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A little over a century ago, Alfred Russel Wallace and Charles Darwin formally presented the concept of evolution to the world. Since Darwin's publication of *The Origin of Species,* the theory of evolutionism has been attacked from various quarters. primarily by individuals without scientific backgrounds. In this country the teaching of evolutionism in high schools has been forbidden by law in several states. Until recently these laws still held in Kentucky, but progress is being made. Just a month ago, Kentucky's Warren County Board of Education reluctantly said that they were no longer trying to keep evolution out of public schools altogether. They asked only that it be taught as theory, not fact.

Within the scientific world evolution has been accepted since the beginning of this century, and some authors prefer to believe that the American public now accepts evolution as a fact. To the contrary, however, though he has heard of evolution, I do not believe that the average American knows what the term evolution means. And I believe that there are many science teachers who do not understand the meaning of evolution, or perhaps, because of a misunderstanding of it, do not accept it. That there are processes, the results of which can be called evolution, is an established fact. This fact is basic to the teaching of biology, for biological evolution is the one factor that can give continuity to the teaching of biology.

The purpose of this paper is to describe one approach to the teaching of evolution on the high school level. This approach employs the use of a flannelgraph and a lot of imagination. Because of the ability of evolution to provide continuity in the teaching and in the understanding of biology, I suggest that it be taught as one of the introductory units of a beginning course in biology. I further suggest that a unit on cell structure and heredity would be appropriate to follow this one on evolution.

In order to understand biology it is important that the student be familiar with the terminology. A list of terms and their definitions given to the students before beginning the study of evolution can facilitate the teaching of it. Such a list of terms might include the following:

mutation	adaptive convergence
natural selection	evolution
environmental niche	serology
polymorphism	embryology
cline	palentology
hybrid	genetics
hybridization	ecology
extinct	variation
extant	vestigial
species	fossil
speciation	
adaptive radiation	

Many other terms can be added at the teacher's discretion.

Prerequisite to understanding the processes of evolution is an under-

standing of the immensity of geologic time and the great lengths of time involved in the evolution of animal forms.

To begin, explain to the students that you are going to take them on a journey, an immense journey back into time. This is a journey that is going to take them back five billion years. It is an imaginary journey that will last exactly one year as you travel from five billion years ago up to the present. Pretend that the journey is beginning at the stroke of midnight on New Year's Eve, and that you will return at the stroke of midnight one year later. The things seen on this journey may not be exactly as they occurred because we don't know exactly how they occurred, but they will be seen as many scientists think they may have happened. On this journey the students will see the long-term effects of the processes of evolution on the plant and animal life on earth.

All right, push the button and your time capsule is on its way. Of course, it will take a few seconds to get back to five billion years ago, so while enroute, evolution can be defined and geologic time illustrated by another method.

First a definition: evolution means change. We speak of the evolution of the solar system, the evolution of life, and the evolution of the automobile. In such cases we are referring to the changes which have occurred in the solar system, in the forms of life, and in the automobile.

Evolution can be divided into three types which can be illustrated on the flannelgraph by using three circles. The first and largest circle represents inorganic evolution or the changes that take place in the nonliving world. The second and somewhat smaller circle represents organic evolution or the changes taking place in living things. It will be noticed that this smaller circle intersects the larger one. This is to show that living things make use of and depend on nonliving things. The third type of evolution is cultural evolution or the changes that take place in the development of man's cultures. This third and smallest circle intersects the other two because in developing his cultures, man makes use of and is dependent on both living and nonliving things. The difference in the sizes of the circles illustrates that inorganic evolution has been going on longer than organic evolution, and that organic evolution has been going on longer than cultural evolution (Fig. 1).

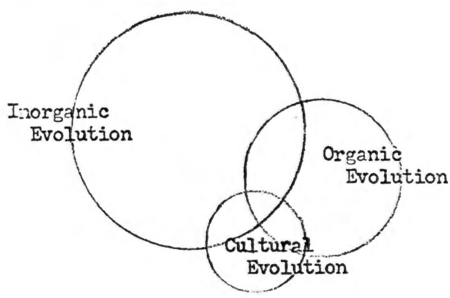

Figure 1
An illustration of the relationships among the types of evolution.

Next, also using the flannelgraph, the immensity of geologic time can be illustrated by using a triangle cut from colored paper. This triangle will represent the five billion years during which the journey is taking place. The base of the triangle represents five billion years ago and the apex represents the present. The triangle can be

made with sections of differently colored construction paper and can be constructed on the flannelgraph as it is described.

For two and a half billion years no life existed on earth. Therefore, one half the area of the triangle represents the period before life existed on earth and the bottom half of the triangle can be put on the flannelgraph.

The next section will represent a period of two billion years during which the only forms of life were probably single-celled plants and animals.

