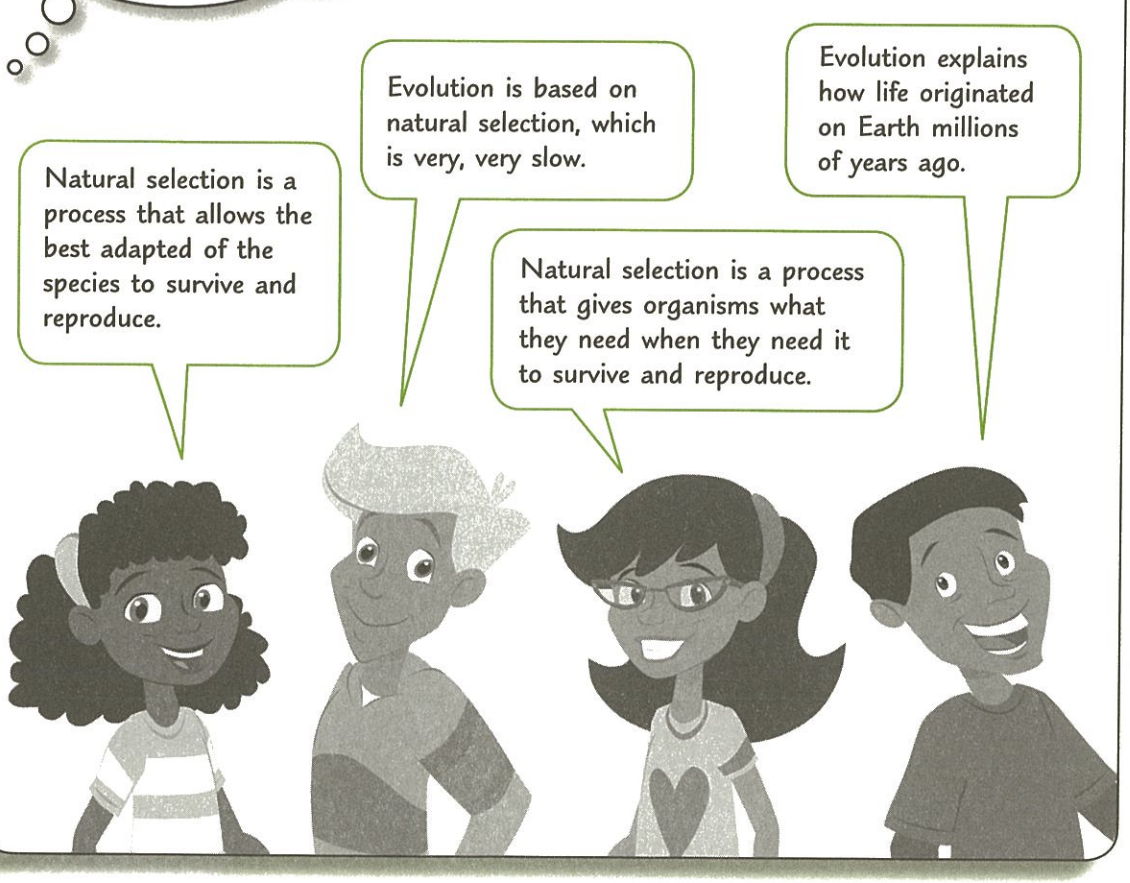
Evolution

TOPIC 5

What do You Think? Evolution



TOPIC

5 Evolution

Vocabulary

adaptive value
evolution
extinction
fossil record
genetic variation
geologic time
mutation
natural selection
overproduction
theory

