

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Bill G. Aldridge, *Principal Investigator and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
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Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers

Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers

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Sacramento H.S., Brian Jacobs

Iowa Coordination Center

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Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers

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North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jessie Jones, *School Coordinator*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers

Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site

UPR Lab H.S.

* * * * *

Pilot Sites

Site Coordinator and Lead Teacher
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* Western NSTA Office, 894 Discovery Court, Henderson, Nevada 89014, 702.436.6685

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**National Science Education Standard—Life Science
Biological Evolution**

Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

Teacher Materials

Learning Sequence Item:

904

Adaptations to Niches and Habitats

March 1996

Adapted by: Lucy Daniel

The Processes of Evolution: Mutation, Recombination, and Natural Selection. Students should explore the adaptive connections of organisms with their niches and habitats (*Biology, A Framework for High School Science Education*, p. 113).

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Matrix

Suggested Sequence of Events

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2. Dry Bones
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4. Moth Tales

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3. Appendix
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904

Learning Sequence

The Processes of Evolution: Mutation, Recombination, and Natural Selection. Students should explore the adaptive connections of organisms with their niches and habitats (*Biology, A Framework for High School Science Education, p. 113*).

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
<p>Seeds, Leaves, and Fingers Activity 1</p> <p>Dry Bones Activity 2</p> <p>Do You Have a Pedigree? Activity 3</p> <p>Moth Tales Activity 4</p> <p>Darwin's Finches Assessment 4</p> <p>Species Assessment 5</p> <p>Organic Evolution Assessment 6</p>	<p>Natural Selection Assessment 2</p>	<p>Use of Appendix Assessment 1</p> <p>Appendix Assessment 3</p>	<p>Variation Under Nature (<i>The Origin of Species</i>) Reading 1</p>

Suggested Sequence of Events

Event #1

Lab Activity

1. Seeds, Leaves, and Fingers (50 minutes)

Event #2

Lab Activity

2. Dry Bones (45 minutes)

Event #3

Lab Activity

3. Do You Have a Pedigree? (45 minutes)

Event #4

Lab Activity

4. Moth Tales (30 minutes)

Event #5

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

The following reading is included in the student version of the unit:

Reading 1 Variation Under Nature (*The Origin of Species*)

Suggested additional readings:

Fishman, J. "Little Bird, Big Find," *Discover Magazine*, January 1993, p. 66.

"Loading the Dice," *The Economist*, Vol. 327, June 19, 1993, p. 89.

Culotta, E. "Minimum Population Grows Larger," *Science*, vol. 270, October 6, 1995, p. 31.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.
2. Open-ended questions asking for essay responses.
3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Seeds, Leaves, and Fingers**How can you demonstrate and illustrate variation in living things?****Overview:**

Students measure and make observations of seeds, leaves, and their own index fingers to document and quantify variation in individuals of the same species.

Materials:**Per class:**

jars or large test tubes, 8

Per lab group (2 students):

metric ruler

pinto bean seeds or other dried bean seeds, 10

graph paper, 3 pieces

leaves, 10 from the same tree species

Procedures:**Part A**

Working in pairs, students measure the length of each of their seeds in millimeters and then sort the seeds according to length. Provide 8 to 10 jars or large test tubes of uniform size, labeled in millimeter intervals corresponding to the range of distribution in size you might find among the seeds. Students add their seeds to the appropriate jars and then measure the height of the seeds in each jar in centimeters. Write these measurements on the chalkboard. A continuous normal curve of distribution results.

Students then plot on graph paper the height of the beans in each jar (vertical axis) as a function of size of the seeds (horizontal axis).

If the seeds are kept dry, they can be saved from year to year for this activity.

Part B

Working in pairs, students measure the length of each of the 10 tree leaves from the end of the petiole to the tip of the leaf (in centimeters). Record the measurements on the chalkboard, organized by the number of leaves that measure within a given range of values. Students then draw a graph and plot the data as before.

Part C

Each student measures his or her index finger from the base of the finger to the tip. Record their measurements on the board and have them graph the data as before in Parts A and B.

