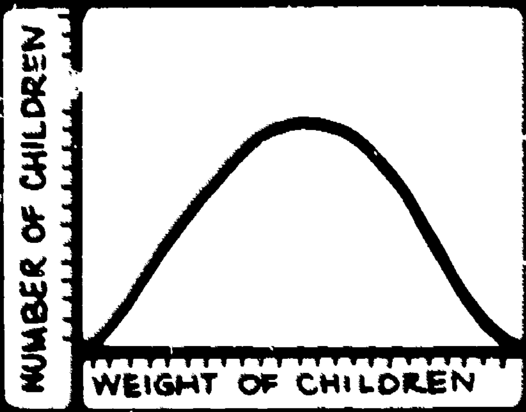
DOCUMENT RESUME

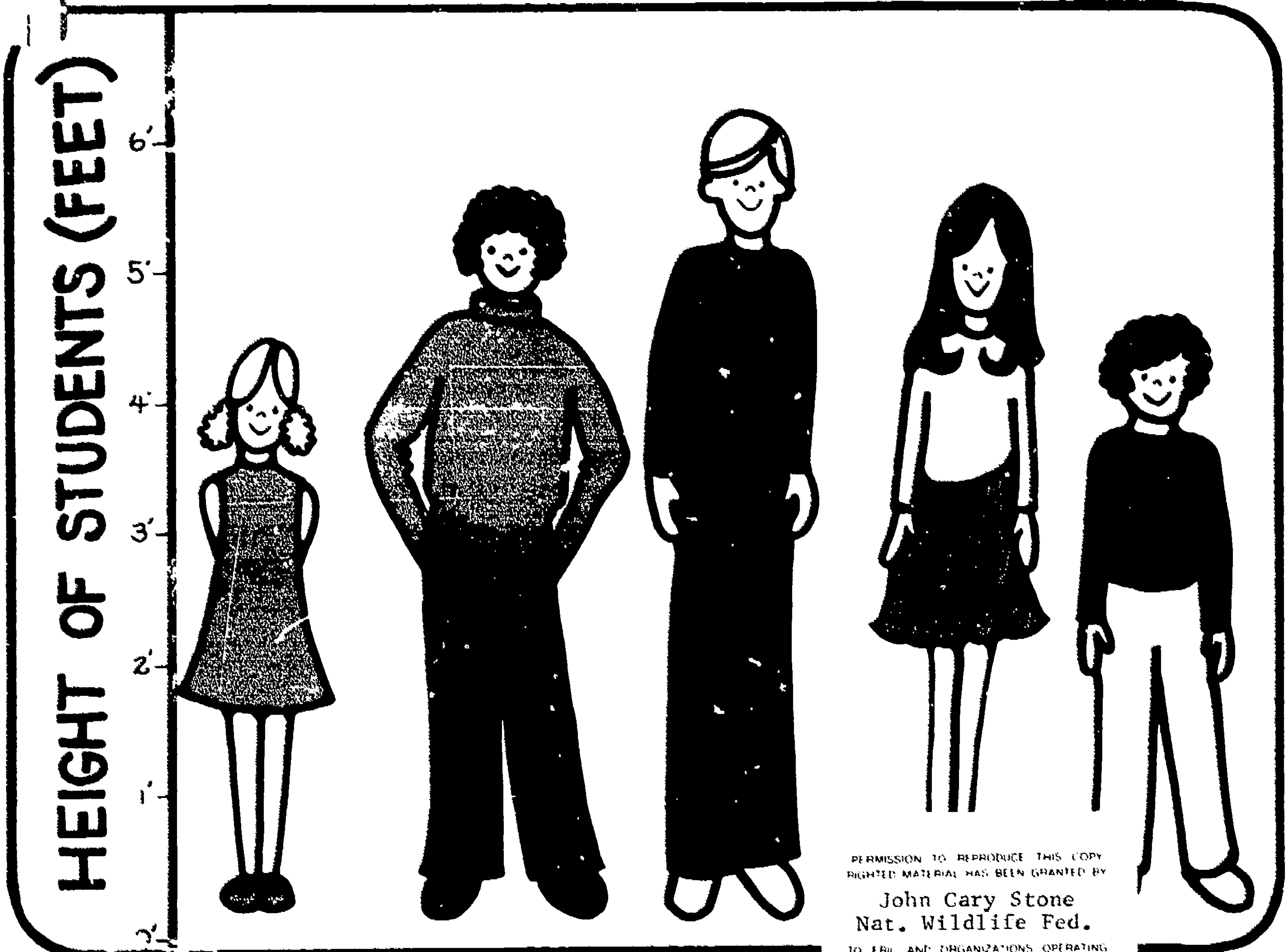
ED 103 239 SE 018 520

TITLE	Genetic Variation, An Environmental Investigation.
INSTITUTION	Minnesota Environmental Sciences Foundation, Inc., Minneapolis.; National Wildlife Federation, Washington, D. C.
PUB DATE	72
NOTE	25p.; Related documents are SE 018 514-534
AVAILABLE FROM	National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036 (Order No. 79123, $1.50)
EDRS PRICE	MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS	Elementary Grades; *Environmental Education; Instructional Materials; Intermediate Grades; Investigations; Junior High Schools; *Learning Activities; Natural Resources; Population Education; *Science Education; Secondary Grades; *Teaching Guides

ABSTRACT

This environmental unit is one of a series designed for integration within an existing curriculum. The unit is self-contained and requires very little teacher preparation. The philosophy of this series is based on an experience-oriented process that encourages self-paced independent student work. In this unit, students explore possible explanations for diversity within populations. The activities are divided into two sections, the first being concerned with the human populations, and the second with seed populations. Students are asked to make observations of variability in physical characteristics of classmates and to develop hereditary patterns by constructing a family tree. Observations of physical characteristics of seeds and their distribution are also included. This unit is designed for students in grades 4-9. It includes a list of materials needed, background teacher information, directions, additional topics, and short teacher and student bibliographies. (MA)





edited and published by
NATIONAL WILDLIFE FEDERATION
written by
MINNESOTA ENVIRONMENTAL SCIENCES FOUNDATION, INC.

THE ENVIRONMENTAL UNITS

This is one of a group of Environmental Units written by the Environmental Science Center and published by the National Wildlife Federation.

In both theory and practice education is the essential base for long range local, regional and national programs to improve and maintain the quality of environment necessary for man's welfare and survival. Citizens must be aware of ecological relationships in order to recognize, appreciate and fulfill constructive roles in society. This awareness should be launched through the existing educational process – in classroom and related school activities. No special courses on ecology can replace the need to integrate ecological learning throughout the existing curricula of our school systems. Furthermore, the life styles and value systems necessary for rational environmental decisions can best be acquired through repeated exposure to ecological learning which pervades the total educational experience.

It was with these thoughts that we developed these curriculum materials. They were designed for the classroom teacher to use with a minimal amount of preparation. They are meant to be part of the existing curriculum – to complement and enhance what students are already experiencing. Each unit is complete in itself, containing easy to follow descriptions of objectives and methods, as well as lists of simple materials.

The underlying philosophy throughout these units is that learning about the environment is not a memorization process, but rather an experience-oriented, experiment-observation-conclusion sort of learning. We are confident that students at all levels will arrive at intelligent ecological conclusions if given the proper opportunities to do so, and if not forced into "right" answers and precisely "accurate" names for their observations. If followed in principle by the teacher, these units will result in meaningful environmental education.

In the process of development, these units have been used and tested by classroom teachers, after which they have undergone evaluations, revisions and adaptations. Further constructive comments from classroom teachers are encouraged in the hope that we may make even more improvements.

A list of units in this group appears on the inside back cover.

About the National Wildlife Federation—1412 Sixteenth Street, N.W., Washington, D.C. 20036

Founded in 1936, the National Wildlife Federation has the largest membership of any conservation organization in the world and has affiliated groups in each of the 50 states, Guam, and the Virgin Islands. It is a non-profit, non-governmental organization devoted to the improvement of the environment and proper use of all natural resources. NWF distributes almost one million copies of free and inexpensive educational materials each year to youngsters, educators and concerned citizens. Educational activities are financed through contributions for Wildlife Conservation Stamps.

About the Environmental Science Center—5400 Glenwood Avenue, Minneapolis, Minnesota 55422

The Environmental Science Center, established in 1967 under Title III of the Elementary and Secondary Education Act, is now the environmental education unit of the Minnesota Environmental Sciences Foundation, Inc. The Center works toward the establishment of environmental equilibrium through education – education in a fashion that will develop a conscience which guides man in making rational judgments regarding the environmental consequences of his actions. To this end the Environmental Science Center is continuing to develop and test a wide variety of instructional materials and programs for adults who work with youngsters.

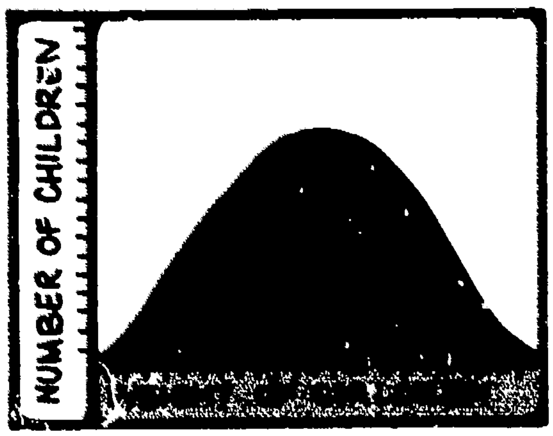
Genetic Variation

An Environmental Investigation

BY

NATIONAL WILDLIFE FEDERATION

MINNESOTA ENVIRONMENTAL SCIENCES FOUNDATION, INC.