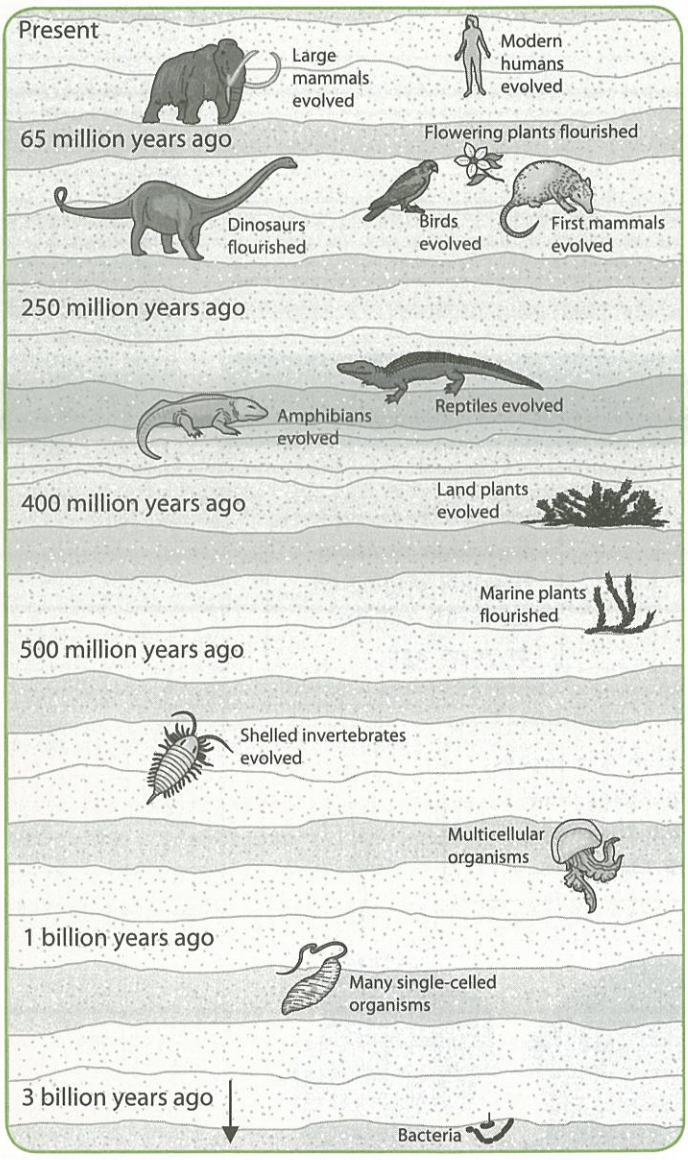


Figure 5-1. Examples from the fossil record

Topic Overview

Extensive evidence indicates that life on Earth began more than three billion years ago. Fossils found in ancient rocks have given us many clues to the kinds of life that existed long ago. The first living organisms were simple, single-celled organisms. Over time, more complex single-celled creatures developed. Then, about a billion years ago, increasingly complex, multicellular organisms began to appear. The idea that explains how this change in species has occurred over time is known as **evolution.**

The Theory of Evolution

The theory of evolution is accepted as the central theme of modern biology. It helps biologists understand how the variations among individuals can lead to changes in an entire species of organism. Since it was first suggested by Charles Darwin, the concept of evolution has been refined by massive amounts of evidence offered by thousands of scientists. So much evidence has been collected that evolution now has the stature of a **theory,** which is a concept that has been tested and confirmed in many different ways and can be used by scientists to make predictions about the natural world.

The theory of evolution helps biologists understand the similarities (such as bone structure and biochemistry) among different organisms. It also helps to explain the history of life that is revealed by the **fossil record,**

which is a collection of fossils that provides clues to the history of Earth's organisms.

The fossil record spans much of **geologic time**—the billions of years of Earth's history—revealing many changes in environments as well as species. Figure 5-1 shows examples from the fossil record through geologic time.

Evolution does NOT necessarily produce long-term progress in any set direction. Instead, evolutionary change appears to be more like the growth of a bush. Notice in Figure 5-2 that some branches survive from the beginning with little or no change. Some die out altogether. Others branch repeatedly, with each new branch representing a new species.

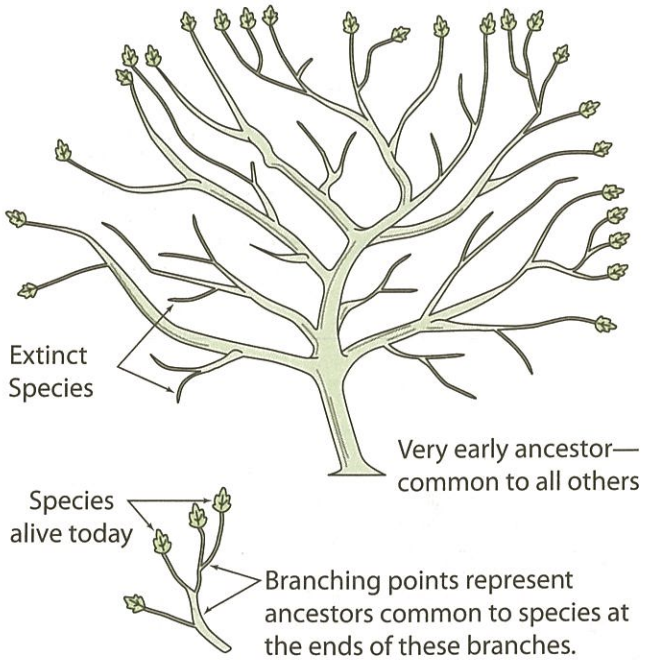


Figure 5-2. Evolution modeled as the growth of a bush: **Evolutionary changes in species are like the growth of a bush in which some twigs grow and branch, while others die. The tips of the living twigs represent species that are alive now.**

