Section: Evidence of Evolution

Read the passage below. Then answer the questions that follow.

The fossil record, and thus the record of the evolution of life, is not complete. Many species have lived in environments where fossils do not form. Most fossils form when organisms and traces of organisms are rapidly buried in fine sediments deposited by water, wind, or volcanic eruptions. The environments that are most likely to cause fossil formation are wet lowlands, slow-moving streams, lakes, shallow seas, and areas near volcanoes that spew out volcanic ash. The chances that organisms living in upland forests, mountains, grasslands, or deserts will die in just the right place to be buried in sediments and fossilized are very low. Even if an organism lives in an environment where fossils can form, the chances are slim that its dead body will be buried in sediment before it decays. For example, the organism may be eaten and scattered by scavengers.

READING EFFECTIVELY

Read each question, and write your answer in the space provided.

1. Why is the fossil record incomplete?
   Many species have lived in areas where fossils do not form.

2. Where do fossils form?
   In wet lowlands, slow-moving streams, lakes, shallow seas, and areas near volcanoes that spew out volcanic ash. Most fossils form when organisms are rapidly buried in fine sediments.

3. In areas where fossils form, why don't all organisms that die become fossilized?
   Many organisms decay before sediments cover them, or they are eaten and scattered by scavengers.
Lamarck vs. Darwin

Lamarck's Hypothesis: The Inheritance of Acquired Characteristics

1. Use and disuse: described how body parts of organisms can develop with increased usage while unused parts weaken. This idea is correct, as is commonly observed among athletes who train for competitions.

2. Inheritance of Acquired Characteristics: Those characteristics developed ("acquired") by individuals are somehow passed on to their offspring, who can continue that development... This idea was incorrect as only changes in genetic material can be passed on to offspring.

3. Natural transformation of Species: described how organisms produced offspring with changes, transforming each subsequent generation into a slightly different form toward some ultimate, higher order of complexity. Species did not become extinct nor did they split and change into two or more species. This idea was also incorrect.

Although Lamarck's theories have been discredited, Lamarck still deserves credit for recognizing that organisms interact with their environment and experience through evolutionary change and for proposing a testable mechanism for this change.

Darwin's Hypothesis: Natural Selection

Fifty years after Lamarck published his ideas, Darwin published The Origin of Species, Darwin's theory that natural selection, or "survival of the fittest," was the driving force of evolution.

1. Overproduction: More offspring are produced than will ultimately survive and reproduce

2. Variation: Inheritable features vary from individual to individual.

3. Change in environment: Changes in climate, topography, food supply, predators, etc.

4. "Struggle for existence": Mainly competition within the species, for food, habitat, survival from being eaten

5. "Survival of the fit" (not necessarily the strongest): Those with more adaptive traits tend to survive longer and/or produce the most offspring; these are the "naturally selected".

6. Inheritance of "selected" features: Traits involved are already inheritable, but may involve new combinations.

7. New Species better adapted to the new environment: When the collective traits of the population differ significantly from the earlier population and when they can no longer reproduce with the earlier population.
Lamarck vs. Darwin

Directions: Read the following statements. For each statement, decide if the idea agrees more with Lamarck's or Darwin's theory of evolution.

Example: Many of the bacterial strains that infect human beings are resistant to a wide range of antibiotics. These resistant strains were uncommon before the use of antibiotics. When people don't finish antibiotics, resistant strains survive and reproduce, leading to a population of antibiotic resistant bacteria. **Circle one (Darwin / Lamarck)**

1. Life arose in the aquatic environment and later invaded land. Once animals came onto land, they grew larger and stronger legs to help them survive. The newly acquired legs were passed on to their offspring. **Circle one: (Darwin / Lamarck)**

2. A given phenotypic trait--for example height, speed, tooth structure--(and therefore the genes that determine it) may have positive survival value, negative survival value or be neither. Individuals with a trait with positive survival value are more fit, and more likely to survive. Whether a trait is positive, negative or neutral depends on the environmental conditions the organism encounters. **Circle one: (Darwin / Lamarck)**