Background:

A basic component of Darwin's theory of natural selection is that populations that reproduce sexually show great variation in phenotype (the physical expression of the genes of the organism). The occurrence of variations within the members of a species is a basic requirement for the mechanism of natural selection. In some cases, a variation in a species will cause some members to survive and reproduce better than others. Over time the variation will become the norm as those members of the species with the variation survive in greater numbers than do those members without the variation. However, most of the time, as in the example of length of index fingers, simple phenotypic variations within a species do not confer any special reproductive advantage for the members that express them.

If a given sample population is large enough and the environment for that organism is stable, the statistics for a given variation will reveal that the mode = mean = median. Under such stable conditions, most variations from the norm, arising through mutation or recombination of existing alleles of genes, are likely to be harmful. The organisms most likely to reproduce successfully are those with a phenotype that is close to the average for the population. The variants are less likely to reproduce and so are at a selective disadvantage compared to the norm. This is stabilizing selection; variants at the extremes of the range are eliminated.

Variations:

Students could extend this activity by comparing the degree of variation of several species of plant leaves. Students could calculate mode, mean, and range of variation for each species to determine if any generalizations can be made based on plant type, age, or location. Is there a difference between native species and imported ones?

Adapted from: none

Science as Inquiry

Dry Bones**How do living things vary? Are the bones of the forelimbs of vertebrates similar in structure and function?****Overview:**

In this activity, students compare drawings of forelimb bones of seven different animals. By investigating variation between various phyla, students consider how each is adapted to its particular niche and habitat.

Materials:**Per lab group:**

colored pencils, at least five different colors
drawings of forelimbs (included with Student Materials)

Procedure:

Students color the bones of each forelimb a different color, e.g., the humerus red, the ulna blue, etc. They determine which of these forelimb bones are similar and how the bones differ (each bone has been modified to perform a different function). They should describe how similar structures relate to evolutionary origins.

Background:

French biologist Jean Baptiste de Lamarck suggested a theory of evolution based on the anatomy or structure of living things. He suggested that when body parts or organs are similar in structure in different organisms, the organisms are related and the parts are said to be homologous. The existence of homologous structures has been used as evidence that many organisms evolved from a common ancestor. Each separate species became better adapted to its respective environment as the structure of its bones gradually changed to those found in modern animals.

A key concept is the difference between homologous structures and analogous structures. Analogous structures have the same function but not the same biological structure (e.g., the wings of bats, birds, and insects). Homologous structures have the same underlying biological structure although they may perform different functions (e.g., the foreleg of a horse and the flipper of a seal).

Although Lamarck was one of the first scientists to recognize that evolution had occurred, his theories about how and why evolution took place proved to be incorrect. Nonetheless, the specific idea of homologous structures is consistent with accepted evolutionary theory.

Variations:

Use skeletons (if available) of various animals and have students compare various homologous structures.

Adapted from: none

Science as Inquiry

Do You Have a Pedigree?**What can you learn from a pedigree?****Overview:**

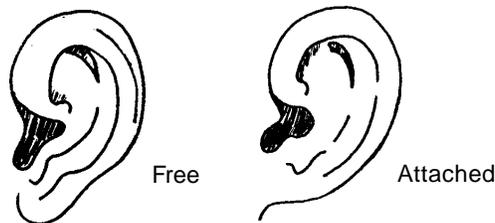
Students examine themselves for a genetic trait known to be controlled by a single pair of genes that are either dominant or recessive. They then construct a pedigree chart for their family.

Materials:**Per lab group:**

none

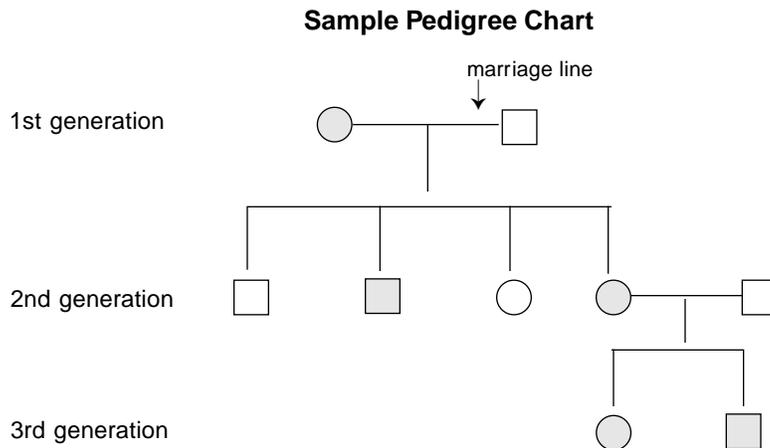
Procedure:

Working in pairs, students examine themselves and each other for the presence of either free or attached earlobes (see figure).