Design and Illustrations by

JAN BEYLER

Genetic Variation introduces children to some possible explanations for diversity in the biological world. As an outgrowth of the activities in this unit, the students will be able—and should be encouraged—to develop their own explanations for this diversity.

Your role will be to guide the students' reasoning, when necessary, and to provide a classroom climate which is conducive to student speculation. In fact, a major emphasis throughout the unit is speculation, because many of the questions the students explore have no answers which are agreed on by everyone in the scientific community.

Although **Genetic Variation** might be considered a science unit, many of the activities relate to problems in social studies, while others would be appropriate for use in a mathematics curriculum. The possibilities are limited only by your imagination and interest. Everything in our environment relates to everything else, and the activities of this unit are no exception.

Table of Contents

INTRODUCTION

In the early sections of **Genetic Variation,** the students will study themselves and their peers. They will do this while collecting data on a single population variation — one's tongue-rolling ability. The later sections of this unit deal with the variation in the physical properties of several **seed** populations. And, in the final section, the students will consolidate their data by generalizing about their experiences in the unit.

Instead of tying all the ideas together for them with a summary statement, let the students make their own conclusions at their own pace. The story, "Johannson and the Bean Seeds," will provide a final opportunity for speculation. Although written in a light tone, the story is intended to offer data for discussion in a context which the students will understand.

A minimum of three weeks should be spent to cover the material in this unit. (This time estimate assumes that an average of ninety minutes per week will be devoted to the activities.) As you read through this unit, though, try to envision some cross-curriculum applications of the activities, and, where appropriate, point these out to the students. The unit could be a launching pad for investigations and discoveries in many other fields . . . because all things vary, and everything relates.

MATERIALS

- grid paper
- pan balances
- centimeter rulers
- field corn (1 lb.)
- Great Northern beans, number one and number two grades (1 lb. each)
- lima beans (1 lb.)
- pinto beans (1 lb.)
- red kidney beans (1 lb.)
- dried peas, unsplit (1 lb.)
- castor beans (1 lb.)
- any other dried vegetables (1 lb. each)
- paper sacks (1 dozen)

Genetic Variation

Human Populations

Each student in your class is different from every other one. They have different personalities; they vary in intelligence, and they present a variety of physical traits which are distributed over a wide range of values. It does not make sense to speak of a "typical child." It *can* make sense to speak of a "typical *group* of children."

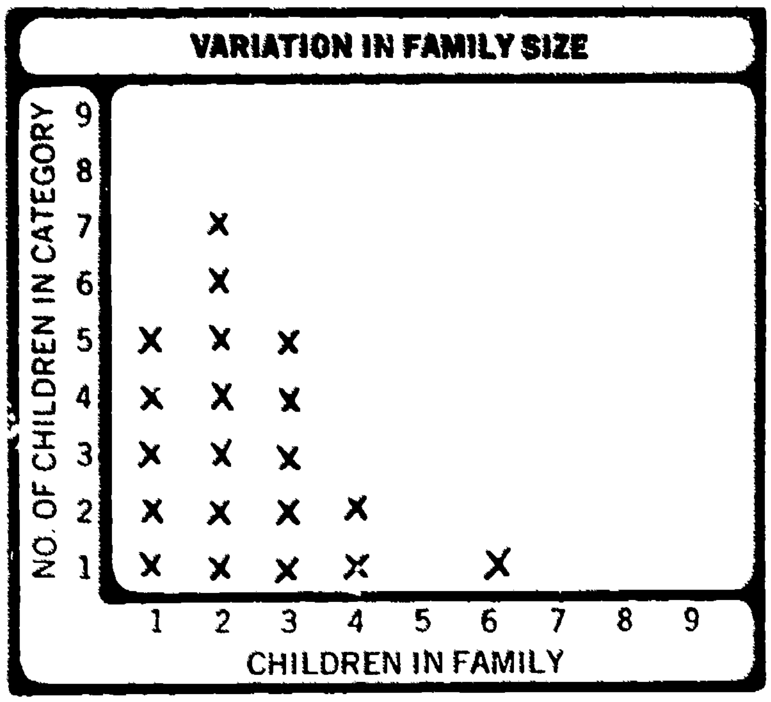
But how does one describe a group of dissimilar individuals? Scientists have been concerned with this question for a long time, because no two specimens they find and no two measurements they make are completely alike. All things exhibit **variation.** Of course, if the differences are very small, such as those among grains of rice in a bowl, it is easy to ignore the differences altogether and think that the grains are really alike. But even the smallest differences can be examined closely. The variations that are found may reveal unsuspected and important information.

In selecting a group of dissimilar individuals for study, one usually has in mind some things the individuals have in common. All the students in your class are at the same grade level, for example, and all the grains in the bowl were rice grains. Once this is recognized, one can turn to the differences among the members of a group, or, more specifically, the traits which show **variation.** It is easy to describe a trait which varies within a group. For example, if the students' height is of interest, simply list the height measurement of each student; that list will constitute a description of the varying trait. If the weight of the grains of rice is of interest, give the weight of each grain. In general then, to describe a trait which varies among members of a group, list the measure of that trait for each individual in the group. *Since the group consists of individuals, the description of the group is the description of all the individuals in it.*

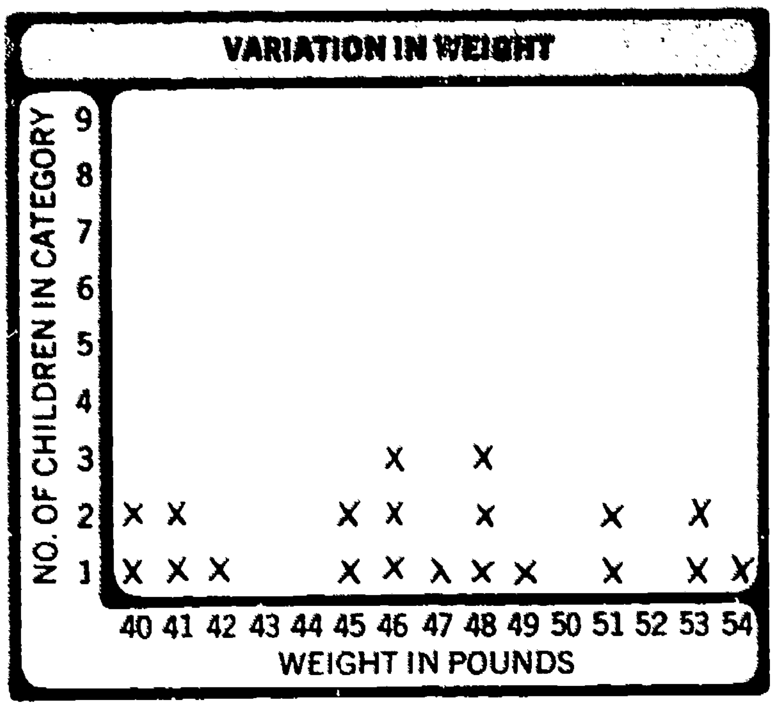
Here, for instance, is a table of data for a first grade class:

Name	Sex	No. in Family	Height (inches)	Weight (pounds)	Birth (month)
John	M	2	46	48	Apr.
Mary F.	F	1	40	41	Jun.
James	M	3	45	46	Oct.
Richard	M	2	44	48	Jun.
Joan	F	2	41	40	Mar.
Alice	F	1	51	54	Aug.
Frances	F	3	46	49	Feb.
Kevin	M	6	47	42	Mar.
Tom S.	M	2	49	47	Oct.
Linda	F	1	42	40	Apr.
Barbara	F	4	42	46	Jan.
Ruth	F	3	50	53	Jul.
David	M	1	41	41	Feb.
Mary P.	F	2	50	51	Apr.
Tom A.	M	2	46	48	Dec.
Robert	M	3	43	45	Apr.
Michael	M	1	47	46	Mar.
Martha	F	3	46	45	Mar.
Peter	M	4	52	51	Jan.
Betsy	F	2	46	53	Oct.