The third section represents the Paleozoic era, a period of about three hundred million years. The dominant form of life during the Paleozoic was the trilobite. A drawing of a trilobite can be shown to the students and some of its characteristics explained. Also during this era came the appearance of terrestrial plants, fish, insects, amphibians, and reptiles.

The fourth section represents the "Age of Reptiles," when the dinosaurs were masters of the earth. This is the Mesozoic, a period of about one hundred and thirty million years. During this era the first mammals and birds came into existence.

This last section completes the triangle—but where does man come in? In a spectacular way the immensity of geologic time and the insignificance of man in respect to geologic time can be demonstrated by showing a hatpin, and while placing it at the apex of the triangle, explaining that the head of the pin represents the existence of man on earth, a period of between one and two million years, and that the point of the pin represents the extent of written history (Fig. 2).

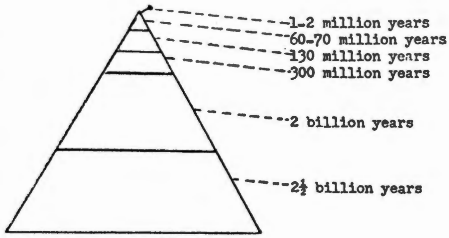

Figure 2
An illustration of geologic time.

With this introduction the time capsule has arrived at a point in time five billion years ago. It's early January. There are two bright lights in the sky (these can be demonstrated by two yellow discs on the flannelgraph). One is our sun—the other is an intruding star. As they pass each other, the force of attraction between them causes a long stream of fiery gases to be pulled from our sun. (These can be cut from yellow construction paper also.) This stream of gases breaks up into small balls of fire (several smaller yellow discs). As the intruder star passes on, the balls start to cool and condense. We'll watch the third ball out from the sun—it looks promising—let's call it Earth. (All but the earth and the sun can be removed from the flannel.) Throughout January the earth is red hot. (A red earth can be exchanged for the yellow one.) Steam forms, rises, cools, condenses, and falls again—only to rise again as steam and fall as rain and rise and fall, rise and fall. (A gray or brown-colored earth can now replace the red one.)

By mid-April we can see large land masses and large bodies of water but no signs of life. (An earth showing the oceans and brown land masses can be put up.)

By May we find, in small pools on

the land, protein-like molecules and complex chemical chains that are capable of reproducing themselves (similar to DNA which should be discussed in the unit on heredity).

June ends, and still no life.

But then, finally, on the fourth of July we find the first living creatures—small virus-like forms capable of making their own food.

On Labor Day we find small animals similar to our present jellyfish.

On November first we find the first trilobites. (The drawing of the trilobite can be shown and discussed again.)

Around the middle of November, we find the first vertebrates, the first animals with backbones. The seas are filled with life, but as yet the land is barren.

Three days before Thanksgiving, the first life leaves the sea and moves out onto the land. This first life on the land is primitive plant life, algae and lichens similar to those existing today. (With the advent of life on the land, the final earth can be put up, one with green land masses and blue seas.)

On Thanksgiving Day, amphibians similar to present-day salamanders slither out onto the earth.

On December first, we see the first reptiles, and the dinosaurs are soon masters of the earth.

On December twentieth we see the appearance of the first birds.

On Christmas eve we see the last of the dinosaurs—and still no men. (At this point the fallacy that man and dinosaurs were contemporaries can be pointed out.)

Very early and very briefly on Christmas morning, the birds are the dominant forms of animal life. Later in the day, the mammals become dominant over the birds. But still no men appear.

Late on December thirtieth, we see the Colorado River starting to cut into the Grand Canyon.

Our journey is near its end—yet we have the uneasy feeling that man still hasn't appeared. Finally at 9:40 P.M., two hours and twenty minutes before we return, we see the first men. At 11:40 the men we see are of the primitive stone-age type. At 11:57 we have the more advanced stone-age men and the beginning of agriculture. At 11:-58:45—one minute and fifteen seconds before midnight—we see the first signs of civilization. At 11:59:54 Columbus discovers America. And at 11:59:59—one second before we return to reality—Charles Darwin is writing his *Origin of Species* and the Civil War is beginning in the United States.

We're back from our journey. It's New Year's Day. Our trip has lasted a year, yet we found life existing for only six months. Birds have existed for eleven days. And man—all-powerful, all-knowing man—has existed for two hours and twenty minutes.

The events of this journey can be described in greater detail in class, perhaps by showing pictures and giving descriptions of some extinct forms of life. Special emphasis might be given to the dinosaurs because dinosaurs are something students know about and are fascinated by.

As a result of this journey, the students should have a better understanding of the great lengths of time involved in animal evolution and of

the very short length of time that man has ruled the earth.

