SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

904

Adaptations to Niches and Habitats

March 1996
Adapted by: Lucy Daniel

Contents

This micro-unit was adapted by **Lucy Daniel** (East Carolina University, Greenville, N.C.)

Student Sheet

Science as Inquiry

Seeds, Leaves, and Fingers

How can you demonstrate and illustrate variation in living things?

Overview:

It is said that no two snowflakes are exactly alike. Can the same be said for living things? How can you determine and show the amount of variation within individuals of the same species? Is variation good for a species? In this activity you will examine variation in seeds and leaves and among students' index fingers. A basic component of Darwin's theory of natural selection is that populations that reproduce sexually show great variation in the physical expression of the genes of the organism. In terms of adapting to the environment, is one variation better than another? How would you decide the answer to such a question?

Procedures:

Part A

Measure the length of 10 seeds in millimeters. Sort the seeds according to length. Place the seeds in the labeled jars corresponding to the length of the seeds.

On graph paper, draw a graph and label the horizontal and vertical axes. Plot the height of the seeds in each jar according to the size of the seeds.

Part B

Measure the length in centimeters of each of 10 leaf blades of the same species. Record your data and give it to your teacher. When the class data have been collected and placed on the chalkboard, draw a graph and plot the data.

Part C

Measure the length of your index finger from the base to the tip. Record your data. When the class totals have been placed on the chalkboard, draw a graph and plot the data.

Questions:

1. What is the range of measurements for the bean seeds?

2. What is the range of measurements for the leaf blades?

3. What is the range of measurements for index fingers?

4. The mode is the most frequently occurring value. What is the mode for the bean seeds, the leaf blades, and the index fingers?

5. Describe the shapes of each of your graphs.

6. What does this tell you about variations within a species?

Science as Inquiry

Dry Bones

How do living things vary? Are the bones of the forelimbs of vertebrates similar in structure and function?

Overview:

French biologist Jean Baptiste Lamarck suggested that when body parts or organs of different living things are similar in structure the organisms are biologically related. He called such similar body parts or organs *homologous*. What do you think? When different animals have similar structures, is it because they are related or because they share similar environments that place similar physical demands on all creatures that live there? Perhaps you can think of another hypothesis. If it can be shown that different animals have homologous structures, what would that indicate about their evolutionary history? In this activity you will study the bones of various animals, considering the differences as well as the similarities and what connections there might be between structures and adaptation to niches and habitats.

Procedure:

Compare the vertebrate forelimbs on the attached sheet. Shade in the bones that are similar among them using the same color.

Questions:

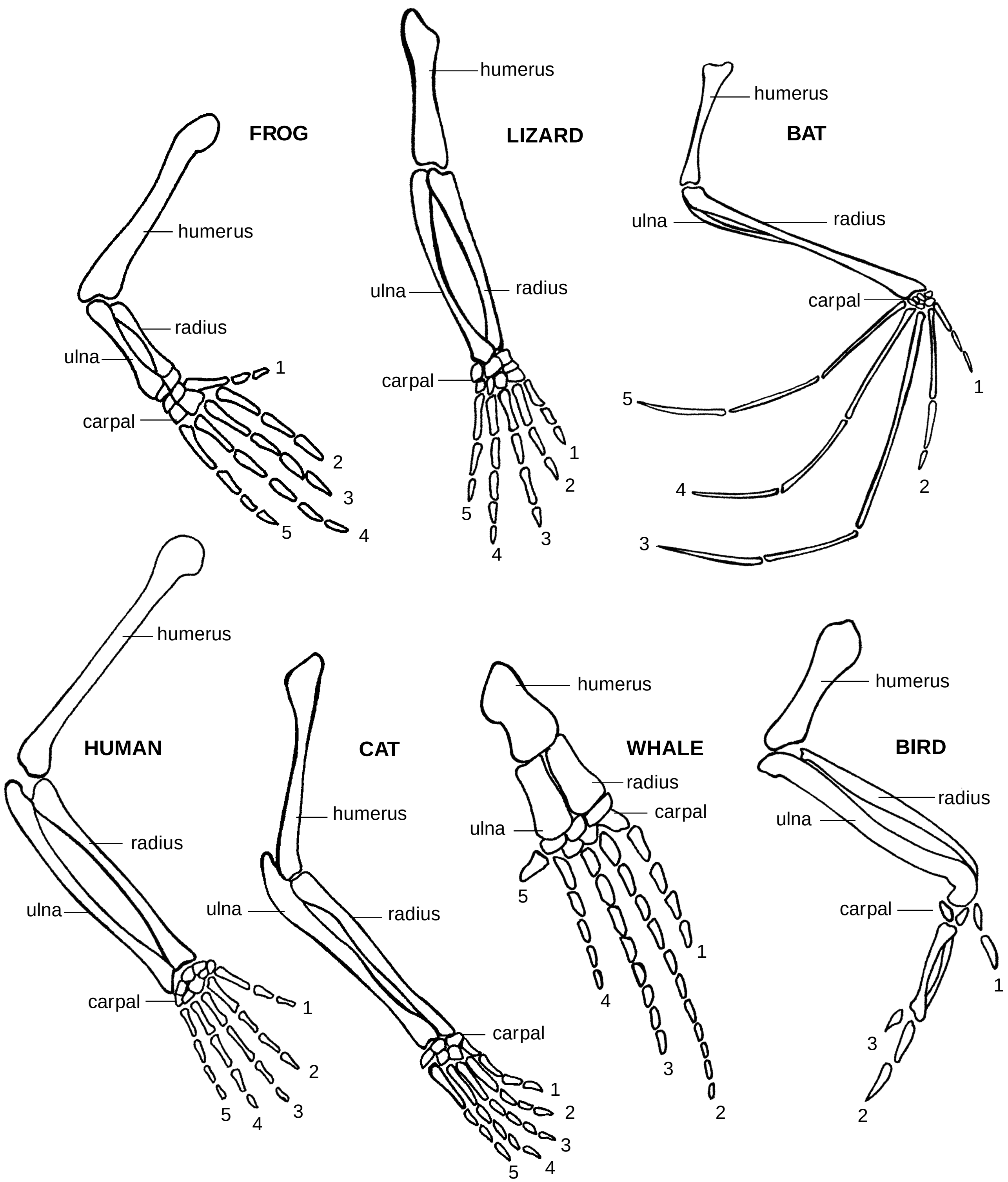
1. Are the forelimbs of these vertebrates made up of the same bones?