3. According to one theory, the dinosaurs became extinct because they did not have adaptations that allowed them to survive the climactic changes that affected their food and water supplies. **Circle one: (Darwin / Lamarck)**

4. The children of bodybuilders tend to be much more athletic, on average, than other children because the characteristics and abilities gained by their parents have been passed on to the children. **Circle one: (Darwin / Lamarck)**

5. The widespread use of DDT in the middle of the last century put pressure on insect populations to evolve resistance to DDT. As a result, large populations of insects today are resistant to DDT. **Circle one: (Darwin / Lamarck)**
possible mutation creating a longer leg trait. This was more beneficial, and allowed it to survive and reproduce, creating more long-legged birds.

6. Consider the long legs of wading birds such as herons and egrets, birds that are common around rivers and marshes. How could such a bird evolve such long legs? Read the following scenarios and discuss each with your partner. Use the questions at the bottom to help in this discussion. Assume that the species ancestral to these birds had short legs, and could only wade into very shallow water along the shoreline, eating snails and small fish.

SCENARIO A. A change in the environment increased competition between the birds, and resulted in a depletion of the food supply in the shallow waters. This created a need for the short-legged birds to wade into deeper water in order to survive, which forced them to stretch their legs, because they didn't want to get knocked over by the little waves. This stretching caused their legs to get a little longer. When these birds produced chicks, the baby birds grew up with the slightly longer legs inherited from their parents. These offspring birds needed to wade out even further, so they stretched their legs even more, and made them a little bit longer yet. And their chicks grew up with even longer legs inherited from their parents. And so on...

Eventually, after many generations of this, the legs of these birds were so much longer than the ancestral birds that the new birds could be described as a new species.

SCENARIO B. Within the species of ancestral short-legged shore birds, there is a range of leg lengths, from a little bit shorter to a little bit longer than the average leg length, and these leg lengths tended to run in families (i.e., leg length was hereditary). A change in the environment increased competition between the birds, depleting the food supply in the shallow waters. The birds with slightly longer legs, of course, could wade out a little farther. As a result, they got more food, lived a little longer, and therefore produced more chicks. Those with the shorter legs would tend to starve to death. Since the tendency for leg length was already inheritable, the surviving "long-leggers" tended to have more long-legged chicks, which likewise tended to get more food and produce more chicks. And so on...

Eventually, after many generations of this, the average leg length of these birds was so much longer than in the ancestral birds (along with other connected changes) that the new birds could be described as a new species.

DISCUSSION:

1. Which scenario sounds like an explanation Darwin might give? B Why?
   - Variation in species
   - Best "fit" survived and reproduced
   - Competition

2. Which scenario sounds like an explanation Lamarck might give? A Why?
   - Birds did not stretch legs, but passed them on
   - The length of leg is a genetic trait

3. What are the specific clues which most clearly distinguish a Darwinian explanation from a Lamarckian explanation?
   Darwin had variation in leg length, it was hereditary, environment change caused competition, best fit survived and reproduced.

4. Which explanation is most likely correct (in terms of the relative evidence between Darwin's hypothesis and Lamarck's hypothesis)?

Under this sheet, write a similar pair of scenarios describing the evolution of the horse from a small, forest animal to a large grass eater on the plains. Write one scenario (4 sentence min) the way Lamarck might explain it, and one the way Darwin might explain it. Be sure to say which is which.
Section: Applying Darwin’s Ideas

Read the passage below. Then answer the questions that follow.

The theory of evolution by natural selection can be summarized as follows: (1) Every population produces more offspring than can survive in an environment with limited resources, known as overproduction. (2) All populations show variation in traits, and much of this variation is inherited. (3) In a given environment, individuals with traits that make them better suited to survive long enough to reproduce leave more offspring than individuals without these traits. (4) Over time, inherited traits that improve the chances of survival and reproduction, called adaptations, become more common than other traits within a population. In other words, the population evolves.