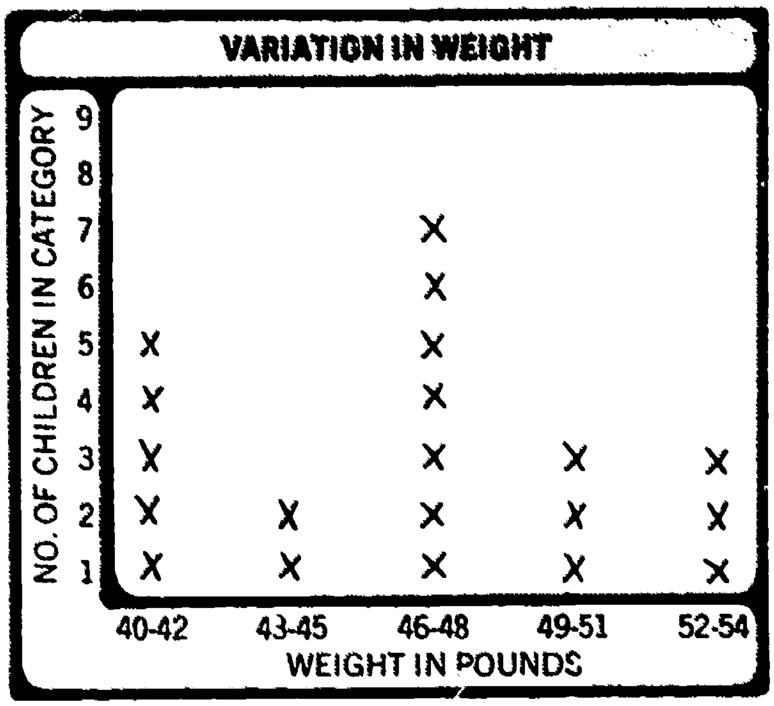
There may be circumstances under which it would be important to know if this class is "typical"—does it show variation typical of a first grade class? There are ten boys and ten girls. As far as sex distribution goes this would seem "typical." Under family size, there are five single children, seven 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 that in making these summaries we have merely counted the students in each category, disregarding the names of the children and all their other characteristics. This is the simplest kind of analysis. The results can be displayed in **histograms** graphs with a cross drawn for each child.



The height and weight data can be treated in the same way.



This graph does not give a very complete picture, however, because the weights of the children are so varied, making generalizations difficult. It is helpful in such a case to choose the weight values in a range of several pounds. For instance, 43-45 pounds could be used as a category along one axis. For this sample, the results cluster in the intervals from 40-42 pounds and 46-48 pounds.



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. This theory proposes that the variation of characteristics within one species living in a particular environment will allow *some* individuals in that species to survive better and reproduce more than other individuals of that species. But those other, less suited individuals may be more effectively adapted to life in an environment different from the one they are living in. If a change occurs, altering conditions of the first environment so that the new conditions are more favorable to the previously less-suited individuals, then that portion of the population that was originally doing well will probably have to alter and become more like the newly flourishing individuals. In succeeding generations, more and more of the animals or plants will exhibit the traits which became advantageous to living in their environment. 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, therefore, a very significant property of populations.*

*Parts of this have been reprinted with permission from *Variation and Measurement Teacher's Manual* written and published by the Science Curriculum Improvement Study, Berkeley. Copyright 1964 by the Regents of the University of California.

I. Variability in Physical Characteristics

A. Variation among Class Members

Begin this section by asking the students in the class to describe themselves as a group. This will have to involve a description of the individuals in the group. Maybe the students have played the game "I'm thinking of someone (or something)," which is very similar to this. The object of this game is to guess whom one individual has in mind (it must be a person visible to all participants) by having that individual describe the physical characteristics of the mystery person. In playing the game, the students become more aware of some of the physical variability which exists among the class members. Of course, this variety is obvious to you and probably to the students, but they may never have discussed it in a formal sense. The major idea for the students to grasp is that *no individual has precisely the same characteristics as anyone else*. **This concept is applicable to every species**—man, dog, amoeba, rose, or oak tree.

Describing a group is an activity similar to that of describing individuals, but the description must be sufficiently general to include all the individuals in the group. This is not an easy task since each characteristic chosen will be represented by a range of values, rather than by a single value. Thus, if the class described height, each individual's height would have to be given. The description of a group must be the description of all the individuals in it.

Ask the students to begin their group description with these ideas in mind. 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.

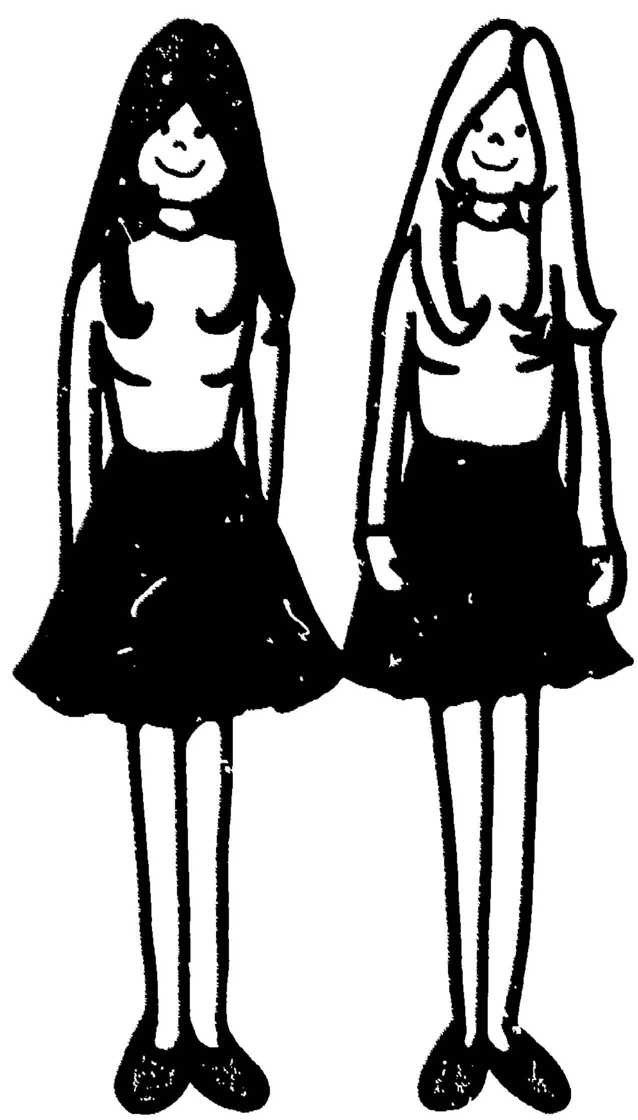
The class may construct a chart like the ones on page 5 listing the characteristics and the values found for each student. Most of the students will know their approximate height and weight. If they are unsure, they can take measurements or they may check with the office or nurse to obtain the information.

When the charts are complete, you will want to discuss them with the class.

ASK THE STUDENTS:

What do the charts seem to reveal about the class? For the characteristics chosen, are any two students exactly alike?

Through discussion, it should become obvious that all children are not identical, even though they may have similar characteristics. Even identical twins, while sharing many traits, are not *exactly* alike.



Most of the characteristics described by the class will not be permanent characteristics—in other words, 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 have to pursue their study of continuous variation in the second major section of this unit, "Seed Populations," by substituting seeds for people.

B. Variation in the Ability to Roll One's Tongue

The characteristics examined so far are variable over a rather wide range of values, as the class charts indicate. To provide contrast, the students will now examine tongue rolling*—a characteristic which does not range in value, but is either present or absent in the population. The mechanism of inheritance of this trait 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.

*The tongue is rolled lengthwise, with the sides turning upward

Students will find they are either capable of rolling their tongues or incapable of doing it. There is no intermediate ability, and it cannot be learned through practice. (Note: Physical characteristics lacking measurable intermediate values seem to be the exception rather than the rule in terms of biological variation. The reason for devoting time to studying one of these traits is simply to provide contrast for other investigations. The significance of this contrast will be further developed in later sections of this unit.)

Start this 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 students may have difficulty in rolling their tongues. These children are probably the ones who are unable to move the proper muscles.

Allow the class a sufficient amount of time for experimentation; then count the number of children who can roll their tongues. If some of the students who are unable to roll their tongues feel that practice will help, let them do so for a while. You may have to tell them that practice will not affect their performance.

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.

ASK THE STUDENTS:

What might be learned if such a survey were to be conducted? How many students will be able to roll their tongues? Of what value might it be to collect additional data? Have any of you conducted surveys before? Are you familiar with any of the national surveys and polls? If so, what do you think such canvasses accomplish and how are they made?

II. Taking the School Survey

In taking a school survey, ask the cooperation of the other teachers and of your principal. Select a specific time so that the students do not cause any 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 shouldn't expect your class to use these techniques. You may wish, however, to discuss some of the *reasons* for systematic rather than haphazard sampling. For the purpose of this survey, your class is the sample and the school is the population. Additional ideas of samples and populations will be discussed later in the unit.

Before beginning the survey, you might want to ask the students to predict what their findings will be. They can use the findings of their own class as a basis for their predictions. After the completion of the survey, compare the class predictions with the data they've gathered. This would be a good time to discuss the validity of using the class as a sample of the school population.

It is advisable for the students to keep records of the information they collect. 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 will result when it is discussed. Talk with the students about these ideas. It is important that they perceive record-keeping as a very significant part of these environmental activities.

