1	47	46	March
Martha	F	3	46	45	March
Peter	M	4	52	51	January
Betsy	F	2	46	53	October

Is this class "typical"? Does it show variation typical of a first grade class?

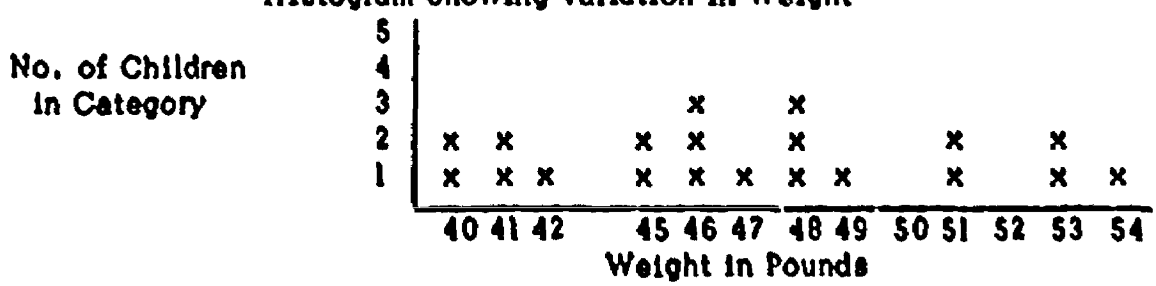
Let us look first at the sex of the children. There are ten boys and ten girls. That would seem "typical." Under family size, there are five single children, seven are from families with two children, five are from families with three, two are from families with four, and one is from a family with six children. To find whether this distribution is typical, one has to consult census data for a larger population. Note, however, that in making these summaries we have just counted the children in each category; we have disregarded the names of the children and all their other characteristics. This is the simplest kind of analysis. The results can be displayed in graphs in which a cross has been drawn for each child. Such a graph is called a histogram.

Histogram Showing Variation in Family Size



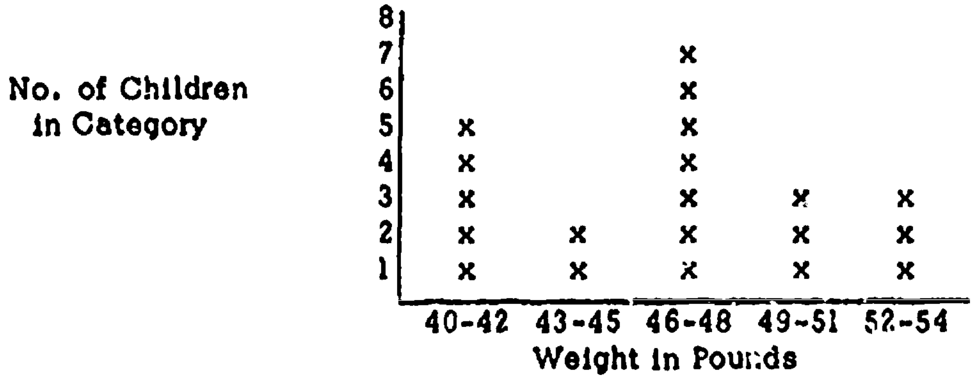
The height and weight data can be treated in the same way, as shown in one example.

Histogram Showing Variation in Weight



This graph does not give such a good picture, however, because the weights of the children are spread around so much. It is helpful in such a case to choose for one category the weight values in a range of several pounds, i.e., 43-45 pounds. Then the graph looks more interesting. For this sample the results cluster in the intervals from 40-42 pounds and 46-48 pounds.

Histogram Showing Variation in Weight



Let us return to the scientist's interest in variation. Charles Darwin's study of variation in plants and animals led him to propose the mechanism of natural selection to account for the evolution and origin of species. The variation of characteristics of one kind of animal living in a particular environment will allow for the existence of some individuals able to survive better and reproduce more than other individuals. The others, however, may be more effectively adapted to life in an environment different from the first. (Think, for example, of the variation in height among college students and the contrast in appearance of the "typical" student and the "typical" basketball player.) If now there is an environmental or other change that alters conditions to make them similar to the second environment, then the composition of the population will change. In succeeding generations, more and more of the animals will exhibit the traits which became advantageous. Eventually the "typical" member of the species may be quite different from the "typical" member of the species before the environmental change. One can say, therefore, that variation is the "raw material" of evolution — the selection process operates on a population of differing organisms. Variation is a most significant property of populations.

The above background has been lifted from the Teacher's Manual for VARIATION AND MEASUREMENT. Science Curriculum Improvement Study, University of California, Berkeley, California. Copyright 1964.

MATERIALS LIST

Item	Source	Quantity
Grid paper, 1/4 millimeter square	School	90 sheets
Pan balances	School, high school	3 or more
Centimeter rulers	School	1 per student
Field corn	Seed house	1 pound
Great Northern beans, number one and two grade	Grocery	1 pound each
Lima beans	Grocery	2 pounds
Pinto beans	Grocery	1 pound
Red kidney beans	Grocery	1 pound
Dried peas, unsplit	Grocery	1 pound
Paper sacks	School, home	1 dozen

Lesson I

Investigation: VARIABILITY IN PHYSICAL CHARACTERISTICS

Introduction to the Activities

Lesson I begins with the examination of several variable physical traits. Students will study themselves and collect data for each individual in the class. They will become aware of some of the physical variability which exists among the class members. Of course, this variability is obvious to you and probably to the students although they may never have discussed it in a formal sense. The major idea for the students to grasp is simply that no one has precisely the same characteristics as anyone else. This concept is applicable to every species of living things — man, dog, amoeba, rose, or oak tree.

When the students have completed their discussion of varying physical traits, a single characteristic will be investigated. Here they will focus upon a trait whose mechanism of inheritance is less complex than those previously examined. The appearance of this trait is determined by the presence of a single dominant gene rather than by many genes.

Chosen for study is the characteristic of tongue rolling. Students will find they are either capable or incapable of doing it. There is no intermediate ability, and it cannot be learned through practice. Physical characteristics lacking in measurable intermediate values seem to be the exception rather than the rule in terms of biological variation. As such, they are essentially insignificant with respect to evolution and the development of new species. Thus, the reason for devoting time to a study of one of these traits is simply to provide contrast. The significance of this contrast will be further developed in Lessons IV and V. Variability in the physical properties of seeds will be compared to variability in tongue rolling.

When each child has determined whether or not he can roll his tongue, the class will make plans to survey its occurrence among all the students in the school. The survey will provide them with additional data more representative of the population. Lesson II will be concerned with the survey, the techniques involved, and the significance of the data gathered.

It is advisable for the children to keep records of the information collected in Parts 1 and 2. Encourage them to make notebooks and enter all data in them. Record keeping is as much a part of the process of science as is experimentation or measurement. Accuracy is also important. *If information is recorded correctly fewer arguments result when it is discussed.* Talk with the children about these ideas. It is important that they perceive record keeping not as a choice, but as a very significant part of science activities.

Procedure

Part 1. Variation Among Class Members

Begin the lesson by asking the children in the class to describe themselves as a group. Perhaps they have played the game "I'm thinking of someone (or something.)" The object of the game, as you know, is to guess who or what someone has in mind by describing the physical characteristics of a person or an object visible to both.

Describing a group is a similar activity but the description must be sufficiently general to include each individual in the group. This is not an easy task since for each characteristic chosen there must be a range of values presented rather than a single value. Thus, if the class described height, each individual's height must be given because a description of a group must be the description of all the individuals in it.

With these ideas in mind, permit the children to begin their group description. Restrict the descriptions to observable physical characteristics avoiding, for example, intelligence or personality. Height, weight, shoe size, hair color and texture, and eye color are some of the traits which can be described. Not everyone will agree about eye and hair color, but agreement is not that important here.

The class may construct a chart listing the characteristics and the values found for each. Most of the children will know their approximate height and weight. If they are unsure, measurements can be made or they may check with the office or nurse to obtain the information.

When the chart is sufficiently complete you will want to discuss it with the class. What does the chart seem to reveal about the class? For the characteristics chosen, are there two students exactly alike? Through discussion, it should become obvious that all children are not identical even though they may have similar characteristics. Identical twins, while sharing many traits in common, are not <u>exactly</u> alike.

Most of the characteristics described by the class are not stable; they will change with age. Normally, variation within a species is studied only in a mature population. Since it would be unreasonable to expect students to gather sufficient data on variation in mature human populations, they will continue their study of continuous variation in Lesson IV substituting seeds for people.