Students then record their phenotypes by recording a capital letter "L" for free earlobes and a small "l" for attached earlobes. Since they have not considered the processes of mitosis and meiosis, it is not appropriate for them to consider genotypes at this time. Therefore, phenotypes should be designated with a single letter (allele) as either "L" or "l". (Note: It is not essential at this point for students to use the terms "phenotype" and "genotype," but you should use them appropriately as the need arises.) Students then draw a pedigree chart for the trait for as many members of their family as possible.

You should explain to students that a pedigree is a family tree that traces the inheritance of a particular genetic trait. It shows the appearance of related individuals and provides a basis for attempting to determine the traits of the individuals. You should draw a simple pedigree chart such as the one shown below and explain the meaning of each symbol. This pedigree represents three generations of a family. Each symbol represents a specific individual as explained in the key.

**Key to Pedigree Chart**

Symbol	Meaning
○	female without the trait
◐	female with the trait
□	male without the trait
◑	male with the trait

Background:

In the sample pedigree chart above, a male and female married and had four children, two boys and two girls. One of these children married, and this couple in turn had two children, one boy and one girl. The individuals whose symbols are darkened show the trait that is being investigated, while the clear symbols represent individuals who do not show this trait.

Some human traits, like free earlobes and attached earlobes, seem to be controlled by a single pair of genes, which are either dominant or recessive. The gene for free earlobes is dominant (represented with a capital "L") over that of attached earlobes ("l").

The two copies of a gene for a specific trait are called alleles. An allele whose effect is expressed in the phenotype (physically able to be seen) even in the presence of a recessive allele is called dominant. Thus, if allele A is dominant to allele a, then AA and Aa have the same phenotype. An allele is recessive when its effect is expressed in the phenotype of the organism only in the presence of another identical allele (e.g., aa).

Adapted from: none

Science as Inquiry

Moth Tales**How is fitness determined?****Overview:**

Students perform a simulation of how camouflage in animals serves as an adaptation for enhanced survival.

Materials:**Per lab group (2 students):**

- aluminum foil, 30 cm × 30 cm square, 1
- aluminum foil, 2 cm × 2 cm squares, 10
- white paper, 2 cm × 2 cm squares, 10
- watch with second hand
- red and green toothpicks (alternate)
- photographs of peppered and melanin moths (additional)

Procedure:

Divide the class into pairs. Have one student in each pair spread 20 small squares on the large aluminum square. Allow each student in the pair 10 seconds to pick up and remove as many squares as possible, one at a time, from the large aluminum square. Have each pair count and report the numbers and types of squares "captured." Report the results on the chalkboard. A greater number of white squares should be removed. Camouflage is the "fit" character being displayed.

Background:

Natural selection is the survival and reproduction of those organisms best adapted to their surroundings. The fitness of an individual is a function of the environment and surrounding factors in that particular environment. If the environment changes, as in the case of peppered moths, then a particular adaptation, such as color or camouflage, may no longer be considered "fit."

The case of the British peppered moth, *Biston betularia*, is well known. In collecting data on the British population of these moths, it was found that among moths collected in 1950, there were more dark than light ones. In 1850 there were many more light than dark moths. However, this finding was true only for moth populations examined from the heavily industrialized Midlands of England. In the rural southern part of England, moths from 1950 showed a ratio of light to dark like that in 1850.

Scientists who investigated this finding experimented by placing both light and dark moths on smoke-blackened tree trunks commonly found in the Midlands. It was observed that birds ate more light than dark moths. Both light and dark moths were then placed on trees common to the south-

ern rural parts of England—soot-free and encrusted with white lichens. In this case, birds ate more dark than light moths.

From these observations and experiments it was concluded that in the industrialized areas dark moths survived predation better than white ones due to their coloration, which served as camouflage on the soot-covered trees. Moth coloration is genetically controlled. Therefore, natural selection was exemplified during the last century. The dark moths were favored by their genetic makeup, which provided the coloration that protected them in the "new" sooty environment. In this example dark coloration can be considered an adaptation to the moths' niche and habitat.