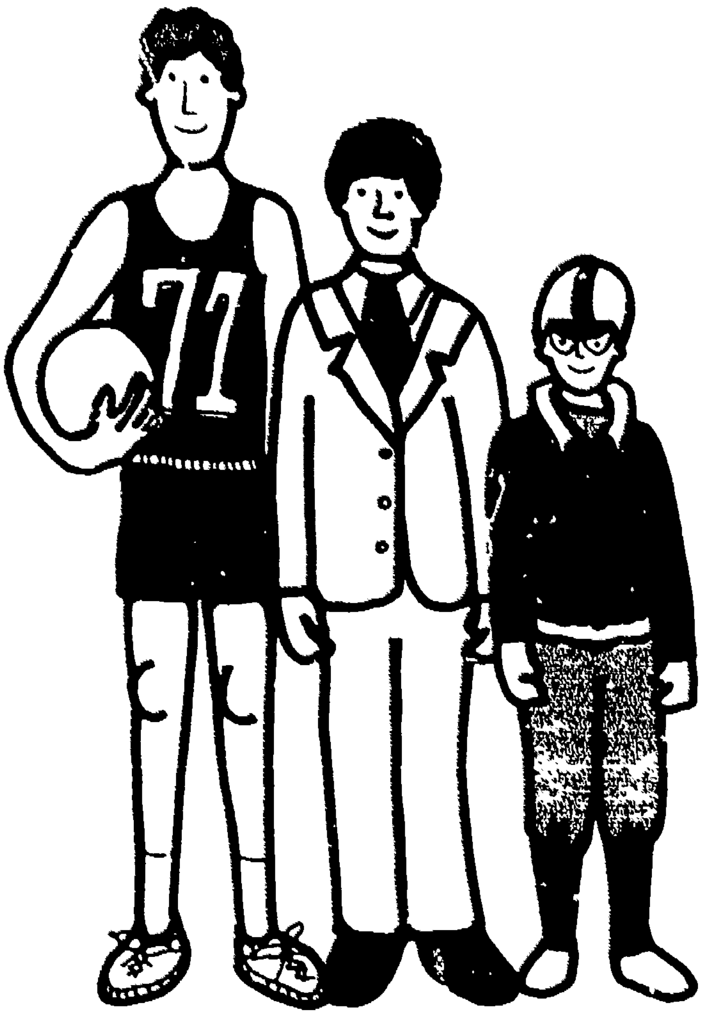
A. The Survey

Before the students determine how they will conduct their survey, they will need to understand something about populations and samples. You can begin this section by asking them if they think there will be as many people in each class surveyed who are able to roll their tongues as there are in their own class. After a brief discussion of this question, ask them to consider:

If you were to conduct a survey to determine the height of the average American adult male, which of the following groups would you choose for your survey and why?

1. **Basketball players**
2. **Your 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 these groups are samples of the population, they are inadequate for survey purposes since they represent the extremes. Fathers are probably the most representative of the three. Could all three groups be used for certain types of surveys?



Relate these ideas to the survey the class is about to conduct. The students have already made a survey of their own class. If they think of their own class as a sample, and if, as a group, they are representative of the school population, ask what results they could expect to obtain through the school survey? This is a good time to have each student make his prediction of the results and record it in his notebook. Now return to a consideration of the survey.

The students must first determine if they wish to poll the entire school.

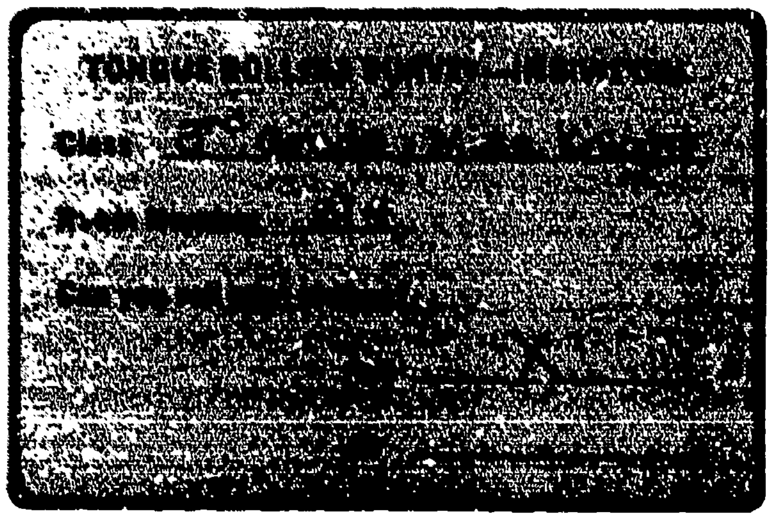
ASK THE STUDENTS:

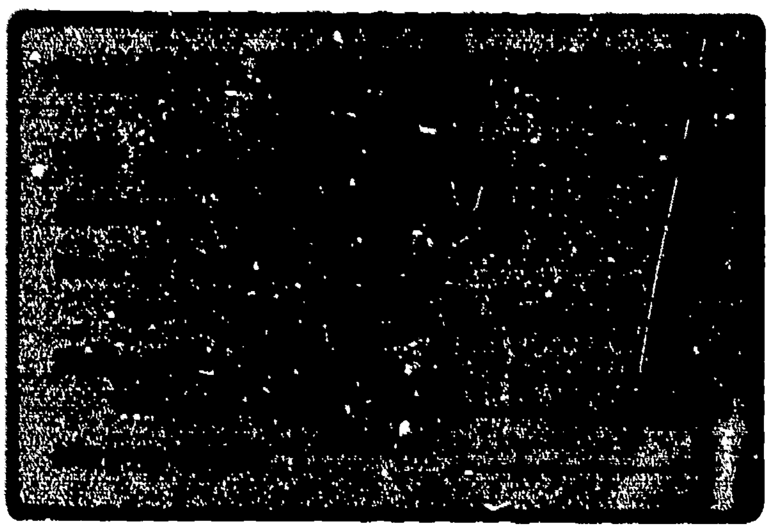
What are some of the problems you will face in making a poll of the entire school? How will you collect your information? Could you develop some kind of chart or survey form so that each student involved in collecting data does so in an orderly fashion? How will you approach teachers and enter their classrooms in a way which will not be disruptive? Should you first speak with the principal?

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

Developing the survey form should not be difficult. There must be a place on the form for each student polled. A separate form for each class in the school can be prepared and distributed to your students, who, in turn, can take one form around to each class to be surveyed. The survey form for each class needs only basic information:

(Note: Below are sample survey forms. Blank copies are provided in the back of the book so that you can duplicate them for your students.)





When the survey is completed, the results should be tallied and discussed in class.

B. Discussion

After the whole school has been surveyed, and results tabulated, examine these results with the class. How many students could roll their tongues? How many could not? It would be helpful if the class could convert the data into percentages. Results expressed as percentages will enable them to more easily compare class results with those of the entire school. Percentages could then be put into graph form.

One source of information states that 7 out of 10 people are able to roll their tongues, or, 70% of the total world population. If the class is a **representative sample** of the population then, approximately 70% should be able to roll their tongues.

ASK THE STUDENTS:

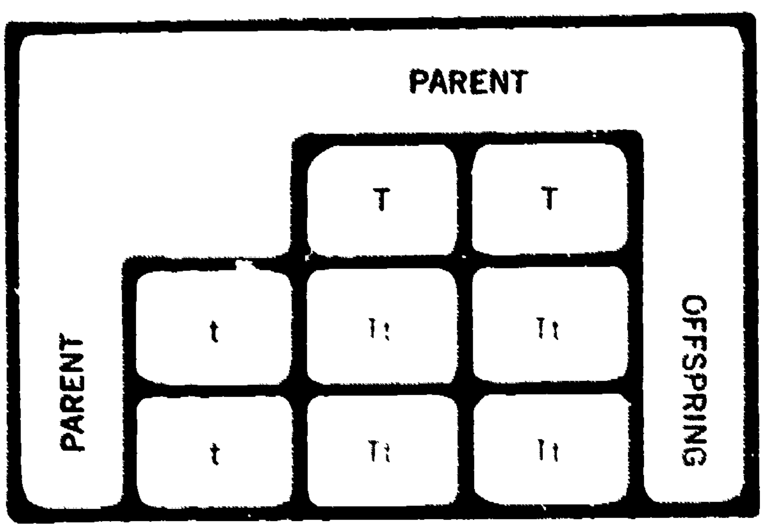
How did the class predictions compare with the actual results of the survey? Was our own class a representative sample of the school population? Were any classes found to be more representative than others? Was the total school population any more representative of the total world population than our class was? Why?

III. Developing Hereditary Patterns

The children have compared and discussed the incidence of tongue-rolling among themselves and throughout the school. In this section they will gather additional data 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 himself does or does not exhibit the tongue-rolling trait.

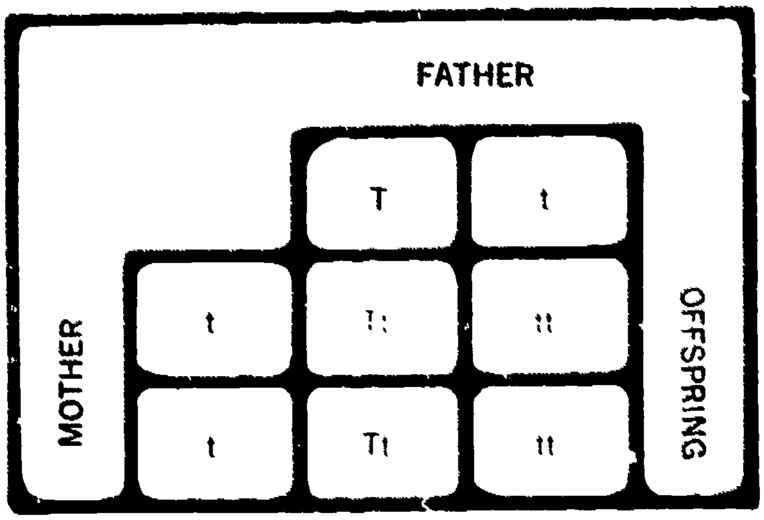
The point of the section is to uncover the notion that characteristics are inherited rather than to develop a detailed genetic theory of inheritance. While the class will work with some simplified techniques for depicting possible means of inheriting the trait, these methods should not be stressed at 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. A sample follows.