Part 2. Variation in the Ability to Roll the Tongue

The characteristics examined thus far are variable over a rather wide range of values as the class chart indicates. Some, such as hair color, are not easily measurable and others, for example height or weight, may not be normally distributed among children because of the age factor. Consequently, other reasonable stable characteristics must be chosen for investigation. To simplify the problem, and provide contrast, a characteristic that does not range in value but is either present or absent in the population will be examined.

Start the activity by asking how many class members are able to roll their tongues. Some will know what you mean immediately. Others will need a demonstration. If you cannot do it, ask a student who can to demonstrate. Some will struggle in an attempt to do it. These children are probably the ones who are unable to perform the necessary muscle action.

Allow the class sufficient time for experimentation then establish the number of children capable of rolling their tongues. If some of the students who cannot roll their tongues feel practice will help, they will need to be told that practice does not affect their performance.

Now discuss with them the possibility of conducting a school-wide survey to discover something about the occurrence of tongue rolling among the rest of the students. What might be learned if such a survey were to be conducted? Of what value might it be for the class to collect additional data? Have any of them conducted surveys before? Are they familiar with any of the national surveys and polls? If so, what do they think such canvasses accomplish and how are they made? Lesson II will deal with initiating the survey. However, make certain that it is an activity the children would like to do before you plan it with them. Little will be accomplished if they do not perceive any value in it.

Lesson II

Investigation: TAKING A SCHOOL SURVEY

Introduction to the Activities

The activities of Lesson I briefly introduced the students to the idea of variation. Some discussion was held concerning the variability of certain physical characteristics, measurements and observations were made, and charts were constructed of class data. After the class completed a tongue rolling survey among its members, decisions were made about extending the survey to include the entire class. If the class decided to make the survey, there are a number of considerations to be made before proceeding.

You should enlist the cooperation of the other teachers and your principal. A time should be selected so that the children do not create interruptions. Developing specific procedures for the survey takers will minimize the amount of time spent in each class.

Surveys are a means of sampling the population. There are rather firm mathematical procedures for selecting a sample to insure its random nature, but you cannot expect your class to employ these techniques. However, you may wish to discuss some of the reasons for systematic rather than haphazard sampling with them. For the purpose of this survey your class is the sample while the school is the population. Additional ideas of samples and populations will be discussed in the body of the lesson.

After the completion of the survey, compare the class predictions with their data. Here would be an opportunity to discuss the validity of the class as a sample of the school population.

Procedure

Before the students determine how they will conduct their survey, they will need to understand something about populations and samples. You could begin the lesson by asking them if they think there will be as many people in each class surveyed able to roll their tongues as there are in their own class. After a brief discussion of this question, ask them to consider this question: If they were to conduct a survey to determine the height of the average American adult man which of the following groups would they choose for their survey and why?

1. Basketball players
2. Their own fathers
3. Jockeys

Through discussion, establish the idea that neither basketball players nor jockeys are apt to be representative of the population. One group is, on the average, far taller than most men, the other is much shorter. While groups such as those mentioned are samples of the population, they are inadequate for survey purposes since they represent the extremes. Fathers are probably more representative. Could all three groups be used for survey purposes?

Relate these ideas to the survey the class is about to conduct. If the class members form the sample and as a group they are representative of the school population, what results could they expect to obtain through the survey? Have each student make a predication of the result and record it in their notebooks. Now return the discussion to a consideration of the survey.

The students must first determine if they wish to poll the entire school. What are some of the problems they will face in doing this? How will they collect their information? Could they develop some kind of chart or survey form so that each student involved in collecting data does so in an orderly fashion? How will they approach teachers and gain entrance to their classrooms in a way which will not be disruptive? Should they first speak with the principal?

The class must consider all of the questions before they begin. School policy must be investigated, especially if the children are to proceed unaccompanied throughout the school.

Development of the survey form should not be difficult. There must be a place on the form for each observation, that is, each student polled. A separate form for each class can be prepared and distributed to your students who in turn take them around to each class to be surveyed. When the survey is completed, the results should be tallied and discussed in class.

Discussion

Examine the results with the class. How many children could roll their tongues? How many could not? If the class can convert the data into percentages, this would be helpful. Results expressed as percentages will enable them to more easily compare class results with those of the entire school. Percentages can then be put into graph form.

One source of information concerning the incidence of tongue rolling in the population states that 7 out of 10 people are able to do this. In percentages that would mean 70% of the population. How does this figure compare to school and class results? If the class is a representative sample of the population, approximately 70% should be able to roll their tongues. If not, is the entire population of the school any more representative of the total population?

How did the class predictions compare with the actual results of the survey? Was the class a representative sample of the population? Were any classes found to be more representative?

Lesson III

Investigation: DEVELOPING HEREDITARY PATTERNS

Introduction to the Activities

The children have compared and discussed the incidence of tongue rolling among themselves and throughout the school. In this lesson they will gather additional data, but this time they will collect it at home. Parents, brothers, sisters, and grandparents if possible, will be surveyed and Family "trees" or pedigrees will be constructed to discover something of the inheritance pattern of the trait. The more complete the information each child is able to gather about his family, the easier it will be to understand why he does or does not exhibit the trait.

The point of the lesson is to uncover the notion of inherited characteristics rather than to develop in detail a genetic theory of inheritance. While the class will work with some simplified techniques for depicting various possible means of inheritance of the trait, these methods should not be stressed at this time.

If the students have worked with matrices in mathematics, they should be familiar with the use of grids. A grid is a useful device for showing possible types of inheritance. Below is a sample:

FATHER

		T	T	
MOTHER	t	Tt	Tt	OFFSPRING
	t	Tt	Tt	

Each parent contributes one gene for each characteristic to each offspring. The contributed genes, in the case of tongue rolling, may be either dominant (T) or recessive (t). The large T gene controls the appearance of the trait. That is, while the offspring may have both large and small T, as in the case above, they will still be able to roll the tongue. This explains why large T has been termed dominant -- it dominates small t. As can be seen in the grid, the mother has only recessive genes for tongue rolling. She cannot, therefore, roll her tongue. The father can, and contributes only dominant genes, therefore, all of the children can roll their tongues.

Suppose one of the children, a "Tt," married someone who could not roll their tongue. The grid depicting the cross between these two would be as below:

PARENT

PARENT		T	t	
	t	Tt	tt	OFFSPRING
	t	Tt	tt	

In this instance, two of the offspring are rollers, two are not. This is a 1:1 ratio. Should one of the children, a Tt, marry another Tt, three offspring would be rollers, one would not, giving a three to one ratio.

PARENT

PARENT		T	t	
	T	TT	Tt	OFFSPRING
	t	Tt	tt	

These are three of five possible crosses — matings — illustrating the inheritance of the tongue rolling trait. Much has been left unsaid. Although a study of the inheritance of a single simple characteristic appears to be relatively uncomplicated, little has been said of what, in fact, is involved. In the first place, not all families produce four offspring. Even if each did, it is possible that all <u>theoretical</u> types may not appear. For example, in the case of the last cross, four children may be produced, all of which can roll their tongues. The theoretical cross, a three to one ratio, merely states that for every four children produced, three will be rollers, one will not. Taking this further, six out of eight children should be rollers in such a cross. But, if the first four children born were rollers, the three to one ratio would not appear to hold.

Dominance and recessiveness have not been thoroughly explained. Rarely is inheritance so simple a matter as straight dominance versus recessiveness. In some cases a "dominant" gene appearing with a recessive for a particular trait, "mixes" with the recessive to produce an intermediate type. This situation is referred to as incomplete dominance. Such is not the case with tongue rolling.

Though this discussion has been, by necessity, brief, you are referred to the bibliography for a more thorough treatment of the subject of simple Mendellian inheritance. What has been discussed may be related to the family trees and children will make. It is possible to theorize about the genes of the parents and the children and to construct grids to illustrate the pattern in a single family. Children may infer from pedigree patterns who has what genes.

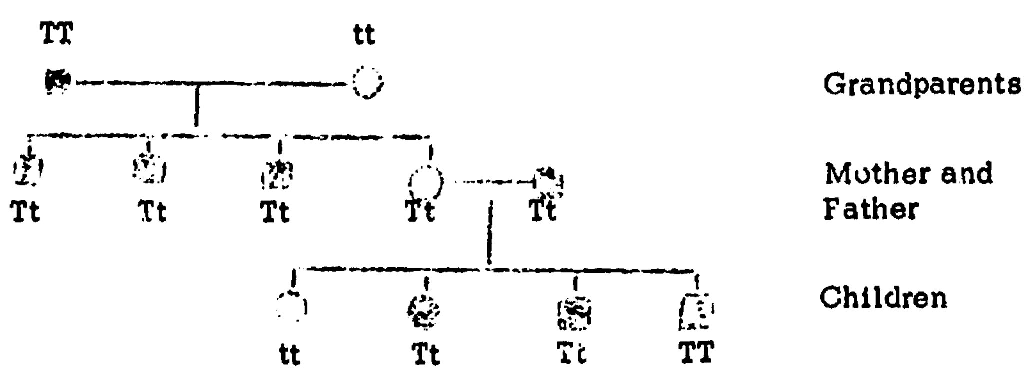
These activities should be of considerable interest to the children since they deal with something about themselves. To what extent you wish to pursue the grid activities will depend upon the children's interest and their understanding. As mentioned previously, you should not stress the science of genetics but rather the fact that characteristics are inherited. Something of how this occurs can be learned through constructing a pattern of inheritance — the family "tree."