SKILL: READING EFFECTIVELY

Read each question, and write your answer in the space provided.

1. What does the word overproduction refer to in the second sentence?

   More offspring are produced than can survive.

2. Define the word adaptation.

   Inherited traits that improve the chances of survival and reproduction

3. How does natural selection lead to the evolution of a population?

   Evolutionary change occurs when individuals with certain characteristics have a greater survival or reproductive rate than other individuals in a population and pass on these inheritable genetic characteristics to their offspring.
Section: The Theory of Evolution by Natural Selection

Read the passage below. Then answer the questions that follow.

Darwin realized that Malthus's hypotheses about human populations apply to all species. Every organism has the potential to produce many offspring during its lifetime. In most cases, however, only a limited number of those offspring survive to reproduce. Adding Malthus's view to what he saw on his voyage and to his own experiences in breeding domestic animals, Darwin made a key association: Individuals that have physical or behavioral traits that better suit their environment are more likely to survive and will reproduce more successfully than those that do not have such traits. Darwin suggested that by surviving long enough to reproduce, individuals have the opportunity to pass on their favorable characteristics to offspring. In time, these favorable characteristics will increase in a population, and the nature of the population will gradually change. Darwin called this process by which populations change in response to their environment natural selection.

SKILL: READING EFFECTIVELY

Read each question, and write your answer in the space provided.

1. Based on the first three sentences of this passage, what can the reader infer was Malthus's idea about the human population?

Malthus believed that while every human has the potential to reproduce many offspring during his/her lifetime, only a limited number of those offspring survive to reproduce.

2. What real-life experiences of his own did Darwin reflect upon when considering Malthus's ideas about human populations?

Observations made on his voyage and his experiences breeding domestic animals.

3. According to Darwin, what causes the nature of a population to change?

Individuals have certain physical/behavioral traits that suit their environment. However, traits, individuals are more likely to survive and reproduce, overtime, more individuals possessing traits will exceed those who do not.
Read this second passage below. Then answer the questions that follow.

Scientists now know that genes are responsible for inherited traits. Therefore, certain forms of a trait become more common in a population because more individuals in the population carry the alleles for those forms. In other words, natural selection causes the frequency of certain alleles in a population to increase or decrease over time. Mutations and the recombination of alleles that occurs during sexual reproduction provide endless sources of new variations for natural selection to act upon.

**SKILL: READING EFFECTIVELY**

Read each question, and write your answer in the space provided.

4. What controls inherited traits?
   
   **genes**

5. What causes a particular trait to become more common in a population?

   *As the # of individuals carrying the alleles for a certain trait ↑, the frequency of that trait ↑.

6. What two events cause new variations of traits in a population?

   *Mutations and recombination of alleles during sexual reproduction.
Evolution by Natural Selection

MODEL 1

1. Describe what is happening in figures 1-3. Is the population of mice different in figure 3 than in figure 1? Explain why.

Living things that are well adapted to their environment survive and reproduce. Those that are not well adapted don’t survive and reproduce. An adaptation is any characteristic that increases fitness, which is defined as the ability to survive and reproduce.

2. For the mice in the figure, what characteristic was an adaptation that increased fitness?

Camouflage allowed gray mice to blend in with env. + ↑ fitness

The table describes four female mice that live in a beach area which is mostly tan sand with scattered plants.

<table>
<thead>
<tr>
<th>Characteristics of each female mouse</th>
<th>Color of Fur</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Black</td>
</tr>
<tr>
<td>Running speed</td>
<td>8 cm/sec.</td>
</tr>
<tr>
<td># pups produced by each female</td>
<td>0</td>
</tr>
<tr>
<td>Age at death</td>
<td>2 months</td>
</tr>
</tbody>
</table>

3. According to the definition given above for fitness, which mouse would biologists consider the fittest? Explain why this mouse would be the fittest.