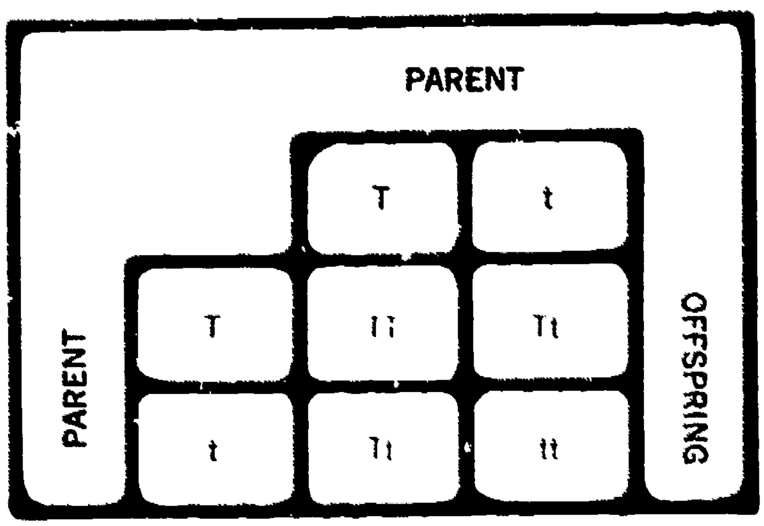


One important point to emphasize is that *each parent contributes one gene for each characteristic to each offspring.* The contributing genes in the case of tongue rolling may be either dominant (T) or recessive (t). If there is one large T gene, it will control the manifestation of the trait. That is, while the offspring may have both a large and small T, as in the case above, they will still be able to roll their tongues because the large T will dominate the small one. 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 has no dominant tongue-rolling genes, and she cannot, therefore, roll her tongue. The father can roll his tongue and contributes only dominant genes. Therefore, all of the children can roll their tongues (each possesses a dominant gene).

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



In this instance, two of the offspring are tongue rollers, two are not. This is a one-to-one (1:1) ratio. Should one of the children, a Tt, marry another Tt, the odds would be that three offspring would be rollers and one would not, yielding a three to one ratio:



These preceding grids show three of five possible crosses or matings illustrating the inheritance of the tongue rolling trait. But much of the workings of the actual process of inheritance has been left unsaid. In the first place, not all families produce four offspring. Even if each did, it is possible that not all *theoretical* types would appear. For example, in the case of the last cross (Tt with Tt) four children might be produced, all of whom *could* roll their tongues. The theoretical cross, a three to one ratio, merely states that for every four children produced the *possibility* is that three will be rollers, and 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. It might take twelve or sixteen children before the ratio appeared to take hold.

Inheritance is rarely so simple a matter as straight dominance versus recessiveness. In some cases a "dominant" gene appearing with a recessive for a particular trait will "combine" with the recessive to produce an intermediate type. But this situation, which is referred to as *incomplete dominance*, does not arise with tongue rolling.

By necessity this discussion has been brief. (Refer to the bibliography for a more thorough treatment of the subject of simple Mendelian inheritance.) But what has been discussed may be related to the family trees the 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 interesting to the class because they deal with something about the students themselves. The extent to which you pursue the grid activities will depend upon the students' interest and understanding. Rather than stressing the science of genetics, you should emphasize the fact that characteristics are inherited. Something of how this occurs can be learned through constructing a pattern of inheritance—the family "tree."

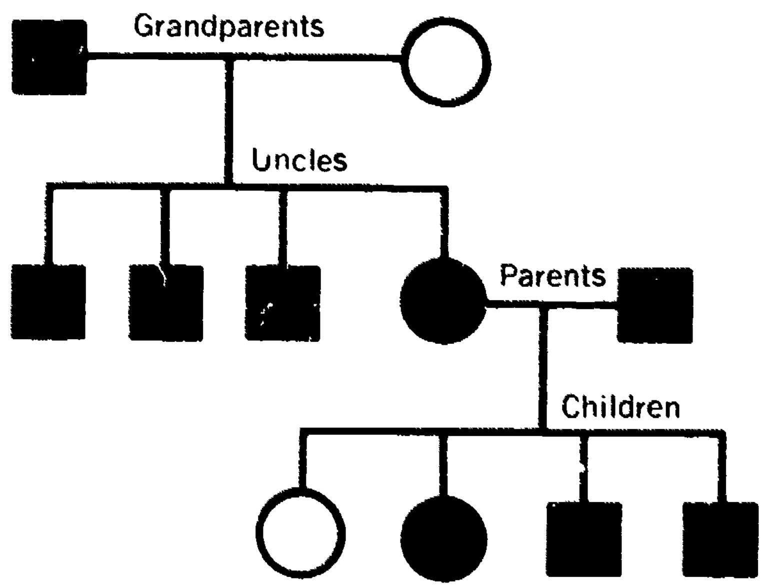
Encourage the students to seek their own answers to the discussion questions, providing only information you are certain they cannot possibly have gained through past experience.

A. The Family Trees

Each student should first ask his parents if they are able to roll their tongues. Then brothers and sisters should be included. If your students can question their uncles, aunts, or grandparents this also would be helpful.

When each class member has the information, he may begin to construct his family tree or ancestry. Below is an example of one such possible tree, with grandparents and uncles from one side of the family also shown.

First Step



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

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

Ask the students if tongue rolling among class members seems to depend on whether or not the parents are able to roll their tongues. It may take some further discussion in order for the students to agree among themselves that "yes" is the answer. Since this is so, something must be passed from parent to child which determines the child's characteristics.

How does each child explain the differences among the children in his family? In other words, how does he explain that he might be able to roll his tongue, but his brother cannot? If both parents exhibit the tongue rolling trait, does it follow that all the children will exhibit it? Here, the answer should be "no." How can students account for the variations? Ask them if it is possible that something is happening which is, in effect, unseen?

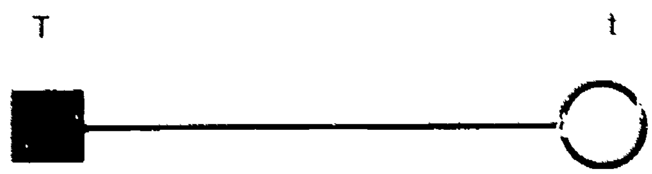
Select a single ancestry or line of ancestors of one student to illustrate a discussion of this last question. You will want the students to begin to infer from a pedigree some of the gene types which create the pattern. In order to make such inferences, they will need to know some of the background information presented earlier in this section. The students will especially need to be aware that the trait of tongue rolling ability is dominant and that this dominance is represented by a capital T. Begin by selecting, as a discussion example, an ancestry in which one parent cannot roll his tongue. Using the symbols you have developed, draw the parental condition on the board.

Above each symbol, describe the trait of each parent as follows: male, "Tongue does roll" (use a capital T); female, "tongue does not roll" (t).

Tongue (male) does roll

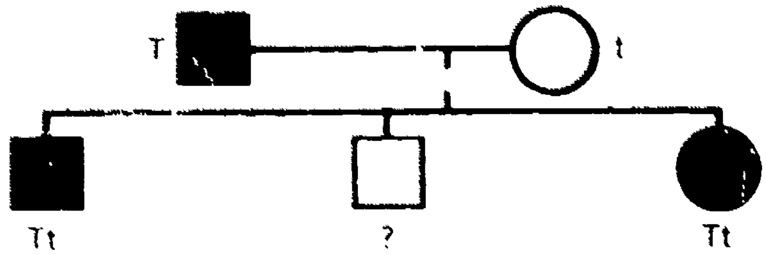
tongue (female) does not roll

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 T and a small t to indicate the condition. Make sure that each student understands the meaning of the new symbols.



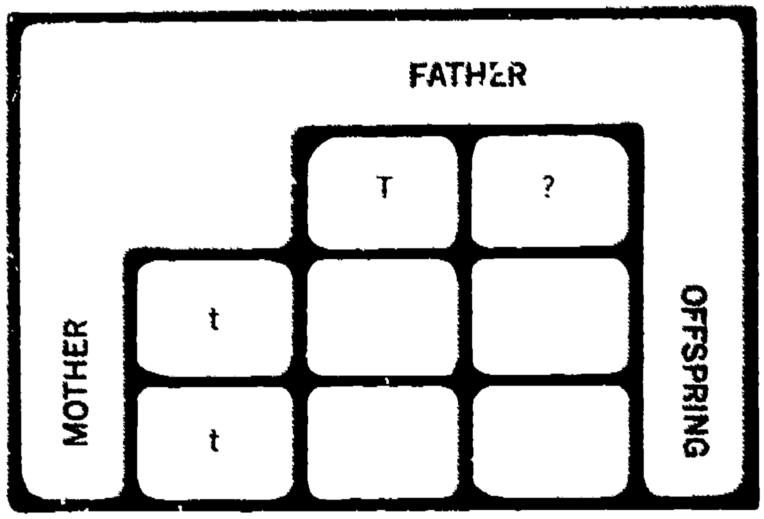
Refer back to the idea of parents "passing on" something to the children. Allow T and t to stand for that "unseen something" which is transmitted. In other words, the father (T) can roll his tongue and the mother (t) cannot, and they have a child (the student) who receives one gene from each parent. 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, ask if this child would be able to roll his tongue. If some say yes, inquire why they think so.