The lesson ends with a discussion of "trees" and some inference of genetic types through examination of trees. Encourage the students to seek their own answers to the discussion questions, providing only information you are certain they cannot possibly have gained through past experience.

Procedure

Each student should first ask his parents if they are able to roll their tongues. Some may have already inquired. Brothers and sisters must also be included. If they are able to question their grandparents this will be helpful.

When each class member has the information they may then begin to construct their family trees. Below is an example of one such possible tree.



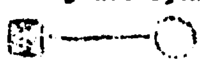
This "tree" depicts three generations. Most of the family members can roll their tongues, but two cannot. The circles represent women, the squares men, and the darkened symbols indicate tongue rollers. The symbols are those conventionally employed by geneticists but you may recommend others to the children.

When each member completes his chart as best he can, display them for the entire class. Are there any families with all members unable to roll their tongue? Or, are there any in which each individual is found to be able to do it? These are the two extremes. It is more likely that a mixture will be found within most families.

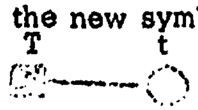
Your first question might be to ask if tongue rolling among class members seems to be dependent on whether or not the parents are able to roll their tongues.

The answer should be yes. It may take some further discussion in order for the children to agree among themselves that yes is indeed the case. If this is so, then perhaps something is passed from parent to child which determines the child's condition.

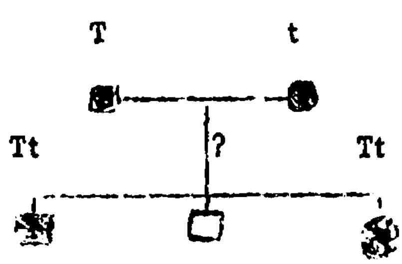
Should this be the case, why are there some differences, especially among the children in the family? If both parents exhibit the trait, does it follow that all the children exhibit it? Here, the answer may be no. The situation is very puzzling. How can students account for the variations? Is it possible that something is happening which is, in effect, unseen?

Select a single pedigree to illustrate a discussion of this last question. You will want the students to begin to infer from a pedigree some of the gene types which occur to create the pattern. In order to make such inferences they will need to know some of the information presented in the introduction to this lesson. Begin by selecting as a discussion example, a pedigree in which one parent cannot roll their tongue. Using the symbols you have developed, draw the parental condition on the board. 

Next to each symbol, describe the trait of each parent as follows: male, "Tongue roller" (use a capital T), female, "tongue does not roll" (t). Then, suggest to the class that instead of writing this information out, there may be a simpler way to represent the data. Erase the descriptions and replace them with a capital and a small letter to indicate the condition. Check to see that each student understands the meaning of the new symbols.



Refer back to the idea of parents "passing on" something to the children. Allow T and t to stand for that "unseen something" which is transmitted. What would the child of these parents receive? Hopefully the children will respond with both T and t. (Remember, the picture is not complete as yet.) Now, if this is the case, would this child be able to roll his tongue? If some say yes, inquire why they think so. They may only be expressing an opinion, but if you capitalize on this opinion you will be able to further pursue the point with them. The proof, of course, resides with the child whose pedigree is under discussion. Supposing, however, that the child cannot roll his tongue or perhaps a brother or sister cannot. This would appear to contradict the above reasoning. Re-examine the pedigree and assign initials to it as follows:



Here, only two out of three children exhibit the trait. How can this be explained? Further, two letters are assigned to the children, but only one to each parent. Might there be something not included as yet which ought to be considered? How can two letters be assigned to parents with some certainty that they are the correct two?

First note the mother. Is it possible for her to "carry" a large T but still not roll her tongue? No, since wherever the large T appears, the individual is able to roll the tongue. Thus, what would be the only alternative? Two small t's. And that is, in fact, the case. The father's type presents a more complicated situation. At this point you may wish to introduce the grid and indicate how it can be of use.

FATHER

MOTHER		F	?	OFFSPRING
	t			
	t			

The class can be certain of the mother's type and of the type of two of the offsprings. Complete the grid for the known types, explaining how it is done.

FATHER

MOTHER		T	?	OFFSPRING
	t	Tt		
	t	Tt		

If the mother's type is tt and she cannot roll the tongue, then one of the offspring must also be tt for one of them, according to the pedigree cannot roll theirs. But from whom does this other small t come? Could it be that the father's type is Tt, as are the types of his children? Replace the question mark with a small t, and see what crosses now result. Two of the children will both be tt and unable to roll their tongues. Does this analysis help to explain the pedigree?

Examine other pedigrees in much the same way to see if the class can arrive at the possible types of themselves and their parents. If such an examination appears beyond their understanding, do not pursue it at this time.

What can now be said of the activities to date? Review the following points in discussion:

1. People can be described in terms of physical characteristics.

2. If measured, these characteristics are found to vary from person to person.

3. Some characteristics are either present or absent in a population.

4. The population may be surveyed and some estimate of the incidence of the characteristics can be obtained.

5. What is true about the population may not be true of the sample.

6. Certain characteristics are inherited.

7. It is possible to discover some of the history of an inherited characteristic through study of several generations.

The above are some of the many ideas developed through the activities thus far. The next set of activities will provide the children with a contrasting situation in which indeterminate variation is studied.

Lesson IV

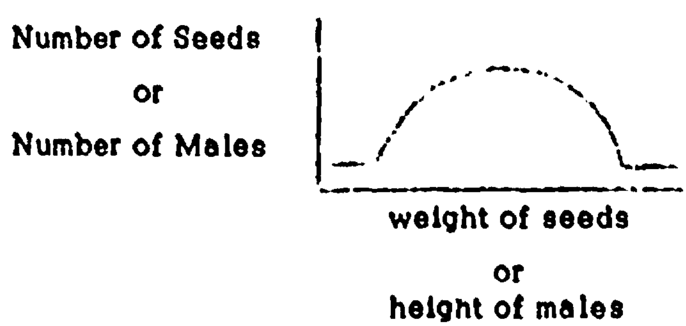
Observation: OBSERVING AND MEASURING SOME PHYSICAL
Measurement: CHARACTERISTICS OF SEEDS

Introduction to the Activities

Thus far, students have observed both wide ranging and limited variation in human physical characteristics. Height and weight were examples of continuous variation whereas tongue rolling was found to be a characteristic either present or absent in a population. It would seem that the characteristics having significance in terms of the evolution of new plant and animal forms are those which vary widely rather than those whose variation is limited. Yet, to fully appreciate the biological importance of continuous variability, a contrasting example should be examined. This, then, was the rationale for the study of the tongue rolling trait.

One point discussed briefly in Lesson I concerned the stability of certain characteristics among youngsters. The traits first observed in Lesson I were found not to be stable as the children are growing at rather rapid rates. For this reason it would be well to consider another population for purposes of measurement. Seeds have been chosen for study. They are easily obtainable, exhibit great variation, and many species are available.

While there is little comparison between man and seed, if you measure and graph the heights of a representative group of adult males you would find the shape of that graph to be about the same as a graph of the weights of a sample of corn seeds. Both graphs might appear similar to the one below.



This curve is called a normal or frequency distribution curve. You probably recognize that its bell shape is the same as a frequency distribution curve of intelligence.

Thus, for your purposes, the objects of study are not important. The fact that all biological species exhibit a similarity in the frequency distribution of certain characteristics is important. The significance of this distribution will be further examined in Lesson V.

As you begin this lesson, the children may be somewhat bewildered by what seems to be an abrupt change of pace. Seeds might appear to have little to do with the preceding activities. If you explain to them that you wish them to describe their seeds much as they did themselves in Lesson I perhaps the connection between the several activities will become more clear. You may also tell them that they will return to their discussion of tongue rolling after they have finished with the seed study. Perhaps these two statements will serve to explain something of the change.