Tan - highest fitness ble its ability to survive + reproduce. It can blend in with surroundings

4. If a mouse’s fur color is generally similar to its mother’s color, which color fur would be the most common among the pups?

Tan fur is a heritable adaptive characteristic. Heritable adaptive characteristics become more common over many generations.
MODEL 2

Evolution by Natural Selection

A characteristic which is influenced by genes and passed from parents to offspring is called heritable. For the mice on the tan sand, fur color was a heritable characteristic. As you saw, tan fur was a heritable adaptive characteristic which became more common in the pups.

In general, individuals with heritable adaptive characteristics survive longer and have more offspring which have similar adaptive characteristics. Therefore, a heritable adaptive characteristic will tend to become more common in the population. This process is called evolution by natural selection.

Evolution by natural selection leads to adaptation within a population. The term evolution by natural selection does not refer to individuals changing, only to changes in the frequency of adaptive characteristics in the population as a whole. For example, for the mice that lived on tan sand, none of the mice had a change in the color of their fur; rather, due to natural selection, tan fur was more common for the pups than for the mother mice.

Questions
1. Explain why a heritable characteristic which helps an animal to live longer will generally tend to become more common in subsequent generations as a result of evolution by natural selection.

Since it will help the individual live longer, there is a greater chance that it will reproduce than those with less favorable traits. Thus the generation will resemble the parent.

2. Suppose an unusual heritable characteristic helped animals to live longer but made them sterile so they could not have any offspring. Explain why this heritable characteristic would not become more common in subsequent generations as a result of evolution by natural selection.

B/C the trait would not allow the parent to pass it down.


MODEL 3
The Case of the Cacti

This series of pictures shows natural selection in a population of cacti. Pictures 1 and 2 show what happened when a deer came to eat, picture 3 shows the cacti a few weeks later (notice the flowers on the right hand corner), and picture 4 shows the situation a few months later.

1. Complete the following table to describe how this cactus example illustrates the three necessary conditions for evolution by natural selection.

<table>
<thead>
<tr>
<th>Necessary Condition for Evolution by Natural Selection</th>
<th>How does the cactus example illustrate this condition?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation in Characteristics</td>
<td>Cacti w/ defenses &amp; w/ none</td>
</tr>
<tr>
<td></td>
<td>those w/ spines are not eaten</td>
</tr>
<tr>
<td>Differences in Fitness</td>
<td>Cacti w/ spines is able to survive &amp; reproduce</td>
</tr>
<tr>
<td>Heritability of Characteristics</td>
<td>Cacti w/ spines has produced offspring</td>
</tr>
<tr>
<td></td>
<td>w/ spines &amp; spines are heritable</td>
</tr>
</tbody>
</table>

2. "Survival of the fittest" is a common expression. What do you think most people mean by this expression? Most think the stronger individual has a greater chance to live longer. However, it refers to those w/ higher fitness.

3. How would you explain this expression to help someone understand how natural selection actually functions?

It is someone w/ high fitness & is able to reproduce.

Nature selects traits that will increase survival.
MODEL 4

The Case of the Lion

The following example illustrates a more complete definition of fitness as the ability to survive and produce offspring who can also survive and reproduce. According to this definition of him fitness, which of the four male lions described below would biologists consider the “fittest”?

<table>
<thead>
<tr>
<th>Name</th>
<th>George</th>
<th>Dwayne</th>
<th>Spot</th>
<th>Tyrone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at death</td>
<td>13 years</td>
<td>16 years</td>
<td>12 years</td>
<td>10 years</td>
</tr>
<tr>
<td># cubs fathered</td>
<td>19</td>
<td>25</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td># cubs surviving to adulthood</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Size</td>
<td>10 feet</td>
<td>8.5 feet</td>
<td>9 feet</td>
<td>9 feet</td>
</tr>
</tbody>
</table>

(Adapted from Michigan State University, Occasional Paper No. 91, Evolution by Natural Selection: A Teaching Module by Beth Bishop and Charles Anderson, 1986)

1. Explain why Dwayne was not the fittest even though he lived the longest and fathered the most cubs.

   c/c many or Dwayne's cubs did not reach adulthood

Complete the following table.

