SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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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:

903

Variations in Living Things

August 1996
Adapted by: Gerald Skoog and Tom Hinojosa

The Processes of Evolution: Mutation, Recombination, and Natural Selection. Students should observe variations found among individuals of the same species, understanding how certain variations enhance the survival of organisms in their environment *(Biology, A Framework for High School Science Education, p. 113).*

Contents

This micro-unit was adapted by **Gerald Skoog** (Texas Tech University, Lubbock) **and Tom Hinojosa** (California SS&C Project, Santa Clara)

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Learning Sequence

The Processes of Evolution: Mutation, Recombination, and Natural Selection. Students should observe variations found among individuals of the same species, understanding how certain variations enhance the survival of organisms in their environment *(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
A Group of Groceries **Activity 1** Changing the Rules **Activity 2** From Hamsters to Horses **Activity 3** Justin's Reptiles **Assessment 1** Designing a Habitat **Assessment 3** Moths **Assessment 5** Deer Hunting **Assessment 6**	Researchers' Rules **Assessment 2** Bone Measurement **Assessment 4**	Researchers' Rules **Assessment 2**	Moths **Assessment 5**

Suggested Sequence of Events

Event #1

Lab Activity

1. A Group of Groceries (40 minutes)

Event #2

Lab Activity

2. Changing the Rules (40 minutes)

Alternative or Additional Activity

3. From Hamsters to Horses (25 minutes for discussion; 20 minutes writing)

Event #3

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

Suggested readings:

Hutman, L.G., "When Nature Makes a Point," *National Wildlife*, Vol. 53, No. 3, April/May 1995, pp. 55–59.

McGowan, C., *Diatoms to Dinosaurs*, pp. 25–29, 61–64. Washington, D.C.: Island Press/Shearwater Books, 1994.

Milner, R., "Adaptation: Shaped for Survival." Excerpt from *The Encyclopedia of Evolution: Humanity's Search for Its Origins*, pp. 3-4. New York: Facts on File, Inc., 1990.

Milner, R., "The Peppered Moth: Adapting to Pollution." Excerpt from *The Encyclopedia of Evolution: Humanity's Search for Its Origins*, pp. 359–360. New York: Facts on File, Inc., 1990.

Assessment items can be found 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.

Teacher Sheet

Science as Inquiry

A Group of Groceries

How much variation exists within a species?

Overview:

Variation occurs among individuals of the same species. In this activity students work individually and as a group to make qualitative and quantitative observations and comparisons of single specimens from a larger pool of specimens in order to determine the amount of variation that exists within a given species.

Materials:

Per class:

plant product (e.g., peanuts, grapes, cherries, apples, bananas, nuts, dried beans, green pea or bean pods, pine needles), large sample at least equal to the number of students in the class, ideally over 100

Per lab group (2–3 students):

measuring tape
balance
graph paper
ruler

Procedure:

Each student should receive one of the items (i. e., a grape or a peanut). The student should observe and record the physical characteristics of the specimen and be prepared to identify the specimen when it is returned to the entire sample. After a suitable period of time, all the specimens are returned to the sample group. Students then select their individual specimens from the sample. A discussion should follow on the variations that made each specimen unique and identifiable.

Each group of two or three students should receive a sample of 10 to 15 specimens of the product, for which they record their observations and measures of appropriate variables (mass, length, circumference, etc.). For example, if peanuts are used, the length, number of peanuts within the pod, and the gradation in color could be noted. The length and/or mass of beans could be recorded.

Data collected by each group should be graphed. Data from all groups then should be pooled together for use in making graphs that represent variations in measures of the total sample. Thus, one graph would show the variation in mass in the total sample. Another graph would show the variation in another measure, such as length. Assuming the sample had a high degree of randomness, graphs should show normal distributions with clumping toward the mean or middle and few samples at the extremes.

Question students about the variation they noted for quantitative factors (length, mass, circumference) and qualitative factors (color, shape, etc.). Ask them to identify markings, textures, and other characteristics that made individual specimens distinctive.