The objectives of this lesson will be to first re-introduce the concept of variation through the study of some physical properties of seeds and, second, to introduce the process of measurement. Before they are measured, the seeds will be examined for their measurable properties and methods for measuring them will be determined. In the next lesson the children will construct histograms of the data.

Materials

1 pound of field corn
1 pound each of number one and two grade Great Northern beans
1 pound of lima beans
1 pound of kidney beans
1 pound of castor beans
1 pound of peas (unsplit)
1 pound of pinto beans
1 pound each of any other dried vegetable
pan balances, as many as obtainable
centimeter rulers, 1 per student
grid paper, 1 millimeter squares

Procedure

Distribute a handful of seeds to each student. Try to avoid distributing more than three handfuls of each variety throughout the class. Have the students spread them out on their desks or tables for observation. If the children have slanted desk tops suggest they arrange the seeds above a book edge to prevent them from rolling onto the floor. To stimulate observation perhaps they might wish to play a game similar to the description game in Lesson 1. Have them write down observable properties, then exchange papers with one another. After the exchange they may take turns identifying the described seeds. Remind them that the object of the game is not to try to confuse one another, but rather to write the most complete description for immediate identification.

After this activity each student will need to take a closer look at his own seeds. What variations can be observed within each population? More specifically, what properties vary and which of these are measurable? What are some means of measuring variability? Measurable properties might be length, width, weight, thickness, etc. Means of measurement would include the use of centimeter rulers, pan balances, and placement on grid paper for measuring length in units other than metric.

Additional means may be suggested; list them all on the board along with the identified measurable properties.

There may be some discussion as to whether or not color is a truly measurable property. It can be, but ordinarily only very sophisticated equipment will do an adequate job. However, if the children wish to devise a continuous spectrum, assigning successive numbers to adjacent colors, they will establish at least one arbitrary means for quantifying color.

When the lists of properties and measuring systems are placed on the board, have each select first the property and then devise a means of measuring, using about 50 of his seeds. The larger the number of seeds measured the closer one comes to defining the limits of each single measurable variable within the population.

Although it is suggested that each student select his own means of measuring, perhaps you could encourage the class to use a variety of means. Some should weigh, some use rulers, others the grid paper (or anything else suggested). When they are finished no doubt they will never want to do this again -- it does tend to become tedious!

Discussion

One of the first questions which might be raised is do the seeds vary in the property measured or are they the same? The answer should be obvious, but often the children do not perceive slight differences as truly significant variations. Since the seeds within each set measured are of the same species (do the children know this word?) should there be any reason for variation? If so, how could they account for it? The answer to this last question is quite involved. One must consider both environmental and genetic factors to adequately explain it. Encourage the children to speculate about the answer, listing possible suggestions on the board. Can any of the suggestions be readily investigated? Perhaps some children will want to plant the seeds to discover, for example, if small seeds develop into small plants. Encourage any suggestions they have for investigation. They may be undertaken as time permits.

In the next lesson the children will order and graph the data obtained in this lesson. Comparisons will be made among graphs and variability will be further discussed.

Lesson V

Recording: Analysis: DISTRIBUTION OF PHYSICAL CHARACTERISTICS OF SEEDS

Introduction to the Activities

In Lessons I and IV you introduced your students to the concept of variation. In this lesson they will develop and use a histogram for recording and ordering quantitative data concerning variation. A histogram is simply a graphical picture of how measurements or counts are distributed around the average measurements or counts.

The students will use those data collected in Lesson IV for the construction of the histogram. When the graphs are completed, they will compare their results. Through comparisons, they should be able to generalize about the distribution of variable inherited traits.

The significance of this distribution is appreciated if one compares it with the distribution of tongue rolling within the population. Widely distributed variability in a trait provides much raw material for the mechanism of natural selection. For example, the wide variety observed among cultivated roses is a result of the careful and purposeful selection of preferred types from a variable natural population. If all of the characteristics of a natural population of roses had been the same, no selection could have occurred. In contrast, tongue rolling is roughly analogous to coin flipping. One can or cannot roll the tongue; one gets either heads or tails when a coin is flipped. There is limited variety. As was seen in Lesson III, only one set of genes controls that characteristic, whereas among roses many genes act to produce variation.

The children will be asked to give some thought to these ideas at the end of this lesson. Lesson II contains activities designed to further explain the significance of the concept of variation.

Materials

Grid paper, 1/4 inch squares, 2 per student
1 pound of number one grade Great Northern beans
1 pound of number two grade Great Northern beans
paper sack
data from Lesson IV

Procedure

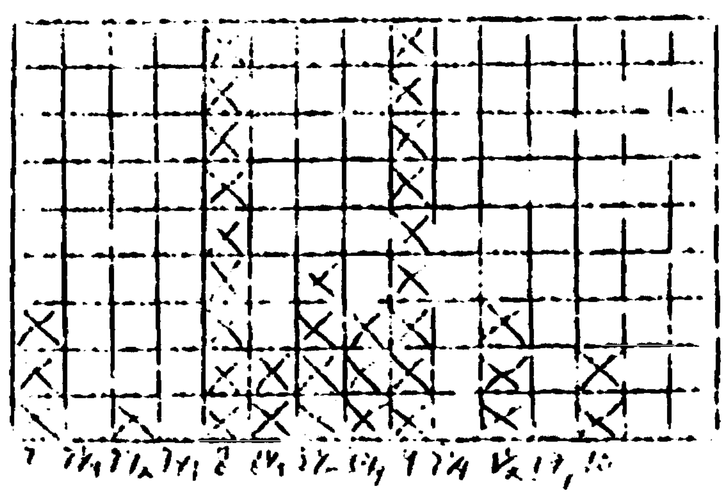
Distribute several sheets of grid paper to each student. Have them examine their seed measurements and think of some methods for organizing them. Some suggestions might be to order them on the basis of increasing magnitude of the values. If they wish, encourage them to try this method. Does this method of organization make the data any more meaningful? What observations can now be made about these measurements?

Some students will observe that measurements are not all the same, yet there are many which are the same or at least close in value. Perhaps another observation might be that there are fewer smaller and larger values than there are intermediate values. For example, in a measured sample of lima beans, three out of thirty-seven were seven units in length; two were ten units while the remaining thirty-two ranged in value from seven and one-half to nine and one-half.

Is this a pattern which is characteristic of each set of measurements the class obtained? Suggest each student examine his data to find out and report his findings to you. If the pattern occurs repeatedly throughout the class, what does this suggest in terms of variability.

Perhaps it might be helpful at this point to develop the histograms. Presumably each student has ordered his data according to the increasing value of the measurements. This order may now be transferred to the grid paper. Below is an example of one type of histogram representing the length of lima beans in terms of the arbitrary units by which they were measured.

Number of Lima Beans



Units in Length

The horizontal line is, in reality, a segment of a number line with 1/4 unit intervals. The x's represent the number of beans found for each length. There are other types of histograms or techniques for constructing them. Perhaps the children have made them before but not in quite the same fashion. Use your own judgment in selecting the best technique for your class. The results will be essentially the same regardless of the method.

After each student completes his histogram, display them for the rest of the class. Is there any similarity among them? If so, ask the class to describe that similarity. Are graphs of the same seeds more alike than graphs of different seeds? How can the students account for the likenesses?

Direct their attention to the one thing all the graphs should have in common and that is the tendency for most of the measurements to be distributed about a central point. Ask them to examine their histograms and determine the location of the majority of their measurements. Are they at either end or do they fall in the middle? Once they have determined this answer, ask them to suggest reasons for their observation. Perhaps they will say that most "things" are middle-sized rather than small or large. If this is the case, are they able to give additional examples to further qualify that generalization? How about people, are most of them middle-sized? Are most of the students in the class middle-sized for their age? What are some other examples of the tendency to be middle-sized?

If time permits, you might ask them to measure the length of their middle fingers. Collect the measurements and construct a histogram on the board. The length of middle fingers is also normally distributed about a central point. It is a good illustration of distribution since the relationship between age and length does not change as the children mature. There are many other examples of this type of distribution. See how many the children are able to suggest before you proceed further.

Some final thoughts for the class to consider might be to explain why there are measurable differences among seeds which are members of the <u>same</u> population? How can they account for the variation? And finally, of what importance if any is the variation? Some possible explanations of these questions will be dealt with in Lesson VI.

Lesson VI

Investigation: VARIATION AND DIVERSITY

Introduction to the Activities

Lesson V dealt with variation within a species-population. At the conclusion of that lesson, the children were asked to consider the significance of variation. In this lesson, they will examine the concept more closely. They should arrive at some conclusions as to the biological importance of variation and thereby be reasonably able to account for biological diversity.