<table>
<thead>
<tr>
<th>If the reason why more of Tyrone's cubs survived was:</th>
<th>Would the offspring of Tyrone's cubs inherit characteristics that increased their chances of surviving to adulthood? Explain why or why not.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyrone had heritable characteristics that increased resistance to infections, and many of his cubs inherited these characteristics.</td>
<td>Yes - they are able to fight disease and survive + pass traits to their offspring.</td>
</tr>
<tr>
<td>Tyrone happened to live near a farmer whose children liked watching lion cubs, so for ten years the farmer put out meat with antibiotics for Tyrone's cubs.</td>
<td>No - this is not a heritable trait. This will only affect the population temporarily.</td>
</tr>
</tbody>
</table>

2. Use this example to explain why natural selection does not operate on a characteristic which affects fitness but is not heritable.

   Feeding antibiotics to the cubs only affects the population now. It will help them survive but they will not develop resistance to infections. This is a non-heritable trait and cannot spread through a population.
Quick Lab

Comparing Limb Structure and Function

Could you tell if two people were related just by looking at them? What kinds of evidence would help you determine their relationship? In this lab, you will observe parts of various animals and look for evidence that these animals are related to one another.

OBJECTIVES
Observe and describe the limb structures of different organisms.
Identify relationships between the structures of different organisms.

MATERIALS
• pen or pencil

Procedure
1. Observe the forelimbs of the animals shown in Figure 1. Count the approximate number of bones in each of the upper and lower limbs. Record this data in Table 1. Then record the function of each limb.

FIGURE 1 LIMBS OF DIFFERENT ANIMALS

Frog's foreleg  Whale's flipper  Dog's foreleg  Penguin's flipper

Human's arm  Bat's wing  Bird's wing  Alligator's foreleg
TABLE 1 COMPARING ANIMAL LIMBS

<table>
<thead>
<tr>
<th></th>
<th>Approximate number of bones in upper limb</th>
<th>Approximate number of bones in lower limb</th>
<th>Function of limb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frog</td>
<td>1</td>
<td>15</td>
<td>locomotion on land</td>
</tr>
<tr>
<td>Whale</td>
<td>1</td>
<td>31</td>
<td>swimming</td>
</tr>
<tr>
<td>Dog</td>
<td>1</td>
<td>23</td>
<td>locomotion on land</td>
</tr>
<tr>
<td>Penguin</td>
<td>1</td>
<td>9</td>
<td>swimming</td>
</tr>
<tr>
<td>Human</td>
<td>1</td>
<td>28</td>
<td>grasping + manipulating</td>
</tr>
<tr>
<td>Bat</td>
<td>1</td>
<td>26</td>
<td>flight</td>
</tr>
<tr>
<td>Bird</td>
<td>1</td>
<td>9</td>
<td>flight</td>
</tr>
<tr>
<td>Alligator</td>
<td>1</td>
<td>28</td>
<td>locomotion on land</td>
</tr>
</tbody>
</table>

Analysis and Conclusions

1. **Examining Data** Observe the arrangement of bones of each animal. Compare these observations with the approximate number of the bones of each animal. How are the limbs of the frog, whale, dog, human, bat, bird, and alligator similar?

   How many arrangement of bones in upper + lower limbs of the animals are similar

   How do the limbs differ?

   **Shape + Function**

2. **Classifying** Look again at the data you collected. Classify the animals according to the functions of their limbs.

   Bird + Bat = Flight  
   Human + Grasp + Manipulate
   Whale + Penguin = Swimming
   Frog, Dog, Alligator = Locomotion on land

3. **Drawing Conclusions** Which is the better indicator of the relationship between two organisms—structure or function? Explain your reasoning.

   Structure
Skills Worksheet

Active Reading

Section: Evolution

Read the passage below and answer the questions that follow.