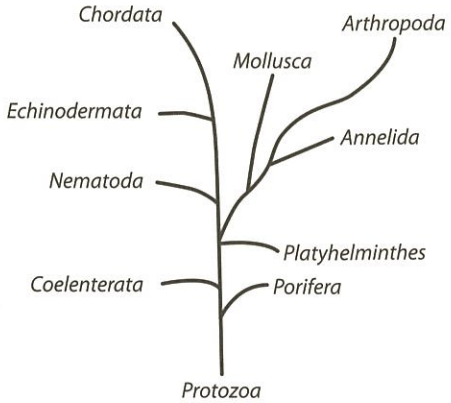
Review Questions

1. Evolution is the process of
(1) development of one-celled organisms from mammals
(2) change in species over long periods of time
(3) embryonic development of modern humans
(4) changing energy flow in food webs

2. Which phrase best defines evolution?
(1) an adaptation of an organism to its environment
(2) a sudden replacement of one community by another
(3) the isolation of organisms from each other for many years
(4) a process of change in species over a period of time

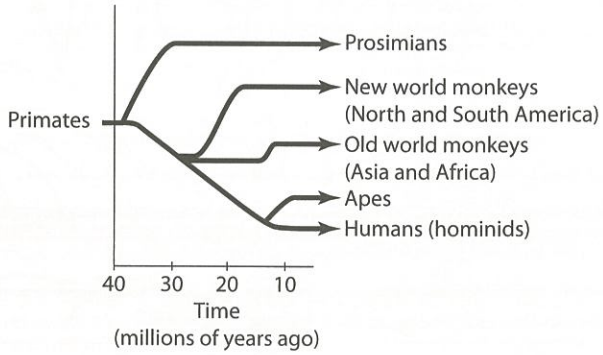
3. The study of fossils has allowed scientists to
(1) describe past environments and the history of life
(2) study present ocean temperatures at different depths
(3) analyze the chemical composition of sedimentary rocks and minerals
(4) describe the details of the process by which life first began on Earth

4. The evolution of species is often represented as a branching tree similar to the one shown in the diagram below. The names shown represent different groups of organisms alive today; the lines represent their evolutionary histories.



The statement that is best supported by the diagram is that
(1) *Annelida* and *Arthropoda* have an ancestor in common
(2) *Echinodermata* are more closely related to *Mollusca* than they are to *Chordata*
(3) *Mollusca* and *Arthropoda* evolved before *Porifera*
(4) *Annelida* and *Arthropoda* evolved from *Echinodermata*

5. The diagram below represents possible lines of the evolution of primates.



Which inference can best be made based on the diagram?

(1) Adaptations for living in trees are inherited by all primates.
(2) Humans and apes have a common ancestor.
(3) The embryos of monkeys and apes are identical.
(4) The period of development is similar in most primates.

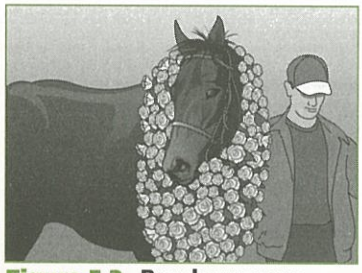


Figure 5-3. Racehorses are bred for speed and stamina: When humans breed plants or animals, they select specific traits, such as speed, flower color, or resistance to insects. In a similar way, "nature" selects any trait that increases an organism's ability to survive and reproduce.

The Mechanics of Evolution

Darwin did not only suggest that species evolved. He also suggested how that evolution might have occurred. Darwin thought that the mechanism of evolution was like the process of artificial selection practiced by breeders of plants and animals. (See Figure 5-3.) He used the term **natural selection** to indicate that the process of evolution was controlled by "nature" rather than by people. In the process of natural selection, individuals that survive are able to breed and pass their genetic information to the next generation. Those that are not as successful in the environment often die without leaving any offspring.