2. Why do individual bones differ among these vertebrates?

3. Of the forelimbs shown, describe how each is suited for the environment and habitat of the animal it belongs to.

4. What are the forelimbs of humans used for? How is the human forelimb adapted for this purpose?

5. Do all forelimbs have the same structure and function? Explain your answer.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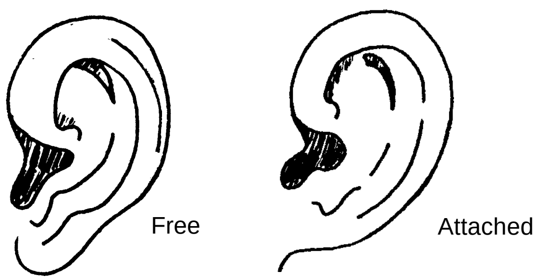
Science as Inquiry

Do You Have a Pedigree?

What can you learn from a pedigree?

Overview:

It is thought that in nature certain "favorable" genetic variations allow those with the trait to better take advantage of unexploited habitats. Simply stated, those individuals are better able to survive, reproduce, and pass on the trait to their offspring. A pedigree is one way to show the history of a certain genetic trait within a family. Some human traits, like free earlobes and attached earlobes, seem to be controlled by a single pair of genes. Genes can be either dominant or recessive. Genetically, the dominant trait is more likely to show up than the recessive trait. The gene for free earlobes is dominant over that of attached earlobes. In this activity you will make a pedigree chart for earlobe type in your family. Is one type of earlobe better adapted to the human habitat? Does this make a difference in the likelihood of finding both types within the human population as a whole? Are your earlobes an adaptive connection to your niche and habitat?



Procedure:

Examine yourself and a partner for the trait described. Record the appearance of the trait by using a capital "L" for free earlobes and a small "l" for attached earlobes. Obtain data for the whole class if possible. If you have the dominant trait you know for certain only that you have at least one dominant gene (capital letter) for the trait.

On a separate sheet of paper, draw a pedigree chart for the trait. Examine as many family members as possible. If your grandparents are available, include them in your charts.

Questions:

1. Would you expect other students in your class to have earlobe pedigrees that are identical to yours? Explain your answer.

2. If two parents have free earlobes, is it likely that they will have children who will have attached earlobes? Explain your answer.

3. How can a pedigree chart help you determine if a trait is dominant or recessive?

4. What is meant when we say a trait is an adaptation to a niche or habitat?

5. Is either earlobe type an "adaptation"? Explain your answer fully.

Student Sheet

Science as Inquiry

Moth Tales

How is fitness determined?

Overview:

The long-term survival of a species is the consequence of complex interactions between that species and its environment. Those who are "fit" have a better chance of survival. But what does it mean to be "fit"? Is fitness determined more by the environment or is it only about physical characteristics of certain individuals? If you identified a fit individual and then dropped him or her into a new and different habitat (for example, forest to desert), would that individual still be fit? How is fitness determined?

Procedure:

Spread the small squares of aluminum and white paper on the large square of aluminum. Make sure the squares are not lying on top of each other. Have your partner pick up as many squares as possible in 10 seconds and record the results. Switch partners and follow the same steps. Give your results to the teacher.