Resistance is the ability of one or more organisms to tolerate a particular chemical designed to kill it. An organism may be resistant to a chemical when it contains a gene that allows it to break the chemical down into harmless substances. By trying to control pests and bacteria with chemicals, humans promote the evolution of resistant populations.

Consider the evolution of pesticide resistance among corn pests. A pesticide is sprayed on corn to kill grasshoppers. Most of the grasshoppers die, but a few survive. The survivors happen to have a gene that protects them from the pesticide. The surviving insects pass on the gene to their offspring. Each time the corn is sprayed, the insect population changes to include more and more resistant members. After many sprayings, the entire population may be resistant, making the pesticide useless. The faster an organism reproduces, the faster its populations can evolve.

IDENTIFYING MAIN IDEAS

One reading skill is the ability to identify the main idea of a passage. The main idea is the main focus or key idea. Frequently, a main idea is accompanied by supporting information that offers detailed facts about main ideas.

Read each question and write the answer in the space provided.

1. When might an organism be resistant to a chemical?

   It contains a gene that allows it to break the chemical down into harmless substances.

2. What main idea do the details in the second paragraph support?

   The evolution of pest resistance among corn pests

VOCABULARY DEVELOPMENT

Read each question and write the answer in the space provided.

3. Define resistance.

   Ability of one or more organisms to tolerate a particular chemical designed to kill it.

4. Write a sentence using the word resistance.
SEQUENCING INFORMATION

One reading skill is the ability to sequence information, or to logically place items or events in the order in which they occur.

Sequence the statements below to show the steps in insects' development of resistance to pesticides. Write “1” on the line in front of the first step, “2” on the line in front of the second step, and so on.

3. Remaining grasshoppers reproduce, passing on the resistant gene.
5. Corn is sprayed with a pesticide.
7. The pesticide is rendered useless after many sprayings.
8. The survivors' offspring are sprayed again.
10. A cycle continues of the most pesticide-resistant members of the population surviving each spraying and reproducing.

RECOGNIZING CAUSE AND EFFECT

One reading skill is the ability to recognize cause and effect.

Read each question and write the answer in the space provided.

11. What makes an organism resistant to a chemical?
   
   It contains a gene that allows it to break the chemical down into harmless substances.

12. What human activity promotes the evolution of organisms that are resistant to certain chemicals?
   
   The attempt to control pests and bacteria with chemicals.

13. When a pesticide is sprayed and there are still survivors, what can you assume about them?
   
   They have a pesticide-resistant gene.

14. If an organism reproduces quickly, its population can evolve faster.
Regents Questions---Natural Selection

1. For the past 10 to 25 years, farmers have planted crop seeds that have been genetically modified to withstand treatment with a common weed killer called Roundup. This allows the farmers to spray their fields to get rid of weeds without harming their crops. Recently, more and more farmers have discovered that their fields have Roundup-resistant pigweed growing along with their crop. Explain the loss of effectiveness of Roundup on the pigweed plant. In your answer be sure to include:
   - the genetic event that resulted in the resistant pigweed.
   - explain how the overuse of Roundup caused the overproduction of pigweed
   - an explanation of survival of the fittest
   - an alternate method of controlling weeds that the farmer may use

   - mutation / sexual reproduction
   - Roundup kills only nonresistant weeds. Resistant pigweed survived and reproduced
   - Only those with the resistance to Roundup were able to survive and reproduce.
   - Use a natural enemy to the weeds

2. Many popular products from hand soap to clothing advertise that they have antibacterial qualities. Most microbiologists recommend against their routine use in our daily lives. Explain in terms of natural selection why this is true. Your answer must include the following terms:
   - variation
   - reproduction
   - survival of the fittest

   - There are variations in bacteria. Some are resistant to antibiotics
   - The bacteria with the resistance will survive and reproduce
   - The bacteria with resistance has a higher chance of survival and will pass on favorable trait to succeeding generations.