Overview of Evolution

Darwin's ideas are easy to understand: In any environment, an individual may be born with a characteristic that makes it stronger, faster—any sort of advantage that will help it survive and reproduce. The individuals that prove to be the best adapted to their environment will be more likely to survive. If they do survive, their favorable characteristics will be passed on to many of their offspring. As a result, these useful adaptations, which first appeared randomly, are likely to become more and more common with each generation. Similarly, characteristics that reduce an individual's chance of surviving and reproducing will tend to decrease over time.

The long-term result of natural selection is a change in the frequency of certain traits in a population. Beneficial traits tend to become more common; harmful traits tend to become less common. As the frequency of a trait in a population increases or decreases over time, it can be said that the species is evolving. Note that the population—not the individual—changes as a result of evolution. An individual does not evolve; each is born with genetic information that may or may not help it survive and reproduce. As natural selection leads to changes in the composition of a population, that population may have more individuals with a certain favorable characteristic than it did earlier.

Interactions and Evolution

The driving force behind evolution is the interaction between individual organisms and their environment. Conditions that are vital to the process of evolution include

- the potential for a species to increase its numbers, known as **overproduction**
- the finite (limited) supply of resources needed for life
- the genetic variation of offspring due to mutation and genetic "shuffling"
- the selection by the environment of those offspring better able to survive and reproduce

All of these conditions, which are explained below, are involved in the process of evolutionary change.

Overproduction In each generation, a species has the potential to produce more offspring than can possibly survive. Species with high reproductive potential include bacteria, insects, dandelions, and rabbits. (See Figure 5-4.) If all the offspring of these organisms survived, they would overrun Earth. However, that does not happen.

Rabbit Population Group	
Number of Generations	Number of Rabbits
1	100
72	3,354
100	13,150

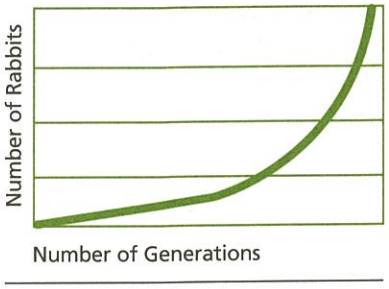


Figure 5-4. Overproduction: Rabbits are known for their high reproductive potential.

Scientists have learned that, in stable environments, the population of a species remains about the same from one year to the next. For example, no matter how many deer are born in one year, at the same time the next year, there will be about the same number of deer as there was the year before. Similarly, some fish species lay millions of eggs, but by the next year, the population of that species is the same as it was the previous year. This happens because not all of the new individuals that are born or hatched will survive to adulthood.

The Struggle for Survival Overproduction leads to competition among the members of a species. Not all offspring survive long enough to reproduce. In many cases, chance determines which offspring survive. For example, wind may blow a dandelion seed to a patch of fertile soil or into a lake. A deer may be born in a wildlife preserve or in the path of a forest fire.

But chance is not the only factor that determines which offspring will survive and which will die. The offspring all have to cope with environmental conditions, such as temperature, disease, parasites, and predators. They also need resources, such as oxygen, water, food, and shelter. However, the supply of these resources is finite. If they are to survive, organisms of the same species must compete for limited resources. Depending on their success as competitors, individuals will get the resources they need to survive, or they will not. Those that are the best suited to their environment are more likely to survive. Many of the losers in this struggle for resources will die before they have a chance to reproduce.

Variation The new traits that can lead to evolution come from normal variation within species. As shown in Figure 5-5, organisms within a species are never exactly alike. For example, some adult grasshoppers have longer legs than others; some have a lighter body color. In any group of gray squirrels, some have sharper or longer claws,

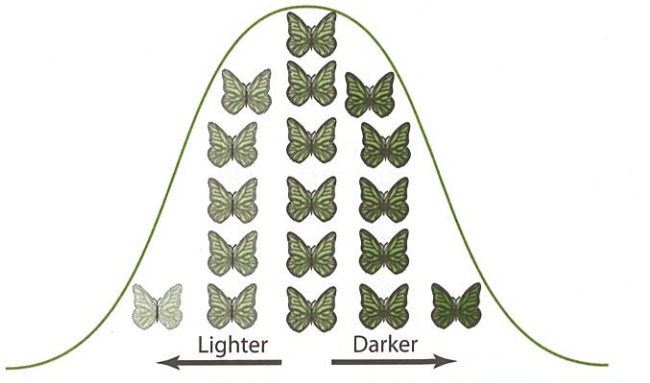


Figure 5-5. Genetic variation: In this example, a species of green butterflies might have individuals that vary in color from very dark green to very light green.

lighter or darker fur, bigger or smaller ears, and so on. The differences among offspring are due to **genetic variation**—the unique combination of traits each organism inherits from its parents.