Background:

Darwin knew that populations that reproduce sexually show great variation in phenotype (the physical appearance of an individual as determined by genes). He also knew that populations are capable of producing far more offspring than ever survive, leading to a "struggle for existence" (i.e., competition between members of the species for scarce environmental resources). Darwin argued that those individuals that possess harmful or less fit variations are more likely to die than others. Because they die before reproducing, their genes will not be passed on to the next generation. He called this process natural selection.

If the environment of a given organism is extremely stable over time, the graph produced in this type of activity may show a quite narrow normal distribution curve, a result of "stabilizing selection," where variants at the extremes of the range are eliminated.

Variations and human selection have shaped the food eaten by humans. Variations in important foods such as rice, corn, wheat, and potatoes have been important in providing better nutrition. Variation and human selection in animals such as cattle, horses, chickens, dogs, and sheep have been important as these animals have been domesticated and used in different ways. Additional research on variation in common foods such as carrots, corn, and apples could be done by individual students. For example, carrots exist in various colors. Texas A&M University has developed a maroon carrot, which happens to be the school color of its athletic teams.

Students should begin to consider the adaptive nature of certain variations found among individuals of the same species.

Variations:

Depending on the product used, different approaches can be used to show both individual variation and the range of variation. For example, a sample of peanuts could be arranged in order by length (short to long) or by color (light to dark).

If available, the lady beetle, *Harmonia axyridis*, is an excellent species to show variation, as the number and location of spots on the backs of these insects vary greatly. Also, there is variation in color. These insects are used for pest control and may be available for purchase locally. They also can be collected from plants such as milkweed. Other local insects could be collected and the variation in selected features noted. As a substitute, photocopies of a population of lady beetles could be used. Have students locate specimens with varying numbers and locations of spots.

Adapted from:

Rowland, M., *Biology*. Walton-on-Thames Surrey, UK: Thomas Nelson and Sons, Ltd., 1992.

Science as Inquiry

Changing the Rules

What's the relationship between an organism's traits and its environment?

Overview:

In this activity students consider the relationships between the physical traits of organisms and the organisms' environment. Working in groups of three or four, students discuss several scenarios then make a presentation to the class based upon their conclusions.

Materials:

Per lab group (3–4 students):
"rules" of the natural world (included with Student Materials)
lab notebook or paper
materials for making group presentations (optional)

Procedure:

Students discuss with other members of their group the adaptive connections of each organism with its normal niche and habitat for each "rule" described below. They then discuss the results of the following "changes" in the rules of the natural world. Each group should have one member record their conclusions.

1. Rule. Male birds are more brightly colored than the females of the same species.
   Change. The coloration of all female birds is now brighter than that of male birds.
2. Rule. The gestation period of a lion is 108 days.
   Change. The gestation period of a lion is changed from 108 days to 216 days.
3. Rule. Grass is green.
   Change. Grass is now violet rather than green.
4. Rule. The human hand has four fingers and an "opposable" thumb.
   Change. The human hand grows an extra finger.
5. Rule. The California condor has a wing span of over six feet (more than two meters).
   Change. The wing span is increased to more than twelve feet (more than four meters).
6. Rule. The elbow joint is a "hinge" joint.
   Change. The elbow joint changes from a hinged joint to a "ball-and-socket" joint (like the hip).
7. Rule. Rattle snakes have rattles on the end of their bodies.
   Change. The rattlesnake no longer has rattles.
8. Rule. Tigers live in India; Lions live in Africa.
   Change. Both tigers and lions now live in Australia.

Finally, each group should prepare a presentation on which change they feel would actually be the most "adaptive" for that organism in its natural habitat. Remind students to be prepared to fully explain their reasoning and to defend their conclusions to the class. You may choose to have students make an illustration or poster to go along with their presentation.

Background:

It may be helpful to students to review and discuss the following definitions in conjunction with this activity:

niche—An ecological niche is a precise description of all the physical, chemical, and biological factors that a species needs to survive and reproduce. It is a way of life described in terms of a suitable environment and how the organism in question will fit into the food web.

habitat—The natural home of an animal or plant, including all the biotic (other organisms in the same habitat) and the abiotic factors (weather, soil, type of water, etc.) that are characteristic of that area.

adaptation—A feature of an organism's structure or functioning that fits it to living in a particular environment.