Variations:

Scatter a box of red and green toothpicks in a grassy area and follow the procedure above. Students can record their results in a notebook and report back later to record their results on the chalkboard. Be sure students count the total number of toothpicks before beginning and that they recover all scattered toothpicks before leaving the grassy area.

Hand out moth photographs and discuss the selection of peppered moths in industrialized England. Have students observe the photographs of two color variations of the peppered moth and ask them which of the moth colors is an advantage and which is a disadvantage. Ask students to explain what Darwin would have said about these colors in terms of fitness.

Adapted from:

Hayes, N.L., *Biological Science: An Ecological Approach*. Boston: Houghton Mifflin Company, 1982.

Science in Personal and
Social Perspectives

Use of Appendix

Item:

If we do not use the appendix, why do we still have one?

- A. There is no strong selective pressure to get rid of it.
- B. Actually, the appendix does have a use; we just don't understand what it is.
- C. Evolution has left it there in case changes in environmental conditions make it more useful.
- D. The appendix is there to let us know when we have eaten too much by getting extremely painful.

Justification:

Discuss whether evolution has a "goal" of fitting species better to an environment.

Answer:

A. Evolution occurs by the process of random mutation and selection for the most successful at surviving to reproduce. The success of a mutation depends on the current environmental conditions.

Evolution never has a "goal" in mind. A species may or may not by chance have the necessary genes to survive an environmental change. Diversity of genes is important in cases of severe environmental stress so that at least some members of the species might have survival skills, even if most don't.

Science and Technology

Natural Living**Item:**

Imagine a portable scanner has been invented that would allow researchers to observe and measure the appendix, a small structure attached to the intestine. If you wanted to determine whether or not this structure is an adaptation connected to a specific niche or habitat, what information would you need in the data base in order to formulate a reasonable hypothesis?

Answer:

An adaptive structure would allow individuals carrying the trait (or enhanced versions of the trait) to better take advantage of their habitat or various physical aspects of their niche. Therefore, important information to know would be:

- the specific nature of the "natural habitat";
- individual measurements of the appendix (assuming larger ones are better);
- statistics on individual life spans (or life expectancy); and
- number of offspring for each individual.

(Other answers/considerations are possible.)

Science in Personal and
Social Perspectives

Appendix

Item:

Since humans still have appendixes after many generations, and as it is still present in children whose parents have had their appendixes removed, how would Darwin explain that this vestigial organ has not disappeared? Are there any structures in the human that are disappearing?

Answer:

There is no strong selective pressure to get rid of the appendix. Evolution occurs by the process of random mutation and selection for the most successful at surviving to reproduce. The presence (or lack of) an appendix has no bearing on reproductive success.

Since genes to form an appendix are present in just about all humans, the structure is likely to remain in the species indefinitely unless circumstances change.

Science as Inquiry

Darwin's Finches**Item:****Part 1**

Prepare an illustrated chart for Darwin's finches, showing beak shapes, foods eaten, and the niches they occupied.

Part 2

Using this chart, compare birds from your community and/or state, indicating names of birds and their habitats.

Part 3

Discuss similarities of foods eaten by these birds.

Answer:

Illustrated chart of Darwin's finches:

Finch beak shape	Foods eaten	Name of similar local bird	Natural habitat of local bird

Using such a chart students should note and compare local birds, finding that birds that inhabit similar habitats and have similar feeding habits and foods are likely to have similarly shaped beaks.

Science as Inquiry

Species**Item:**

Cows, tigers, and sharks are similar in some ways and different in others. Which two are most similar? Explain how you know this and in what specific ways they are similar. You may use, but are not limited to, the following terms: natural selection, adaptation, evolution, and natural selection.

Answer:

Students should discuss specific characteristics of each animal in terms of adaptations and respective niche and/or habitat. Consideration should be given to any answer that makes a case for similarities between any two of the animals as long as the reasoning is based on specific characteristics and/or behaviors of the animals.