The proof, of course, resides with the child whose pedigree is under discussion. Suppose that that child cannot roll his tongue or perhaps a brother or sister cannot, while one of the siblings can. This would appear to contradict the above reasoning. Re-examine the pedigree and assign initials to it as follows. (assuming there are three children in the family):

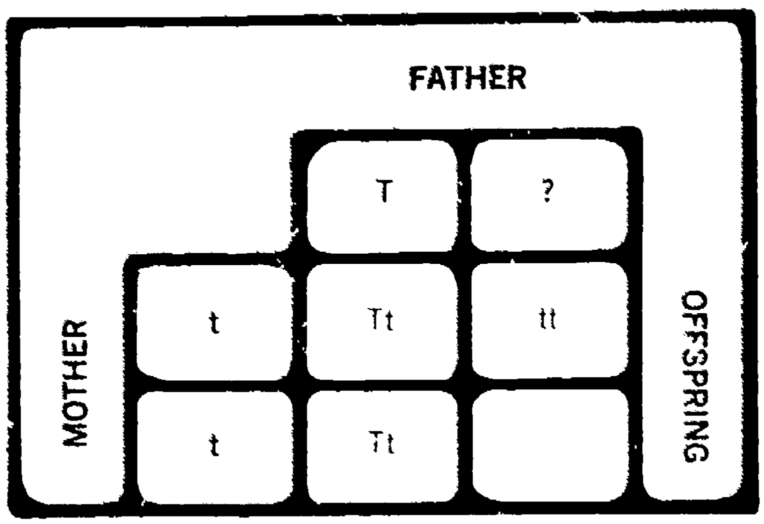


He . . only two out of three children exhibit the trait. How can this be explained? Two letters are assigned to the children, but only one to each parent. Ask if there might be something not included as yet which ought to be considered. How can two letters be assigned to parents with some certainty that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

First, observe the mother. Ask if it is possible for her to "carry" a large T but still not be able to roll her tongue. This cannot be the case, because whenever the large T appears, the individual *can* roll his tongue. Ask then what the only alternative would be. Hopefully, the students will realize that there must be two small t's. 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.

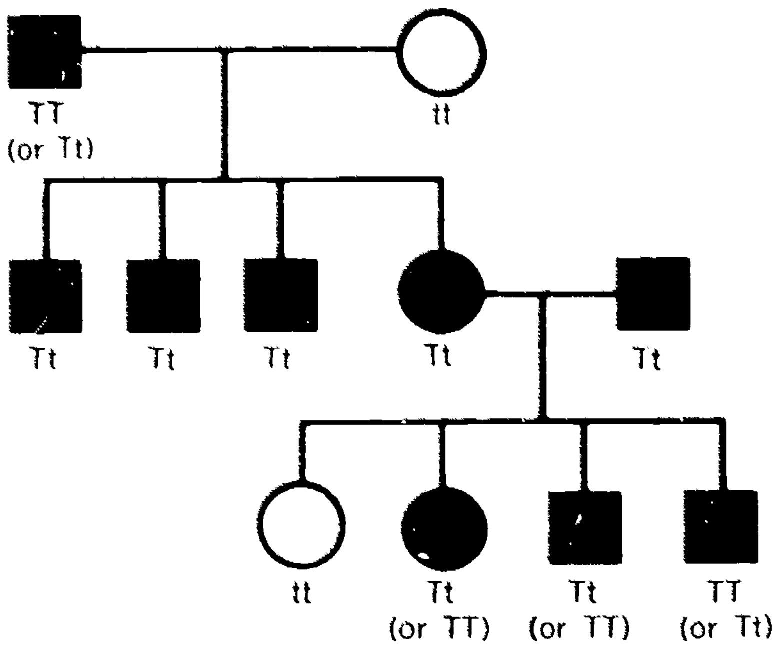


The class can be certain of the mother's type and of the type of the three offspring. Complete the grid for the known types, explaining how it is done.



If the mother's type is tt and she cannot roll her tongue, then one of the offspring must also be tt because one of them, according to the pedigree, cannot roll his. Ask: 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, theoretically, will 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 students can arrive at the possible genetic types of their parents and themselves. Some of the students might want to further expand the information in their line of ancestry charts. The example below is a completed version of the chart on page 10.



B. Discussion

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 examining several generations.

The next set of activities will provide the children with a contrasting situation in which indeterminate variation is studied.

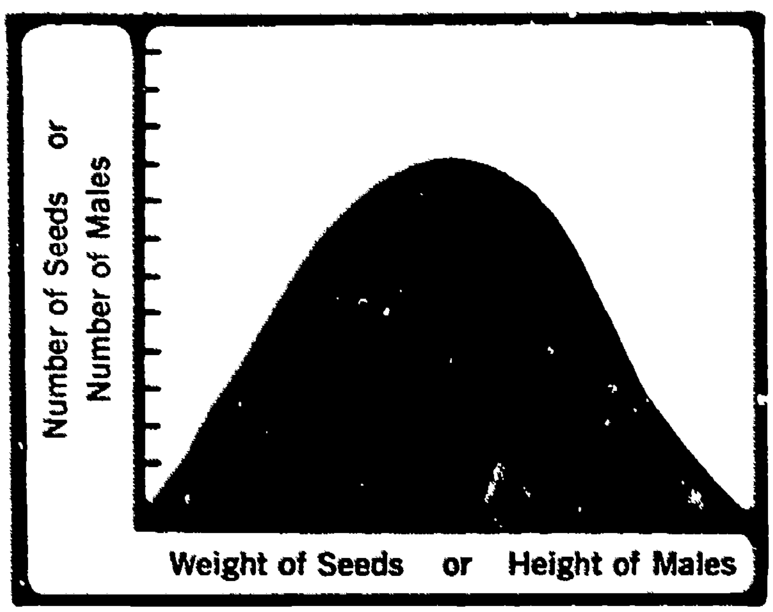
Seed Populations

I. Observing and Measuring Physical Characteristics of Seeds

So 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 is an example of *limited variation*—it is a variation found to be either present or absent in an individual 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.

Seeds are chosen for this next study because they are easily obtainable, exhibit great variation, and are available in many species.

While there is little comparison between man and seed, measuring and graphing the heights of a representative group of adult males will yield about the same shape graph as that of the weights of a sample of corn seeds. Both graphs might appear similar to the one below:



This is a normal or frequency distribution curve. Its bell shape is the same as a frequency distribution curve of intelligence.

Thus, the objects of study are not important. What is important is the fact that **all biological species exhibit a similarity in the frequency distribution of certain characteristics.**

In beginning this section, the students may become bewildered by what seems to be an abrupt change of pace. Seeds might appear to have little to do with the preceding activities. Explain that you wish them to describe their seeds much as they described themselves in the section "Human Populations." (You might also tell them that they will return to their discussion of tongue-rolling after they have finished with the seed study.)

The objectives of this section will be to reintroduce the concept of **variation** through the study of some physical properties of seeds and to introduce the process of **measurement**. Before the students measure the seeds, they will examine them for their measurable properties. The students will also determine methods for taking these measurements.

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

A. Seed Measurements

Distribute a handful of seeds to each student, one type per student. Try to avoid distributing more than three handfuls of each variety throughout the class. Have the students spread the seeds out on their desks or tables for observation. If the children have slanted desk tops, suggest that they arrange the seeds above a book edge to prevent them from rolling onto the floor. Also give one of each kind of seed to each student (i.e., one kernel of corn, one of each size of Great Northern bean, one lima bean, etc.) and have them keep the seeds in a separate pile on their desk.

To stimulate observation, the students may wish to play a game similar to the description game in the section "Human Populations." On separate sheets of paper, have each student describe his handful of seeds which are all alike. Have the class write down observable properties. Remind the students that the object of the game is to avoid confusing another person who might read the list or description. They should strive to write the most complete description they can for immediate identification. When they have finished with their descriptions ask them to write their names on the back of their papers and pass them to the front of the class. Then re-distribute the lists to the students so that no one receives his own paper. By reading the descriptions they now have, and referring to their pile of assorted seeds, they should try to determine which seed their sheet describes. After everyone has had time to work on this question, each student can check with the person who wrote the description to see if he was able to determine the seed which the paper really attempted to describe. You can have several exchanges of this sort, since there will be a number of different types of seeds distributed.

After this activity, each student will need to take a closer look at the seeds he described originally.