With this background the students should be ready to move into a second phase in this discussion on evolution. This phase will be divided into three parts: first, some of the evidences for evolution will be pointed out; second, some of the mechanisms of the evolutionary process will be explained; and third, some of the fallacies that have arisen concerning evolutionary history will be pointed out and some of the frequent arguments against evolution will be answered.

The evidences for evolution are numerous and varied. Only a few of the more obvious and striking ones will be mentioned here.

The results of evolution can be seen in the structure of living things. For example, the similarity in structure and in derivation of a bird's wing, a dog's foreleg, and a man's arm suggest that somewhere in their evolutionary history they may have had a common ancestor.

The presence of vestigial structures is an indication that evolution is taking place. Examples would be: the appendix in man, which at one time probably aided in the digestion of plant matter; goose bumps, which result involuntarily from a reaction to a certain temperature state and cause the hair to stand up, an old means of preserving body heat; and Darwin's points (Fig. 3), vestigial lobes found in some human ears, may be remnants of earlier days when ancestral men had pointed ears as many other animals have today.

Other evidences for evolution can be found in the fossil record. The evolution of the horse is very well known from the fossils of intermediate stages in its development. From these fossils it can be shown that ancestral horses once had four toes on their forefeet and three toes on their hind feet.

Figure 3
Darwin's points may be an indication of a time in evolutionary history when men had pointed ears.

From serology it can be shown that somewhere in evolutionary history whales and rabbits had a common ancestor.

From comparative embryology similarities can be seen in the development of all chordates, and in instances, in the development of all animals.

From modern genetics and the study of fruit flies the mechanisms of evolution can be observed.

Numerous other examples can be cited, and these and others can be enlarged upon to give the student a more complete picture of how we know about evolution.

What are the mechanisms of evolution; how do these changes come about? At this point it should be stressed to the students that evolution or change in an animal or plant species is influenced by many factors, and that the alteration of any one of these factors can change the outcome of the evolutionary process.

The ultimate factors involved in the evolution of living organisms are mutation and natural selection.

A mutation is a change in the gen-

eral make-up of an organism resulting in a new characteristic which may be passed on to offspring. Mutations in animals occur that result in changes in the number of fingers or toes; in the color of the eyes, hair, or skin; in many other physical abnormalities; and possibly in different behavior patterns. Many different examples of mutation should be given to the students, and in addition, the students should be encouraged to suggest some other examples.

Natural selection is the result of survival in the struggle for existence among organisms possessing characteristics which give them an advantage. Once a mutation has occurred, its survival in the population depends on its usefulness to the population. If the new characteristic is harmless, it can remain; if harmful, it is selected against; and if beneficial, it is selected for. Now the mutations that were suggested should be discussed in terms of natural selection. Would they be favorable to the animal, unfavorable to the animal, or would they affect the animal at all? This is an opportunity for considerable class participation. Further examples of favorable mutations and natural selection that could be given might involve the appearance of protective coloration or structures: increase in size, speed, or intelligence; or increase in reproductive potential.

Mutation should be discussed further in the unit on heredity.

Topics closely associated with natural selection which might be discussed now would include: speciation, polymorphism, extinction, variation, adaptive radiation, and adaptive convergence.

Since Darwin, many things have been said about evolution that are false or at the most are only partly true. It is important that these things be revealed and discussed.

To begin, if you had mentioned the word "evolution" to your class before beginning this unit and had asked the students what they thought it meant, you would probably have gotten some answers something to the effect that "it means man is descended from the monkeys." This seems to be a common error concerning evolution. Man could not be descended from the monkeys or apes because the monkeys and apes are our contemporaries. Ask your students if they are descended from each other. No, such descent is impossible. But perhaps some of the students are cousins or are related more distantly. This is the type of relationship that the study of evolution reveals man to have with the apes. Man may be a distant cousin of the apes. Somewhere in our evolutionary history man and the apes may have had a common ancestor.

If man and the apes have had a common ancestor, does this mean that man doesn't have a soul? This is another mistake that is often made, mixing religion and science. Science deals with phenomena which can be detected, studied, and measured by use of scientific instruments. The soul is not such a phenomenon. It cannot be seen, or weighed, or analyzed chemically; nor can it be studied by the methods of the psychologist. Thus discussion of the soul would be out of place in a scientific discussion.