The lesson begins with a game intended to reveal, through analogy, something of the process of natural selection. Another game has been designed to contrast limited with continuous variation. Finally, a short "story" has been included for which the students will provide the ending. A discussion of the story will serve to summarize the entire unit's work.

Materials

Beans and peas
Paper sacks
Grid paper, 1 millimeter squares
Pan balances
Centimeter rulers

Procedure

Place the varieties of beans, peas, etc., into separate sacks. Distribute the grid paper and write on the board the ranges previously found, in weight or length, for each seed variety used. Ask the class to review these ranges and keep in mind some of the ideas discussed during Lesson V. Explain that you are going to give them the opportunity to select one seed from each sack. They are going to predict, before selection, something about the physical properties of that seed. For example, if lima beans were originally measured on grid paper for length, then how many units in length might the selected seed be? Or, if they were weighed, how many grams would the selected seed weigh?

Once they understand how the game is played, they need only to refer to the ranges which should be accompanied by the particular property measured and units of measure employed in order to make a prediction. Have them write down their predictions first, taking all seed varieties into consideration. After they have done this, then ask them to verify their predictions through measurement. Record the measurement next to the prediction and compare the results.

How accurate were their predictions? On what data were they based? If there was an exceptional degree of accuracy between prediction and verification, how do they account for it? Were most of the seeds selected found to be "middle-sized"? If so, why should this be the case? You want them to be able to state with some certainty that since most seeds are middle-sized, the chances of selecting a middle-sized seed is greater than that for selecting either small or large seeds. Have them arrive at this conclusion themselves through discussion.

After this discussion, suggest they return the seeds to the proper bags. Then choose a student to do some additional selecting. In this case you will want the entire class to predict how many seeds must be selected in order to get one which falls at one or the other extreme of a range. It makes no difference which kind of seed is used here. Be certain that the child is not searching for either a large or a small seed.

The class should discover that a relatively large number of seeds must be selected before one of the extremes is found. Not only are they fewer in number, but the smallest tend to fall to the bottom of the sack. For this reason, it is a good idea to shake up the sack and have the student dig into the seeds rather than select from the top. You may try this with several students using different seeds. Is the same effect observed for all seeds? If so, why should this be true?

To illustrate the importance of variation, prepare two sacks of seeds in advance of this lesson. (If time permits, make up additional sets.) Prepare one sack by selecting only medium-sized lima beans from a mixed population. The seeds should be so similar that differences are not at all apparent. The other sack should contain a mixed population of lima beans. Be certain the mixed population contains some very small beans and some very large ones. You need only use several handfuls for each sack, since the children will be asked to quickly order them.

Appoint two children to order the seeds from each sack. Have them keep the sets separate. The ordering should be from the smallest to largest for each set. The child working with the mixed population should have relatively little trouble, whereas the other child may complain that he cannot see differences. They are all the same. Further, he may say there is no variation. This is the observation you hope the child makes. When there is a lack of variety, no selection can take place.

Return to the tongue rolling characteristic and ask what range in variety exists for that trait. In other words, are there intermediate abilities? Can people be born with a partial ability? Were there any intermediate abilities found when the survey was taken? If not, what can be predicted for the populations of the future?

With respect to the lima beans, what kind of variation could one expect to find in future populations if only intermediate-sized seeds were to be planted? Encourage them to discuss ideas among themselves. The concluding story will perhaps provide them with more clues to the answer.

A further illustration of the significance of variety is the selection practiced by pedigreed dog raisers. Does anyone in the class have a poodle? If so, what is the size of the poodle? Do poodles come in only one size? The children probably know there are standards, the largest, miniatures, and toys, the smallest. And there are very definite height qualifications for each variety. Toys are less than ten inches, miniatures ten to fifteen, and standards, over fifteen. The important question is how were the three varieties developed? Permit the children to speculate about the answer.

Develop this discussion in such a way that they begin to realize that diversity among species is a result of variation within a species. Poodles do not qualify as a good example because they are of the same species. However, dogs, wolves, hyenas, bears and racoons all had a common ancestor at some time in their historica development. Perhaps from within the present-day population of dogs, new species may evolve as selection is practiced over a period of time. In summary, the diversity seen among biological forms today is a result of the operation of many factors, primarily environmental and genetic, upon variations once existent within ancient populations.

Read "Johannson and the Bean Seeds" to the children as a concluding activity.

Discuss what his results might have been as time permits. You may also wish to have them read related material in their texts. The bibliography contains a number of books which would be appropriate to recommend for students interested in further pursuing the topics of the unit.

Johannson and the Bean Seed

It has been almost seventy years now since a man named Mr. Johannson planted his first bean seed. This event does not seem very important, especially when you consider the fact that it happened in the far off country of Denmark.

Mr. Johannson was not a farmer, nor did the plant that grew from that first seed reach up through the clouds near the home of a wicked giant, as happened in Jack and the Beanstalk. No, the bean seed simply grew into a normal everyday bean plant, which, in time, developed seeds of its own. In fact, he planted many seeds, which grew into many normal everyday bean plants, which, in time, developed seeds of their own.

Mr. Johannson, who was a plant scientist, noted some interesting things when he examined the new seeds from the plants he had raised. The plants which had grown from large seeds had produced larger seeds, and the plants which had grown from small seeds had produced smaller seeds. Mr. Johannson suspected at first that this might be just a coincidence, so he began a careful experiment. By weighing each seed which came from his new plants, he grouped them into piles of small, medium, and large. Then he planted these three groups of seeds and anxiously awaited the results. In time, the plants grew, flowered, and finally produced seeds Mr. Johannson eagerly picked the seeds and began weighing them. At first he was overjoyed at the results. The seeds from the large seed plants were larger than ever; the ones from the small seed plants were smaller than ever; and those from the middle-sized seeds were middle-sized. His happiness soon began to fade and doubt started to enter his mind; he was again questioning his results. Did he pick the small beans too soon? Did he not give enough water to the small seeds? Could he have made these or other mistakes?

The only way to prove his theory for sure was to grow this latest crop of seeds, and to compare the weights of the seeds which the new plants produced. Mr. Johannson began the whole process anew. He weighed seeds and planted them according to weight — large in one place, small in another, and middle-sized in a third. Again the long weeks of waiting. He was very careful, this time, about the amount of water and sunlight which the plants received. He wanted everything to be the same for each group. At last the day came when the beans were ready to pick. This time he was sure he had waited long enough. The beans were placed on the scale and weighed. Mr. Johannson recorded the results .... but that was over 70 years ago and thousands of miles away. His results were lost in time and space.

What do you think he found?

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TUBS OF TILES

CONTENTS

BACKGROUND INFORMATION
SAMPLING TECHNIQUES

An understanding of sampling techniques is invaluable to work in the environmental sciences. Outdoor studies usually involve the sampling of different components of the environment such as soil type of acidity, animal population of a pond or area, temperatures of air or soil under differing circumstances, plant population changes in relationship to water, etc.

In continuing these studies the children will need the knowledge of how to define the population to be examined and its exact boundaries. The children will consider the factors which influence the validity of "sampling" when they decide how many samples they must take, where the samples must be taken, and how large the sample should be.

This sampling technique is not only important to the environmental sciences. It is good for all of us to realize we are constantly sampling and making judgement from these samples.

"Our knowledge, our attitudes, and our actions are based to a very large extent on samples. This is equally true in everyday life as it is in scientific research. A person's opinion of an institution that conducts thousands of transactions every day is often determined by the one or two encounters which he has had with the institution in the course of several years." (From William G. Cochran, Harvard University, Sampling Techniques)

When we eat at a new restaurant we sample their food, service and atmosphere, and make judgements from this.

"In science and human affairs alike we lack the resources to study more than a fragment of the phenomena that might advance our knowledge." (William G. Cochran)

From samples statistics are built. Erroneous conclusions are often drawn from statistics based on incorrect sampling (data gathering) procedures. It is often difficult to recognize poor sampling procedures when interpreting the statistics we are continually faced with in our society. Consequently, we are often guilty of unquestioned acceptance when confronted with an impressive looking collection of figures.

This primary unit is designed as an introduction to sampling. The population and its boundaries are clearly defined. Handfuls of brightly colored objects are defined as the samples. Seeing the variety in numbers in a sample and different colors (members) will begin to indicate how samples of the same population can vary greatly. When the children begin to project the numbers in one sample to the whole picture they will observe how a small imbalance in a sample can, when projected to the total, show a very false picture.

Let me emphasize that this is the beginning of a very sophisticated study. It is hoped that this unit will assist children in their continued population studies (i.e. button bags, beans, mealworm count, variation, yeast and snails), and in their continued environmental studies.