Variations:

You may wish to substitute your own (local or regional) examples of "rule" and "change." The activity can be made more timely by adding certain environmental changes for students to consider, such as global warming, ozone depletion, deforestation, introduction of foreign or alien species to the local ecosystem, etc.

Adapted from: none

Science as Inquiry

From Hamsters to Horses

Why is the gestation period different for different mammals?

Overview:

This inductive lesson is designed to show that varying gestation periods of mammals are adaptive connections to their niches and life styles. Students examine data, discuss and analyze them, and then compose an explanation for the relationships they are able to discern.

Materials:

Per lab group (3 students)
data sheet on gestation and body weight (included in Student Materials)
lab notebooks or paper

Procedure:

Working in groups of three, students examine data showing average gestation period in days and average adult body weight in grams for several mammals. They should rank order the different mammals on the basis of their estimation of the number of young at one birth. Student questions are designed so that students inductively note the relationship between gestation period and whether the animal is a carnivore or herbivore.

The following chart provides data regarding the average number of young at birth in addition to the data provided in the student activity.

Animal	Average Gestation Period in Days	Average Number of Young at One Birth	Average Adult Body Weight in Grams
Hamster	16	6	100
House mouse	21	6	35
Rabbit	31	8	2,800
Lion	108	3	190,000
Tiger	109	3	209,000
Cow	284	1	500,000
Horse	336	1	500,000
Zebra	360	1	280,000
Bactrian camel	400	1	450,000
Black rhinoceros	540	1	764,000
Indian elephant	624	1	7,000,000

Background:

Large herbivores, such as the horse, rhinoceros, and elephant, eat large amounts of vegetation each day and, as a result, must move frequently. Some herbivores migrate with the seasons. Thus the young of herbivores are born well developed and strong and can move with the herd shortly after birth. Also, herbivores are vulnerable to the attacks of carnivores, and their young must be able to move swiftly very soon after birth. Because the herbivore's young at birth are well developed, the number per birth is low and the survival rate is high.

Carnivores are more territorial than herbivores. Thus, a lion or tiger will have a den where the young can be nurtured. A long pregnancy would handicap a female carnivore in terms of hunting because the extra weight would slow her speed. However, the young at birth, because they remain in a den, can survive if born unable to walk and without their vision fully developed. However, the average litter size in carnivores is larger than in herbivores because the survival rate of the newborn is lower.

The size of the hamster, mouse, and rabbit influences length of life, rate of metabolism, and average number of young at birth. Because of the high mortality rate, the average number of young per litter is high.

Variations:

You may wish to have students add more animals and data to the list and see whether their predictions/conclusions are borne out in these additional examples. Alternately, students could research examples and patterns of adaptive characteristics seen in plants. A possible project could be a comparative study of plants and animals that live in desert regions.

Adapted from:
Skoog, Gerald, and Violetta Lien, *Strategies for Teaching Life Science*. Lubbock, Tex.: Science and Mathematics Education Center, Texas Tech University, 1989.

Science as Inquiry

Justin's Reptiles

Item:

Justin read in a book about reptiles that snakes are one of the most successful groups of reptiles. He also read that there are several species of lizards that, through evolution, have lost their legs over time and some species appear to be in the process of losing them. He finds this amazing because it seems that life would be much more difficult if he had no arms or legs. He wonders what the advantage might be to an animal to lose its legs. What advantages do snakes have by not having legs?

Answer:

Answers should focus on how lack of legs enhances the survival of snakes in their own environment. Some students may try to argue that the absence of legs (in general) could be adaptive (beneficial) for other species. This is a mistake.

Answers should include specific examples of how lack of legs could benefit snakes, such as efficiency of movement, which allows snakes to slide through holes and other small places in search of prey or to avoid predators.

Science and Technology/
Science in Personal and Social Perspectives

Researchers' Rules

Item:

The United States government has strict rules requiring researchers to confine genetically engineered organisms to the laboratory. Why do you think they have such rules?

Answer:

This question is related to the suggested reading "A Mystery in Your Lunchbox" from micro-unit 9.02. However, students could answer it based only on the content of this micro-unit.