This relationship between science and religion can be shown on the flannelgraph by using four circles

(Fig. 4). The largest circle represents totality, everything in existence. The

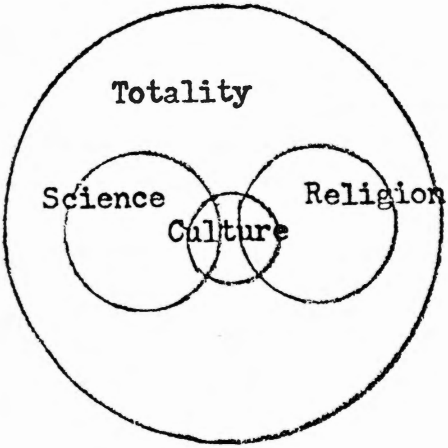

Figure 4
The relationship between science and religion.

two non-intersecting circles that are next largest in size represent the things that we know through science and the things that we know through religion. Because they do not intersect, do not share a common area, they should not be in conflict with one another. The fourth and smallest circle represents man's cultures. This circle intersects both the circle representing knowledge through science and the circle representing knowledge through religion. Man in his cultures employs both science and religion. Part of the circle representing culture doesn't intersect either the circle for science or the circle for religion. This part of culture is man's languages, art, and music, which of themselves are not scientific nor religious, but which may be used to describe both science and religion. The three smaller circles just fill the center of the largest circle, the circle representing totality. The area of this circle that is still visible represents those things which we don't yet know about.

Man and apes may have had a common ancestor and science should not interfere with religion nor religion with science. But the question still comes up: "Doesn't evolution contradict the Bible?"

First of all, the Bible was written as a book of religion, not as a book of science, and we have just shown that science and religion do not intersect. But perhaps a further explanation would be of benefit. The men who wrote the Bible were trying to convey the word of God to the people in a way that the people could understand. In so doing, these men described nature as they and their contemporaries saw it. Examples of some of these descriptions can be given that illustrate that it is absurd to accept the Bible as a book of science: we know that the earth isn't flat with a sea under it (Genesis 7:11); or that the earth isn't stationary (Psalm 93:1; Psalm 104:5) and that the sun, moon, and stars do not move through the heavens for the special purpose of illuminating the earth (Genesis 1:14-18); and that there are no windows in the sky through which the rains come down.

BIBLIOGRAPHY

American Institute of Biological Sciences, *High School Biology, Biological Curriculum Study Green Version.* Chicago: Rand McNally & Co., 1963.

Huxley, Julian, *Evolution in Action.* New York: Harper & Row, Publishers, 1964.

Moody, Paul A., *Introduction to Evolution.* New York: Harper & Row, Publishers, 1962.

Moon, Truman J., Otto, James H., and Towle, Albert, *Modern Biology.* New York:

Holt, Rinehart & Winston, Inc., 1963.

Simpson, George G., *Horses*. New York: Doubleday & Company, Inc., 1961.

Simpson, George G., *The Meaning of Evolution*. New Haven: Yale University Press, 1949.

Smith, Homer W., *From Fish to Philosopher*. New York: Doubleday & Company, Inc., 1961.

SCIENCE CURRICULAR PROJECTS

Inquiries have been received concerning science curricular projects at the elementary and junior high level. Project title and addresses are given for those who would like more information on these projects. A brief description of these and other projects will be found in *Report of the International Clearinghouse on Science and Mathematics Curricular Development*, 1967, Dr. J. David Lockard, Director, Science Teaching Center, University of Maryland, College Park, Maryland 20740.

Elementary Science

Science—A Process Approach, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.

Elementary School Science Project, John K. Wood, Utah State University, Logan, Utah 84321.

The Elementary Science Project, Departments of Education and Physics, Box 574, Howard University, Washington, D.C. 20001.

Elementary Science Study, Charles Walcott, 55 Chapel Street, Newton, Massachusetts.

Minnesota Mathematics and Science Teaching Project (Minnemast), 720 Washington Avenue, S.E., Minneapolis, Minnesota 55414.

School Science Curriculum Project, 805 W. Pennsylvania Avenue, University of Illinois, Urbana, Illinois 61801.

Science Curriculum Improvement Study, Department of Physics, University of California, Berkeley, California 94720.

Study of a Quantitative Approach in Elementary School Science, Physics Department, State University of New York, Stonybrook, New York.

University of Illinois Elementary School Science Project, 805 W. Pennsylvania Avenue, Urbana, Illinois 61801.

Junior High School Science

The Earth Science Curriculum Project (ESCP), P.O. Box 1559, Boulder, Colorado 80302.

Intermediate Science Curriculum Study, Kellum Hall Basement, Florida State University, Tallahassee, Florida 32306.

Introductory Physical Science (IPS), Educational Services, Inc., 55 Chapel Street, Newton, Massachusetts 02160.

Michigan Science Curriculum Committee Junior High School Project, Department of Biology, Western Michigan University, Kalamazoo, Michigan 49001.

Time, Space and Matter, Secondary School Science Project, Princeton University, 171 Broadmead Avenue, Princeton, New Jersey 08540.

NSTA-NASA Aerospace Science Education Project, Dr. Albert F. Eiss, National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D.C. 20036.