TUBS OF TILES

This unit involves the child with play, observations, and communication. The child manipulates the colored tiles to progressively create patterns, organize simple patterns, similar patterns, and finally develop specific patterns. The specific patterns then form a graph.

To form these patterns the child randomly selects tiles from a tub containing 600 tiles. There are five different colored tiles in the tub. Through the game activities, the child is lead to the techniques of sampling a population. In this case the population is the tiles in the tub and each child's random selection is a sample of the whole.

As children group together and combine their small samples into a larger one, a more regular representational pattern develops.

The child, in the game activities, will graph his sample by placing them in color rows. He will then graph the larger sample of his group in the same manner The tile represents the tile and also represents the square of a graph.

The child and the groups can then graphically show an orderly representation of their sample.

In this way, through play and fun, each child can experience two scientific procedures, sampling a population and graphing. It is hoped that this experience will add understanding to a continued use of these techniques.

OUTLINE

Game I

Procedure #1

a. A random handful of times for each child
b. Play activity
c. Observation (see unit)
d. Communication (see unit)

Procedure #2

a. A random 10 tiles for each child
b. Play activities
c. Observation
d. Communication

Procedure #3

a. A random 10 tiles for each child
b. Ask children to create patterns (note any differences)
c. Observation
d. Communication

Procedure #4

a. A random 10 tiles for each child
b. Ask children to create rows of tiles
c. Observation
d. Communication

Procedure #5

a. 10 randomly selected tiles
b. Ask children to put rows in color order
c. Observation
d. Communication

Procedure #6

a. Pass tile size square graph paper
b. Have children reproduce own pattern of tiles on graph using color crayons

Procedure #7

a. 10 tiles per child
b. Join in groups of six with tiles - put all tiles together and create one graph on the floor - reproduce on graph paper
c. Observe own and other graphs
d. Communication

Procedure #8

a. Combine all the sample tiles for one graph
b. Record the number of each color and appearance on graph

Procedure #9

a. All tiles
b. Lay all tiles out on the floor and get an accurate picture
c. Look back and communicate about most accurate samples.

Game II
a. A tile = a child 1-10
b. Graph room population

Game III
a. A tile = a color, shoe
b. Graph the shoe population by color

Game IV
a. A tile = a pencil
b. Sampling technique
c. Problem solving
d. Predict total pencil population
   1. from 1 person's pencils
   2. from 1 group's pencils
e. Use graph paper to show results

PURPOSE

The purpose in creating this unit is to introduce sampling techniques, and to build the understanding of graphing gradually through the use of tiles

Each game has four areas of concern:

1. Initiating individual involvement
2. Activity (play, building, pattern development, similar and like patterns)
3. Observing (satisfying curiosity)
4. Communicating (socialize on reaction and observations)

MATERIALS

Tub 3/10 200 yellow tiles
2/10 100 brown tiles
2/10 100 blue tiles
2/10 100 green tiles
1/10 50 white tiles

Graph paper - tile size

Crayons

Yarn to show general curve of graph

Strips of colored construction paper

COMMUNICATION SIGNAL TECHNIQUES

Establish a signal of some kind that can be used throughout the unit's activitie

Many teachers use a small desk bell or a chord on the piano to get the attention of all the children who may be engaged in different activities.

I have found it very helpful with both lower and upper grades to switch the room lights off when I want attention from everyone, with the understanding that when I do so, it means "freeze". The children seem to enjoy the game element of this technique.

Another very effective signal is the use of bongo drums. The sound is soft, but discernable, even in a busy room. Joyce Kennedy, first grade teacher in Bloomington, has used this successfully. She can tap a rhythm pattern on the bongos and express an entire predetermined message (i.e. it's time to go to the gym) or she can tap a rhythm pattern for attention and then sing her message or tell the class whatever she wishes. This technique seems most promising with a unit of this kind where you want to create a free, thoughtful atmosphere and still need a tool to direct the children's attention when necessary.

TUB OF TILES

Procedure #1

a. Pass a random handful of tiles to each child. Make no effort to give each child the same number of tiles, the more number variance the better. Or you may want the children to take their own handful or two as long as they are not selecting as to number or color.
b. Free play - the length of time will depend upon you, the teacher, and upon the individual situation in your classroom.
c. Observation - Ask the children to "really look at" their tiles and the structure or pattern they have created. They will probably not need much time for this but give the children as much time as you judge appropriate. Use your established signal to direct the children to the next activity.
d. Communication - Talk about their own tile design, listen to others, "really look at" other patterns, ask questions, wonder about colors and size of design, socialize, move about. The time given for this will depend upon the class, their interest, and your judgement. There are several ways for children to talk about an experience. They can be any of the following or others:

    1. Conversation between two or three children
    2. Walking around individually commenting and questioning here and there
    3. Teacher organized tour of the desks
    4. Calling the children together for a rather formal discussion

Because of the nature of this unit we recommend a variety of techniques with as much individual freedom as possible.

When this first activity (in actuality a practice run) is finished have the children return all tiles to the tub and mix them up.

Procedure #2

a. Randomly select ten tiles for each child, or have the child take ten if they are not selecting as to color
b. Free play
c. Observation (see Procedure #1)
d. Communication (see Procedure #1)

Return tile to tub and mix up or continue with Procedure #3.

Procedure #3

a. Randomly select 10 tiles for each child (see Procedure #2)
b. Ask each child to create a pattern with his tiles - note any differences in approach
c. Observation (see Procedure #1)
d. Communication (see Procedure #1)

Return tiles to tub and mix or continue with Procedure #4

Procedure #4

a. 10 tiles for each child
b. Ask each child to place his tile in rows using the same color in each row
c. Observation
d. Communication

similarity of patterns

Procedure # 5

a. 10 tiles for each child
b. Ask each child to place his tiles in rows using a certain color order (blue first, yellow second, etc.)
c. Observation
d. Communication

Each child now has a graph of his sample of tiles in the tub. The word "graph" as the name of what they have already done can be introduced at this time.

Procedure #6

a. Pass tile size graph paper to children
b. Have them lay their tiles on the paper one tile per square
c. Ask each child to reproduce his own graph pattern on the graph

Return tiles to tub and mix or continue with Procedure #7

Procedure #7

a. Randomly select 10 tiles for each child (see Procedure #1)
b. Ask the children to bring their tiles and sit in groups of six. Ask them to put all their tiles together to create one graph on the floor. Some groups may need a time to play with the tiles in the group first. Ask the children to reproduce their tile graph on a larger piece of graph paper (double and tape together) using the appropriate color crayon.
c. Observation (see Procedure #1)
d. Communication

Preserve the tile samples of each in a box or place so that they may be used with Procedure #8.

Procedure #8

a. Use the same tile samples that were used in the groups for Procedure #7
b. Combine all the tiles from all of the groups and lay them on the floor to create a graph of this large sample.
c. Observe and record this graph by placing long narrow strips of paper of the same color as the tile next to each row of tiles. This will be used to compare this sample with the total. It would be good to color in a paper graph if you have a child or

group that has that kind of tenasity.

d. Communication - the graph is a form of communication.

Procedure #9

a. Have the children lay all the tiles on the floor to form a graph
b. Observation - look back to find most accurate sample
c. Communication - discuss the use of the word population to indicate all the tiles in the tub. The population of the tub then is all tiles in the tub.

Game II A tile = a child

Procedure A

1. Give each child one tile to represent himself. Girls may be given one color (yellow) and boys a second color (green)
2. Make one graph of the class population, girls and boys
3. Observation
4. Communication

Procedure B

1. Give each child in the reading groups a colored tile (white, green, yellow)
2. Make one graph of the class population on these terms
3. Observation
4. Communication

Procedure C

Any other class grouping (rows, etc.) may also be done

Game III A tile = a shoe color

Procedure A

1. Give all the children with black shoes a certain color tile (yellow) Give all children with brown shoes another colored tile (aqua) Give all children with white shoes, red shoes, blue shoes, and other colors different colored tiles. Hopefully, five colors will be sufficient or you will need to make some combinations.
2. Graph shoe population by color and by group. Have each row or every five or six children prepare a graph of shoe color and reproduce it on graph paper.
3. Observation
4. Communication - notice the difference between the group sample of the whole population and the graph of the whole

Game IV A tile = a pencil

This game is designed to show the children how sampling works. It is more important that the children follow directions and project the sample of one child pencils to arrive at a total. Each child will want to keep his own pencil count a secret until it's time to review the actual number count. This game is also designed for problem solving. It is most important that you, the teacher, pose the problem, but not assist in its solution. The problem, "how many in all" can be solved in a number of intuitive ways - please permit the children sufficient time and freedom to come up with an answer.