Questions:

1. Which squares were removed in greater number?

2. Why were these squares removed in greater number?

3. If the squares could reproduce by splitting, which type would be more numerous in the next generation? Explain.

4. How would you define fitness for the squares?

5. Using your observations from your recent lab activities, describe the adaptive connections of organisms with their niches and habitats. Use specific examples in your description.

History and Nature of Science

Variation Under Nature

(Abridged from ***The Origin of Species*** by Charles Darwin)

No one definition of species has satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species. Generally the term includes the unknown element of a distant act of creation. The term "variety" is almost equally difficult to define; but here community of descent is almost universally implied, though it can rarely be proved. We have also what are called monstrosities: but they graduate into varieties. By a monstrosity I presume is meant some considerable deviation of structure, generally injurious, or not useful to the species.

It may be doubted whether sudden and considerable deviations of structure such as we occasionally see in our domestic productions, more especially with plants, are ever permanently propagated in a state of nature.

Individual Differences

The many slight differences which appear in the offspring from the same parents may be called individual differences. No one supposes that all the individuals of the same species are cast in the same actual mould. These individual differences are of the highest importance for us, for they are often inherited and they thus afford materials for natural selection to act on and accumulate, in the same manner as man accumulates individual differences in his domesticated productions. These individual differences generally affect what naturalists consider unimportant parts; but parts which must be called important, whether viewed under a physiological or classificatory point of view, sometimes vary in the individuals of the same species. I am convinced that the most experienced naturalist would be surprised at the number of the cases of variability which he could collect.

Individuals of the same species often present great differences of structure, independently of variation, as in the two sexes of various animals, in the two or three castes of sterile females or workers amongst insects, and in the immature and larval states of many of the lower animals. There are, also, cases of dimorphism and trimorphism, both with animals and plants. Thus, Mr. Wallace has shown that the females of certain species of butterflies, in the Malayan archipelago, regularly appear under two or even three conspicuously distinct forms, not connected by intermediate varieties. Although in most of these cases, the two or three forms, both with animals and plants, are not now connected by intermediate gradations, it is probable that they were once thus connected. Mr. Wallace describes a certain butterfly which presents in the same island a great range of varieties connected by intermediate links, and the extreme links of the chain closely resemble the two forms of an allied dimorphic species inhabiting another part of the Malay Archipelago. It certainly at first appears a highly remarkable fact that the same

By Charles Darwin. Chap. 2, "Variation Under Nature," *The Origin of Species*, 1859. Abridged by Nancy Erwin (NSTA, Arlington, VA) from *The Origin of Species*, New York: New American Library, 1958.

female butterfly should have the power of producing at the same time three distinct female forms and a male. Nevertheless these cases are only exaggerations of the common fact that the female produces offspring of two sexes which sometimes differ from each other in a wonderful manner.

Doubtful Species

The forms which possess in some considerable degree the character of species, but which are so closely similar to other forms that naturalists do not like to rank them as distinct species, are the most important for us. We have every reason to believe that many of these closely allied forms have retained their characters for as long a time as have good and true species. Practically, when a naturalist can unite by means of intermediate links any two forms, he treats the one as a variety of the other: ranking the most common, but sometimes the one first described, as the species, and the other as the variety. Difficulties sometimes arise, however, in deciding whether or not to rank one form as a variety of another. In very many cases one form is ranked as a variety of another, not because the intermediate links have actually been found, but because analogy leads the observer to suppose either that they do now somewhere exist, or may formerly have existed.

Many years ago, when comparing, and seeing others compare, the birds from the closely neighbouring islands of the Galapagos archipelago, one with another, and with those from the American mainland, I was much struck how entirely vague and arbitrary is the distinction between species and varieties. On the islets of the little Madeira group there are many insects which are characterised as varieties in Mr. Wollaston's admirable work, but which would certainly be ranked as distinct species by many entomologists. A wide distance between the homes of two doubtful forms leads many naturalists to rank them as distinct species; but what distance, it has been well asked, will suffice? Is the distance between the several islets of these small archipelagos sufficient?

Some few naturalists maintain that animals never present varieties; but then these same naturalists rank the slightest difference as of specific value; and when the same identical form is met with in two distant countries, or in two geological formations, they believe that two distinct species are hidden under the same dress. The term species thus comes to be a mere useless abstraction, implying and assuming a separate act of creation. But to discuss whether a form ought to be called species or varieties, before any definition of these terms has been generally accepted, is vainly to beat the air.

Certainly no clear line of demarcation has as yet been drawn between species and sub-species—that is, the forms which in the opinion of some naturalists come very near to, but do not quite arrive at, the rank of species: or, again, between sub-species and well-marked varieties, or between lesser varieties and individual differences. These differences blend into each other by an insensible series; and a series impresses the mind with the idea of an actual passage.