ASK THE STUDENTS:

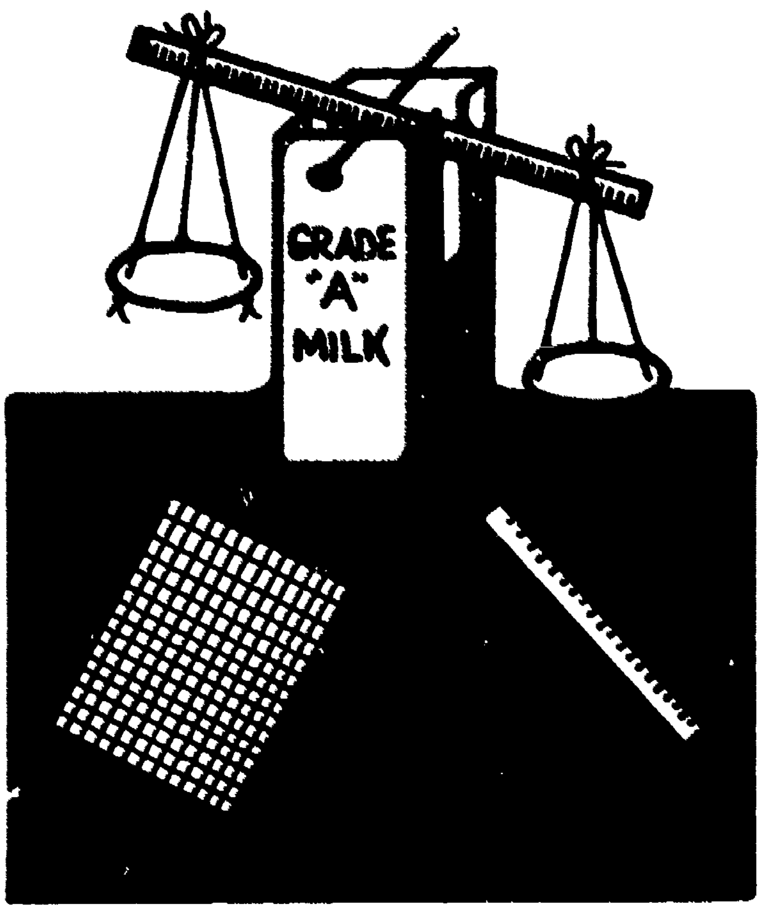
What variations can be observed from one seed to another within that handful or population? More specifically, what properties vary? Which of these are measurable? What are some means of measuring variability?

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 centimeters. 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 students wish to devise a continuous spectrum, assigning successive numbers to adjacent colors, they will be able to establish at least one arbitrary means for quantifying color.

When the lists of properties and measuring systems are placed on the board, have each child select a property and then devise a means of measuring it, using about 50 of his seeds. The larger the number of seeds measured, the closer the student will come to defining the limits of a 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 methods. Some should weigh the beans, some use rulers, others might use the grid paper (or anything else suggested).



B. Discussion

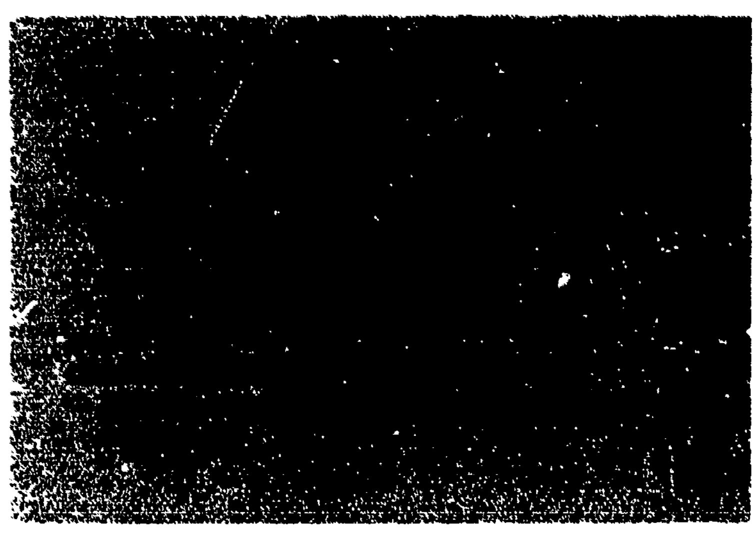
One of the first questions which might be raised is "Do the seeds vary (in the property measured) or are they the same?" Often the children do not perceive slight differences as being significant variations. Ask: Since the seeds within each set measured are of the same **species,** should there be any reason for variation from one seed to another? (If the children do not know about "species," you might want to supplement this unit with **Differences in Living Things** another unit in this series.) If so, how could the students account for this variation? To answer this last question, one must consider both environmental and genetic factors. Encourage the children to speculate about the answer, listing possible suggestions on the board. Can any of the suggestions be readily investigated? Some children will probably want to plant the seeds to discover, for example, if small seeds develop into small plants, and large seeds into large plants. Encourage any suggestions they have for investigation. These may be undertaken as time permits.

II. Distribution of Physical Characteristics of Seeds

In this section the students will develop and use a histogram for recording and ordering quantitative data concerning variation. The histogram will show that measurements or counts are distributed around the **average** measurements or counts.

The students will use the data collected in Part I, "Observing and Measuring Some Physical Characteristics of Seeds" for the construction of the histogram. When the graphs are completed, the students will compare their results. Through comparisons, they should be able to generalize about the distribution of variable inherited traits.

The importance of this distribution is pointed out by comparing it with the distribution of tongue rolling within the population. Widely distributed variability in a trait provides much raw material for the process 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 varying 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 Section III of the first part of this unit only one set of genes controls tongue rolling, whereas among roses many genes act to produce variation. You should ask the students to give some thought to these ideas at the end of this unit.



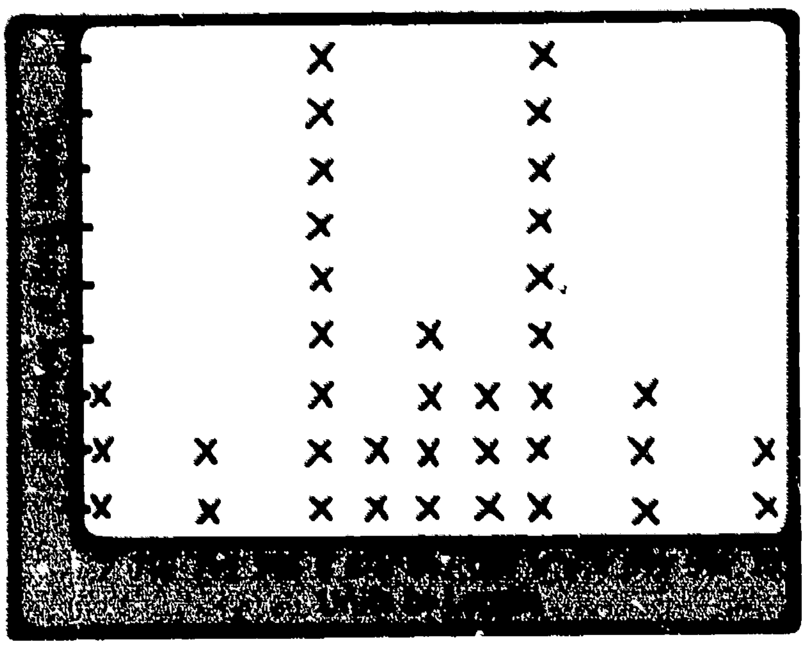
A. Histograms

Distribute several sheets of grid paper to each student. Have the students examine their seed measurements and think of some methods for organizing them. They might order them on the basis of **increasing magnitude** of the values. Ask them if this method of organization makes the data any more meaningful. What observations can now be made about these measurements?

Some students will observe that measurements are not all identical, yet there are many which are the same or at least close in value. Perhaps another observation might be that there are fewer small and large 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 units.

Suggest that each student examine his data and report his findings. If a pattern occurs repeatedly throughout the class, what does this suggest about variability?

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.



The horizontal line is, in reality, a segment of a number line with $\frac{1}{4}$ 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 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 it for the rest of the class.

ASK THE STUDENTS:

Is there any similarity among the histograms? (If so, ask the class to describe that similarity.) **Are graphs of the same kinds of seeds more alike than graphs of different kinds? How can you account for the likenesses?**

Direct the students' attention to the one thing all the graphs should have in common, **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. Ask if they are at either end or if they fall in the middle? Once they have determined this answer, ask them to suggest reasons for their observations. Maybe 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?

ASK THE STUDENTS:

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 index fingers. Collect the measurements and construct a histogram on the board.

The length of index fingers is also distributed normally about a central point. 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 questions for the class to consider might be: Why are there measurable differences among seeds which are members of the same population? How can the students account for the variation? Of what importance is the variation?

III. Variation and Diversity

In this section, the students will examine the concept of variation more closely. They should arrive at some conclusions as to the biological importance of variation and be reasonably able to account for biological diversity. This section begins with a game intended to reveal, through analogy, something of the process of natural selection.

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

B. The Game

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. Ask the class to review these ranges and keep in mind some of the ideas discussed during Section II, "Distribution of Physical Characteristics of Seeds." Explain that you are going to give them the opportunity to select one seed from each sack. But before selecting, they are going to predict something about the physical properties of that seed. For example, if lima beans were originally measured on grid paper for length, the students must predict how many grid units in length the selected seed might be. Or, if they were weighed, they must predict how many grams the selected seed would weigh. (Note: You may find that some of the seeds of the same variety were measured for more than one quality. In other words, one student may have measured length of lima beans while another student measured weight. You will probably want to put all of the histogram data on the board and let the students choose the properties they wish to predict.)