There should be much communication going on while the problem is being solved.

Procedure A - use one color for all pencils

1. Have one child (Jimmy) find and count all his pencils i.e. (3). Give him that many tiles of one color. Give everyone in his group (row, etc.) that many tiles (3 to each). Problem: How many tiles in Jimmy's group if everyone has 3 pencils (or as many as Jimmy has?) Allow time for solution. Record solutions to problem.
2. Give everyone in the room the same number of tiles (3). Problem: Using Jimmy's sample, how many pencils do we have in the room? Again permit time and freedom to independently solve this problem. Collect all tiles. Have Jimmy return his pencils to his desk if he has not already done so.

Procedure B

1. Have all the children in one group (row, etc.) take all of their pencils with them and sit in a circle together.
2. Give everyone in this group as many tiles of one color as pencils. Now we have another larger sample to project.
3. Have the rest of the class group in small circles on the floor. (They are <u>not</u> to bring their pencils.) Pass each group the same number of tiles as the origianal group has. These represent the pencil population in the room using the sample of one group.
4. Problem - How many pencils does this sample indicate that we have in the room. Permit time to solve this problem individually. Record answers.

Procedure C

1. Have all children place all their pencils out on their desks.
2. Problem - how many really? Allow time for individual solutions.
3. Record solutions
4. Determine correct solution, record.
5. Compare with all samples and discuss closeness of sample to real count.

Extended Activities

Raisin Bread - raisin population - by Ivan Kalman, Minneapolis Public Schools

Materials:

1 loaf raisin bread (with enough slices for the class)
Napkins
Drawing paper
Crayon

Purpose:

To sample the raisin population in a loaf of bread by giving each child one slice as a sample.

Activities:

1. Ask all children to wash their hands well
2. Pass a napkin to each child
3. Pass one slice of raisin bread to each child
4. Ask the children to count the raisins in their slice of bread. Have them count both sides and see if both counts are the same . If not, have them decide why and ask them to arrive at as accurate a count as possible.
5. Have one or two children count the number of slices in the whole loaf.
6. Ask the children to decide, from the number of raisins in their slice, how many raisins are in the whole loaf? They may use any device to figure this out (i.e. tiles, paper scraps., tooth picks, etc.)
7. Have each child draw his slice of bread and draw in the raisins - as a record.
8. Record, probably on the blackboard or large tag board, all the raisins.
9. Compare these results and discuss differences.
10. If there is a real interest, the number of raisins in all slices may be added together for a total count.
11. Have a "happy raisin bread" eating party.

Weighing Rocks in "Washer" Measure - by Ivan Kalman, Minneapolis Public Sch‹

Materials:

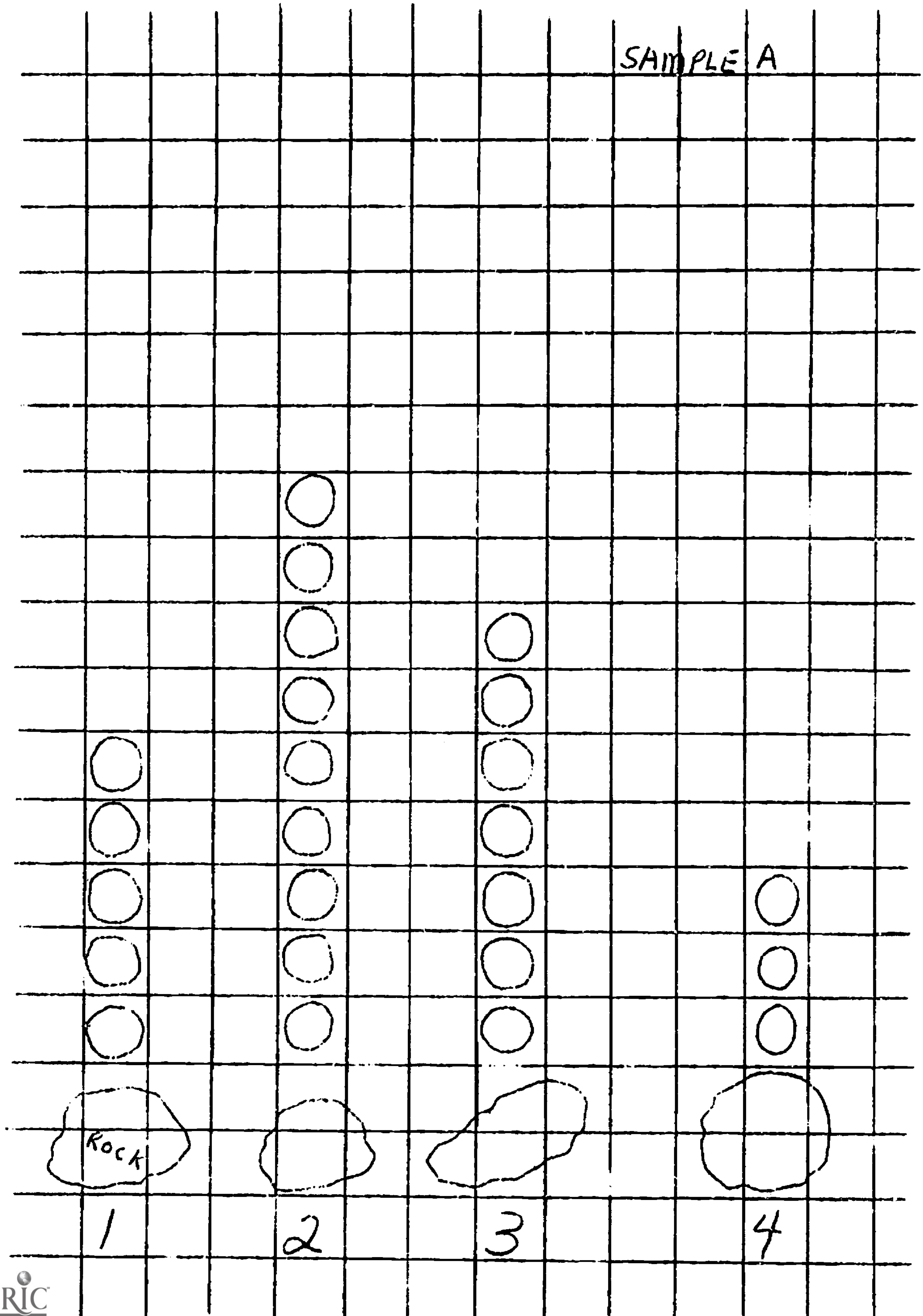
Rocks
Balance
Scale
Medium weight washers
Graph paper
Crayons

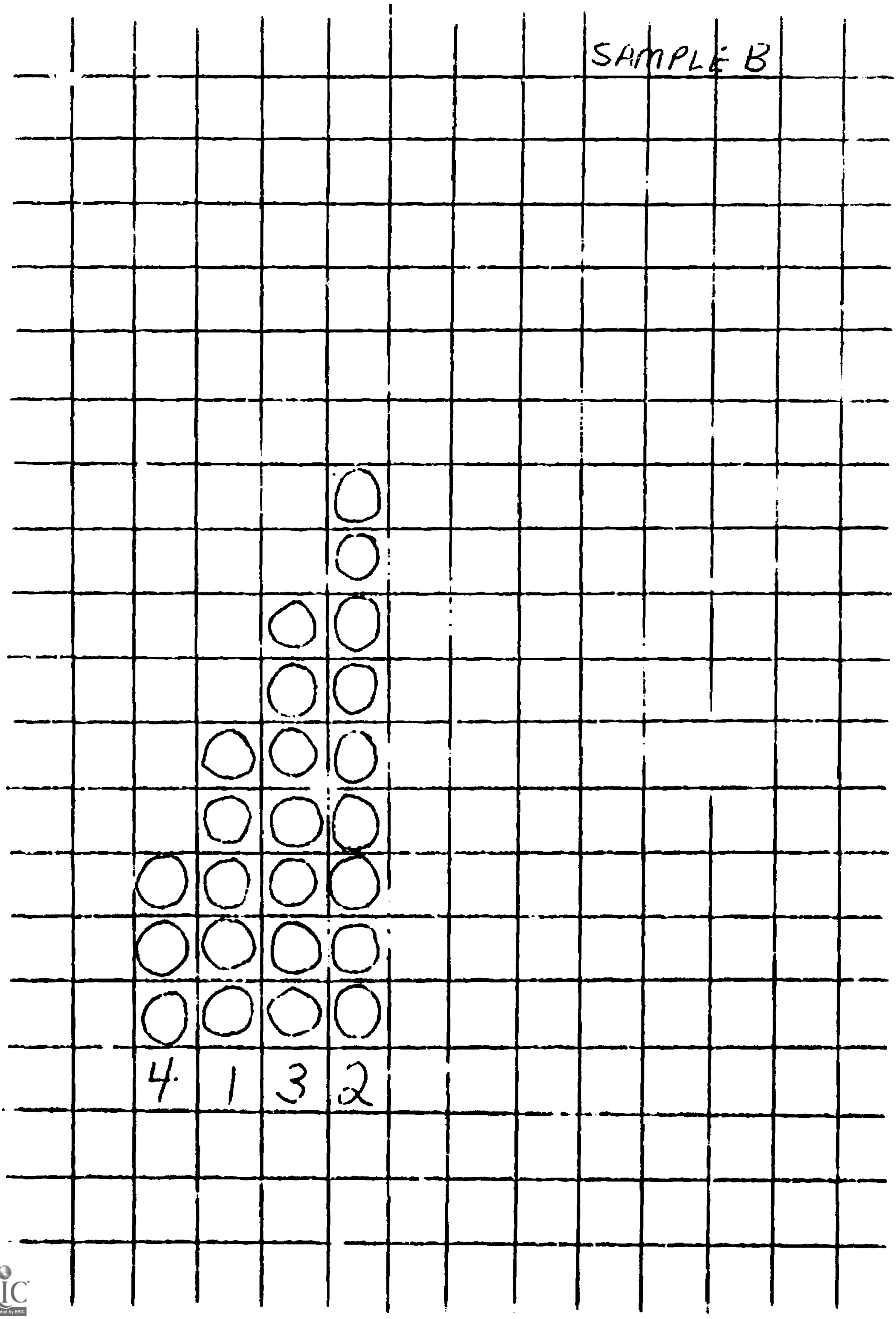
Purpose:

To use the balance scale accurately. To weigh an object (rock) with objects that are lighter (washer). To determine what weight represents a set measure, the washer, and its relation to the object to be weighed.

Activities:

1. Place one rock on a balance scale.
2. Determine how many washers are needed to balance it.
3. Paste these washers on a piece of graph paper per sample A attached.
4. Paste rock under column of washers per sample A attached.
5. Place a letter under each rock per sample A attached.
6. Do steps 1-5 with four rocks.
7. Re-examine completed graph with an eye to which is heaviest and which is lightest.
8. Place in order on a new piece of graph paper using only the symbol (letter) for the rocks and drawing the washers in on the graph paper per Sample B.
9. Re-do this activity using 5-10 rocks.


SAMPLE A
Rock
1
2
3
4


SAMPLE B
4
1
3
2

BACKGROUND INFORMATION

GRAPHING

The ability to understand a graph, how to record data on a graph, and how to interpret from a graph is a very valuable tool in math, science, and many of the social sciences.

Graphing involves representation, changing the data you wish to record to a position on a graph. Your knowledge of what your symbol represents and what its position represents is essential to the very beginning of understanding.

However, beginning graphing need not be representational. This unit is designed so that the first graphs are made from the tiles themselves and later colored in - in actual size.

The step by step understanding is as follows:

1. Tiles form the graph

2. Tiles form graph on tile size graph paper

3. Child outlines tiles and colors squares in

4. Child compares his row of tiles to his graphic picture of it

5. Child continues to use this size graph paper

6. As the rows of tiles get longer and longer, the teacher can introduce graph paper with smaller squares and have them represent the tile

7. Children can count the tiles and count thesquares on small grid graph paper

POPULATION SAMPLING

Populations of any kind can be sampled by counting. The sample will contain a small representation of the whole population if each sample contains enough individuals and if the individuals are randomly distributed within the whole population.

The Environmental Science Center activities with tiles and buttons illustrate how sampling can give a picture of the relative numbers of different individuals in a population. Also an approximation of the actual number of different individuals can be determined if the total population is known.

This activity will, on the other hand, demonstrate how it is possible, by sampling, to predict a total population that is unknown.

THE METHOD

If the total number of a large population is unknown, it is possible to estimate this number. Individuals are collected, marked in such a way that they can be identified again, and are distributed randomly and evenly back into the total population again. A sample is taken again and the number of marked individuals collected is compared to the number of all individuals collected in the sample. This proportion is comparable to the proportion of all marked individuals to all members of the total population. Let's use an ideal example.

A bag contains some beans — more beans than we want to count. We take a handful out and count them. We count 100. We color the 100 beans red (soak in food coloring).

Now we put the red beans back in the bag and shake the bag so that the red beans are distributed evenly throughout the whole population. We take out a handful of beans again. We count 120 beans. But 20 of the 120 in the sample are red.

If the sample is comparable to the total population, then the 20 out of 120, or 20/120, is comparable to the original 100 marked beans out of the unknown total. That is 20/120 compares to 100/? 20/120 is the same as 1/6, which would be the same as 100/600. 100 red beans when mixed in with the total population, produced a sample with 1/6 of the individuals red, thus indicating a total population of 600 beans.

$$20 : 120 = 100 : X$$

or more formally -

$$\text{Population Estimate} = \frac{\text{Total marked in population} \times \text{Total number in sample}}{\text{Number marked in sample}}$$

Now this is an ideal situation. A very large population would require a larger number of marked individuals. Otherwise a marked individual would rarely be found in later samples.

Also it is highly unlikely that each sample of 120 beans will have exactly 20 red beans. The results will vary. The most reliable prediction of the total population can only be made after totaling the results of many repeated samplings. Each time return the samples to the total population or the total population will be change

Sample	No. of Marked Indiv. in Sample	Total No. in Sample	Total No. of Marked Indiv. in Population	Total Predicted Population
1	26	100	200	768
2	18	74	200	811
3	9	89	200	1977
4	22	120	200	1090
5	19	104	200	1094
6	17	97	200	1141
7	20	100	200	1000
8	21	90	200	852
9	20	105	200	1050
10	15	83	200	1106
		AVERAGE		
	18.7	96.2	200	1028

Actual population was 1,000 (Prediction based on average of samples)

An activity can be set up to test the sampling procedure by using a known total population of beans, buttons, or tiles. 600 to 1,000 is a good number to work with. Introduce 100 or 200 marked or different individuals into the total. That is, there would be 200 red beans (or corn) and 800 white beans in a total population of 1,000. A record of samples could be kept as follows: (Be sure to put back the samples taken at one time and mix before others are taken.) (See chart above)

The predicted total population based on the averages of all samples will probably be statistically more reliable than any individual sample. This is illustrated by the record shown above, where the population predicted by each separate sample is seen to vary considerably, but the average is close to what we know is the total population. The more samples you take and average, the closer you come to the real population.

SAMPLING A LIVING POPULATION

Many kinds of animals could be used for this activity. A variety of suggested animal populations appears at the end of this lesson.

Mealworms are used for ease in preparation of this lesson. A population of 500 or more mealworms are needed. They should be kept in a metal, glass, or other 'unchewable' container, so they will not escape. They should be kept in a goodly quantity of cornmeal or other "chunky" food (not flour-too messy), about two to three gallons volume for 500 to 1000 mealworms. Don't bother counting the total number of mealworms. That is what will be determined by the activity.

Count out 100 or 200 mealworms and place them on a large sheet of paper. Allow them to remain undisturbed until they begin to crawl about. This insures that they will have their backs upward. Using a can of colored spray lacquer (flourescent paint is easiest to see), coat the backs of the worms lightly with color. This should not hurt the insects if they are not made wet with the paint. Hold the spray can 10 to 12 inches away and spray in short bursts from nearly overhead for best results.

The mealworms will shed the paint the next time they shed their skins.

In order that they be found randomly spread throughout the culture container they must be active enough to spread out before they shed their skins. Therefore, it is best to choose active, medium to almost full grown mealworms and to sample the population within two or three days after marking them.

Sample the population with each student taking 75 to 100 insects. You will note that this sample will be 1/5 to 1/10 of your population. Several samples can be taken at one time without affecting the validity of the count as long as the total population is rejoined and mixed after each sampling period.

The sample can be taken with a paper cup or other scoop. Do not select individual insects, but take a volume of meal which would include enough insects for your count. A little experience will give a good idea of how much volume is needed.

If a moist paper towel is placed on the surface of the meal the insects will collect under it. This does not seem to have a selective affect for or against the marked individuals and is a good way of getting an easy sample. However, students often find it more fun to hunt for their insects in a sample of meal.

Count the total sample, count the number of marked individuals. Enter the data on a form like that shown in the bean test. Repeat the sampling many times (perhaps students in the class will wish to take samples over a period of one or two days). Remember to return the samples to the total population and allow the insects to disperse themselves before other samples are taken.