Hence I look at individual differences, though of small interest to the systematist, as of the highest importance for us, as being the first steps towards such slight varieties as are barely thought worth recording. And I look at varieties which are in any degree more distinct and permanent as steps towards more strongly-marked and permanent varieties; and at the latter, as leading to sub-species, and then to species. With respect to the more important and adaptive characters, the passage from one stage of difference to another may be safely attributed to the cumulative action of natural selection and to the effects of the increased use or disuse of parts.

From these remarks it will be seen that I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, for convenience' sake.

Wide-ranging, Much Diffused, and Common Species Vary Most

Plants which have very wide ranges generally present varieties as they are exposed to diverse physical conditions, and as they come into competition with different sets of organic beings. Furthermore, the species which are the most common, that is abound most in individuals, and the species which are most widely diffused within their own country oftenest give rise to varieties sufficiently well marked to have been recorded in botanical works. And this, perhaps, might have been anticipated; for, as varieties, in order to become in any degree permanent, necessarily have to struggle with the other inhabitants of the country, the species which are already dominant will be the most likely to yield offspring, which, though in some slight degree modified, still inherit those advantages that enabled their parents to become dominant over their compatriots, which share similar habits of life and with which they come into competition.

Species of the Larger Genera in Each Country Vary More Frequently Than the Species of the Smaller Genera

If the plants inhabiting a country be divided into two equal masses, all those in the larger genera (i.e., those including many species) being placed on one side, and all those in the smaller genera on the other side, the former will be found to include a somewhat larger number of the very common and much diffused or dominant species. That many species of the same genus inhabit any country shows that there is something in the organic or inorganic conditions of that country favourable to the genus.

From looking at species as only strongly-marked and well-defined varieties, I was led to anticipate that the species of the larger genera in each country would oftener present varieties than the species of the smaller genera; for wherever many closely related species (i.e., species of the same genus) have been formed, many varieties or incipient species ought, as a general rule, to be now forming. Where many large trees grow, we expect to find saplings. Where many species of a genus have been formed through variation, we might expect that the circumstances would generally be still favourable to variation.

To test the truth of this anticipation I have arranged the plants of twelve countries and the coleopterous insects of two districts, into two nearly equal masses, the species of the larger genera on one side, and those of the smaller genera on the other side, and it has invariably proved to be the case that a larger proportion of the species on the side of the larger genera presented varieties, than on the side of the smaller genera. Moreover, the species of the large genera which present any varieties, invariably present a larger average number of varieties than do the species of the small genera. Both these results follow when another division is made, and when all the least genera, with from only one to four species, are altogether excluded from the tables. These facts are of plain signification on the view that species are only strongly-marked and permanent varieties; for wherever many species of the same genus have been formed, or where the manufactory of species has been active, we ought generally to find the manufactory still in action.

All that we want to show is, that, when many species of a genus have been formed, on an average many are still forming: and this certainly holds good.

Many of the Species Included Within the Larger Genera Resemble Varieties in Being Very Closely, but Unequally, Related to Each Other, and in Having Restricted Ranges.

There are other relations between the species of large genera and their recorded varieties which deserve notice. We have seen that there is no infallible criterion by which to distinguish species and well-marked varieties; and when intermediate links have not been found between doubtful forms, naturalists are compelled to come to a determination by the amount of difference between them. Now Fries has remarked in regard to plants, and Westwood in regard to insects, that in large genera the amount of difference between the species is often exceedingly small. In this respect, therefore, the species of the larger genera resemble varieties, more than do the species of the smaller genera.

Moreover, the species of the larger genera are related to each other, in the same manner as the varieties of any one species are related to each other. As Fries has well remarked, little groups of species are generally clustered like satellites around other species. And what are varieties but groups of forms, unequally related to each other, and clustered round certain forms—that is, round their parent-species? Undoubtedly there is one most important point of difference between varieties and species; namely, that the amount of difference between varieties, when compared with each other or with their parent-species, is much less than that between the species of the same genus.

There is one other point which is worth notice. Varieties, and species which are very closely allied to other species, and in so far resemble varieties, generally have much restricted ranges.

Summary

Finally, varieties cannot be distinguished from species,—except, first, by the discovery of intermediate linking forms; and, secondly, by a certain indefinite amount of difference between them.

We have also seen that it is the most flourishing or dominant species of the larger genera within each class which on an average yield the greatest number of varieties; and varieties tend to become converted into new and distinct species. Thus the larger genera tend to become larger; and throughout nature the forms of life which are now dominant tend to become still more dominant by leaving many modified and dominant descendants. But by steps hereafter to be explained, the larger genera also tend to break up into smaller genera. And thus, the forms of life throughout the universe become divided into groups subordinate to groups. * * *