Possible answers include:

- Possible unknown new characteristics/traits in the genetically engineered organisms that could be harmful to other life-forms
- Unknown consequences of interactions between the newly engineered forms and the naturally occurring form of the organism, such as possible extinction of the natural form
- Lack of control once the genetically altered organism leaves the lab
- Unforeseen and complex changes in the natural ecosystem

Science as Inquiry

Designing a Habitat

Item:

Consider the list of available materials below.

Materials:

water
aquatic organism *(elodea* is one possibility)
glass beaker, 100-mL
petri dish
incandescent light source
colored light bulbs, clear red, blue, and green
heating device for the water
plastic straw
fine gravel

Procedure

Describe or illustrate what you feel would be the best setup for survival and growth of a given organism. Use only the materials you feel are necessary. You may assume that the system will be set up indoors. How long would you expect the organism to stay healthy and alive in your setup? Explain your reasoning.

Answer:

Answers should demonstrate an understanding of how traits/characteristics of the chosen organism are related to the environment, which would support the survival and growth of that organism.

Science and Technology

Bone Measurement

Item:

Measurements of bones and ratios of bone size, thickness, proportions, braincase volume, etc., tell us about the way extinct animals lived. Give several examples of how these measurements can tell us specific things about the animals.

Answer:

The ratio of braincase volume to body size, for example, seems to roughly correlate with intelligence (a larger body size must be accounted for, as this body mass requires more neurons to move and coordinate). Heavier bones with greater thickness imply the use of large amounts of force.

Science as Inquiry/
History and Nature of Science

Moths

Item:

People living in industrial England in the late 1800s noticed over a period of years that the population of peppered gray moths was "disappearing" and being replaced by a population of black moths. How did this occur?

A. Spontaneous generation of black moths
B. Natural selection decreased the number of gray moths
C. Gray moths were weakened and died off
D. The food source for the gray moths decreased

Justification:

What circumstance(s) could cause a reversal of this kind?

Answer:

B. This item is directly related to the suggested reading "The Peppered Moth: Adapting to Pollution." A decrease in the output of sooty pollution could reestablish the gray moth population by allowing the natural gray tree bark to reappear and provide favorable camouflage for the gray moths.

Science as Inquiry

Deer Hunting

Item:

Annual hunting trips to the forest allow hunters to bring home deer with the largest antlers. Describe the effects on succeeding next generations of deer in terms of evolution.

Answer:

Removal of deer with the largest antlers will leave only deer with medium to small antlers to mate with does. Thus the next generation of deer will have a lower frequency of deer with large antlers. Large-antlered deer may have a greater chance of mating with females because of their ability to fight off males with smaller antlers. Since the next generation does not contain many large-antlered deer, the probability that medium- to small-antlered deer will mate with females is higher than it was previously. Over the next generations, the frequency of large-antlered deer will be greatly reduced. In terms of evolution, the antler size has changed over time.

Consumables

Item	Quantity per lab group	Activity
data sheet on gestation and body weight (included with Student Materials)	1	3
graph paper	—	1
materials for making class presentation (optional)	—	2
paper or lab notebook	—	2, 3
plant product (e.g., peanuts, grapes, cherries, apples, bananas, nuts, dried beans, green pea or bean pods, pine needles)	1+ per student in class, ideally 100+ for class	1
"rules" of the natural world (included with Student Materials)	1	2

Non-Consumables

Item	Quantity (per lab group)	Activity
balance	1	1
measuring tape	1	1
ruler	1	1

Key:
1. A Group of Groceries
2. Changing the Rules
3. From Hamsters to Horses

Activity Sources

Rowland, M., *Biology*. Walton-on-Thames Surrey, UK: Thomas Nelson and Sons, Ltd., 1992.
Skoog, G. and V. Lien, *Strategies for Teaching Life Science*. Lubbock, Tex.: Science and Mathematics Education Center, Texas Tech University, 1989.

Student Readings

Gemerty Hutman, L, "Adaptations." Excerpt from "When Nature Makes a Point," *National Wildlife*, Vol. 53, No. 3, April/May 1995, pp. 55–59.