Science as Inquiry/
History and Nature of Science

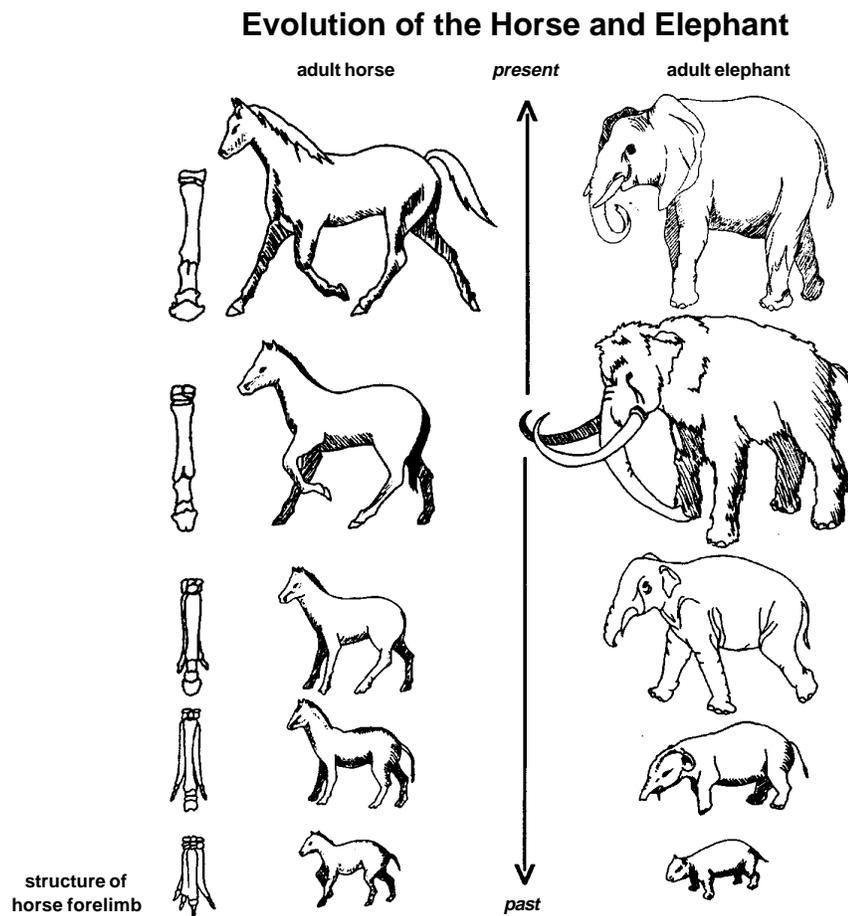
Organic Evolution

Item:

Look at the diagram below, which shows the probable stages in the evolution of the horse and elephant.

A. One of the most obvious changes in the elephant's lineage is the development of the long trunk. Explain how the environment of the elephant's ancestors could have favored animals with long trunks.

B. According to the chart, both species evolved into larger forms. Explain how this would be adaptive for each species.



Answer:

Students should explain in specific terms that adaptive characteristics seen in all animals are such that they provide species with the ability to better take advantage of their habitat or in some other way enhance their ability to survive (e.g., predator avoidance).

Consumables		
Item	Quantity per lab group (2 students)	Activity
aluminum foil, 30 cm × 30 cm square	1 square	4
aluminum foil, 2 cm × 2 cm squares	10 squares	4
graph paper	3 pieces	1
leaves from the same tree species	10	1
paper (white), 2 cm × 2 cm squares	10 squares	4
pinto bean seeds (or other dried bean)	10	1

Nonconsumables		
Item	Quantity per lab group (2 students)	Activity
colored pencils	5 or more (of different colors)	2
jars or large test tubes	8 (per class)	1
metric ruler	1	1
photographs of peppered and melanin moths (additional)	—	4
toothpicks, red and green (alternate)	—	4
watch with second hand	1	4

Key to activities:

1. Seeds, Leaves, and Fingers
2. Dry Bones
4. Moth Tales

Activity Sources

- Hayes, N.L. *Biological Science: An Ecological Approach*. Boston: Houghton Mifflin Company, 1982.
- Purves, W.K., G.H. Orians, and H.C. Heller, *Life, The Science of Biology*. Sunderland, Mass.: Sinauer Associates, Inc., 1992.
- Volpe, P.E., *Understanding Evolution*. Dubuque, Iowa: Wm. C. Brown Publishers, 1985.

Student Readings

- Darwin, C., "Variation Under Nature." Chapter Two from *The Origin of Species*, 1859. Abridged by N. Erwin from *The Origin of Species*, New York: New American Library, 1958.