Once they understand how the game is played, they need only refer to the ranges for the particular property measured and the 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, have each student take one seed out of each sack and verify his prediction by measuring the seed. Record the measurement next to the prediction and compare the result with the actual data recorded on the histograms.

ASK THE STUDENTS:

How accurate were predictions? On what data were they based? If there was an exceptional degree of accuracy between prediction and verification, how do you 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 student is making a random selection rather than 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 the extremes 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. Ask if the same effect of the small ones settling to the bottom is observed for all seeds? If so, ask why this should be true.

To illustrate the importance of variation, prepare two sacks of seeds. (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 put them in order quickly.

Choose 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. (All the beans are the same.) Further, he may say there is *no variation*. (This is the observation you hope he 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.

ASK THE STUDENTS:

Are there intermediate abilities in tongue rolling? 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 the students to discuss ideas among themselves. The concluding story in the back of the book will hopefully provide them with more clues to the answer.

A further illustration of the significance of variety is the selection practiced by pedigreed dog raisers. Ask if anyone in the class has a poodle. If so, ask what the size of the poodle is. Do poodles come in only one size? The children probably know there are standard sizes in the poodle family. The largest are called "standard," the middle-sized ones are called "miniatures," and the smallest are called "toys." There are very definite height qualifications for each variety. Toys are less than ten inches high, miniatures ten to fifteen inches, and standards, over fifteen inches. Ask the students how they think the three varieties were developed? Permit them to speculate about the answer.

The students should 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 historical development. Maybe from within the present-day population of dogs new species may evolve as selection is practiced over a period of time. The diversity seen among biological forms today is a result of the operation of many factors, primarily environmental and genetic. Its roots are in variations which once existed within ancient populations.

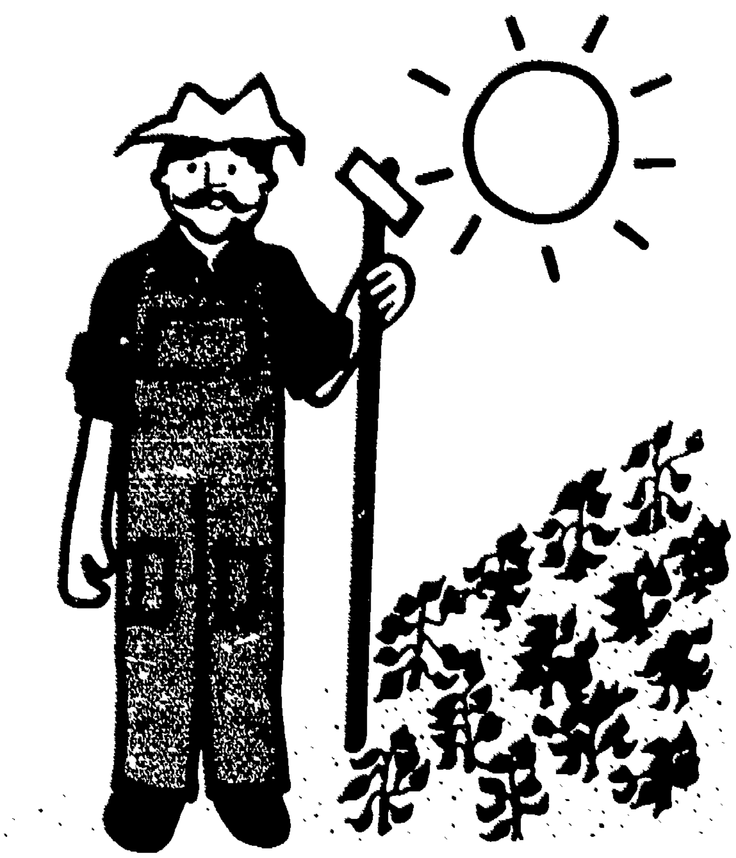
In the back of the book is a story, "Johannson and the Bean Seeds." You might read it to the children as a concluding activity.

Discuss what Johannson's results might have been. You may also wish to have the students read related material in their texts. The bibliography contains a number of books which would be appropriate to recommend for students interested in 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. 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, and they, too, in time, developed seeds of their own.



Mr. Johannson 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 be picked. 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 nearly 70 years ago and thousands of miles away. His results were lost in time and space.

What do you think he found?

TONGUE ROLLING SURVEY—INDIVIDUAL

Class ______________________________

Room Number ______________________________

Can you roll your tongue?

yes ______________________________

no ______________________________

TONGUE ROLLING SURVEY—CLASS SUMMARY

Class ______________________________

Room Number ______________________________

Number of students ______________________________

Number of students who can roll their tongues __________

Number of students who can't roll their tongues __________

Number absent ______________________________

BIBLIOGRAPHY

Teacher

Hanson, Earl D. *Animal Diversity*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964.

Moore, Ruth. *Evolution*. (Life Nature Library). New York: Time-Life, Inc. 1968. (Juvenile edition only age level 9 and up)

Morholt, Evelyn, et al. *A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace, Jovanovich, 1966.

Srb, Adrian M., et al. *General Genetics*. San Francisco: W. H. Freeman and Co., 1965.

Student

Asimov, Isaac. *Breakthroughs in Science*. Boston: Houghton-Mifflin Co., 1960.

Boyd, W. C., and Asimov Isaac. *Races and People*. New York: Abelard-Schuman, 1955.

Hutchins, Ross E. *The Amazing Seeds*. New York: Dodd-Mead, 1965.

Keen, Martin L. *How and Why Wonder Book of Prehistoric Mammals*. New York: Wonder Treasure Books, Inc., 1962.

Stefferud, Alfred. *The Wonders of Seeds*. New York: Harcourt, Brace, Jovanovich, 1956.

White, Anne T., and Lietz, Gerald S. *Built to Survive*. Champaign, Illinois: Garrard Company, 1966.

THE ENVIRONMENTAL UNITS

Below is a list of the twenty-four titles in the Environmental Discovery Series. Next to the titles, we have suggested the grades for which each is most appropriate. We emphasize that these are suggested grade levels. The teacher is encouraged to adapt the activities to a wide range of grade levels and subject areas depending upon the interests and abilities of the students.

Order No.	Title	Grade Level	Price	Order No.	Title	Grade Level	Price
79007	Plants in the Classroom	3-6	$1.50	79123	Genetic Variation	4-9	$1.50
79016	Vacant Lot Studies	5-9	1.50	79132	Soil	2-9	1.50
79025	Differences in Living Things	4-8	1.00	79141	Tile Patterns and Graphs	1-2	1.00
79034	Shadows	1-8	1.00	79150	Plant Puzzles	1-6	1.50
79043	Wind	3-6	1.50	79169	Brine Shrimp and Their Habitat	1-5	1.50
79052	Snow and Ice	1-6	1.50	79178	Nature's Part in Art	3-6	1.50
79061	Man's Habitat—The City	4-9	1.50	79212	Contour Mapping	4-9	1.50
79070	Fish and Water Temperature	4-9	1.50	79187	Change in a Small Ecosystem	5-9	1.50
79089	Oaks, Acorns, Climate and Squirrels	1-6	1.50	79196	Transect Studies	3-9	1.50
79105	Nature Hunt — Spec. Ed.	K-1	1.00	79203	Stream Profiles	4-9	1.00
79098	Sampling Button Populations	3-9	1.00	79221	Color and Change	K-2	1.00
79114	The Rise and Fall of a Yeast Community	6-9	1.00	79230	Outdoor Fun for Students	1-12	1.50

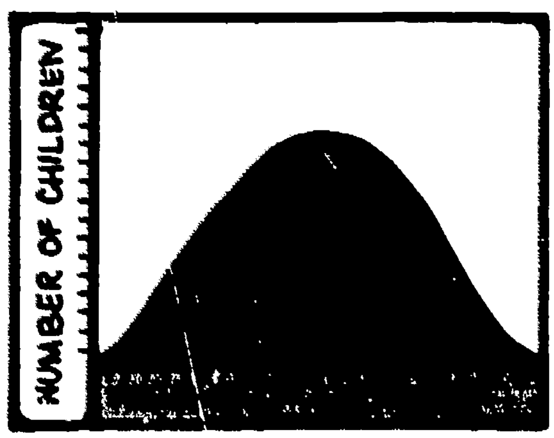
If you would like a free brochure describing activities in the individual units, write:

The National Wildlife Federation
Educational Servicing
1412 16th Street, N.W.
Washington, D. C. 20036

Written and developed by:

NWF
John Cary Stone
James D. Davis
Wendy Kay
Phil Nicholson
Tom L. Smith

MESF
Edmund Bray
Barbara Clark
Robert Collins
Joann Current
John Heitkamp
David Jones
Karen Jostad
Edward Landin
Richard Myshak
Michael Naylon
Robert O'Hara
Noreen Teachout
Carl Vogt



NATIONAL WILDLIFE FEDERATION
1412 Sixteenth Street, N.W.
Washington, D.C. 20036