Some variations give individuals an advantage over others in their struggle for resources. Any trait that helps an organism survive and reproduce under a given set of environmental conditions is said to have **adaptive value.** For example, a rabbit's ability to blend in with its surroundings may allow it to escape capture by a fox. The coloration it inherited has adaptive value for the rabbit, allowing it to escape predators and survive. When the fox population is high, this adaptation may be especially valuable to rabbits that inherited it.

Selection by the Environment As Darwin proposed with his idea of natural selection, traits with an adaptive value in a specific environment give individuals in that environment a competitive advantage. If the beneficial trait is passed to the offspring, they, too, are more likely to survive and reproduce. The proportion of individuals with these advantageous characteristics will increase because they are better able to compete than individuals without the beneficial trait. Eventually, nearly all the individuals in the population will have the beneficial trait. This change in the characteristics present in population over time is evolution.

Although some evolution may occur without much change in the environment, it is usually the adaptation of a species to changes in its environment that brings about evolution. Therefore, a changing environment is often the driving force for evolutionary change.

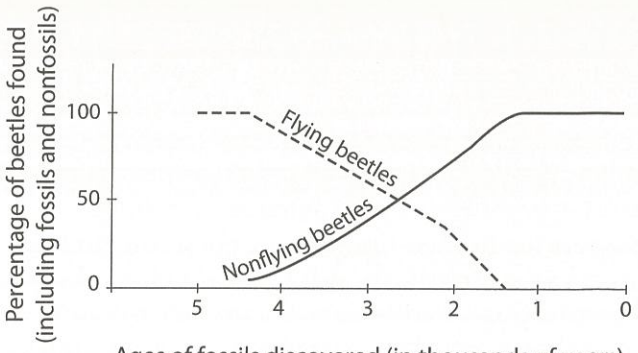
Review Questions

6. The process of natural selection is based on the assumption that

(1) environmental changes will cause changes in body structure in individuals
(2) most changes from generation to generation are the result of mutations
(3) part of the population of organisms always remains stable
(4) different traits inherited by offspring have different survival value.

Base your answers to questions 7 and 8 on the information below and on your knowledge of biology.

A study of beetles on an isolated oceanic island formed by volcanic action and far from any other land shows that all of the beetles that are presently on the island are incapable of flying. A study of fossils from different rock layers of the island shows that the island was once populated with flying beetles. The graph shows the probable change over the last 5,000 years.



7. The loss of flying ability by the beetle is most probably the result of

(1) predators eating the beetles' wings
(2) beetles not using their wings
(3) genetic changes in the beetles
(4) lack of vegetation for the beetle to feed on

8. The graph indicates that the non-flying beetles probably

(1) were better adapted to the environment
(2) arrived from other islands 5000 years ago
(3) mutated and produced flying beetles
(4) became extinct about 1.5 thousand years ago

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9. When lions prey on a herd of antelope, some of the antelope are eliminated. Which part of the theory of evolution can be used to describe this situation?

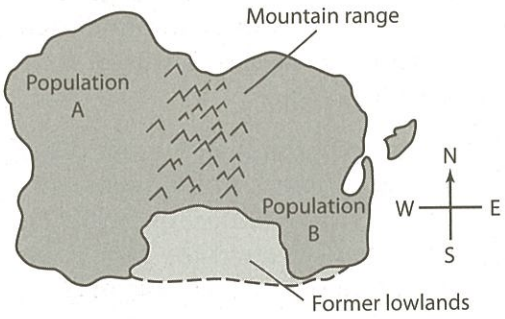
(1) asexual reproduction of the fittest
(2) isolation of the species
(3) survival of the best adapted
(4) new species development due to mutation

10. Every spring, each mature female fish of a particular species produces several million eggs. However, the total population of this species remains at around 10,000 from one year to the next.

State two reasons why the fish population remains approximately the same from one generation to the next. [1]

Base your answers to questions 11 and 12 on the diagram below and on your knowledge of biology.

The diagram represents a small island divided by a mountain range. The mountain range prevents populations A and B from making contact with each other. At one time in the past, however, lowlands existed in the area indicated, and the ancestors of population A and population B were members of the same population.



11. Over many years, the climate on the west side of the island has undergone drastic changes while the climate on the east side has remained the same. It is most likely that population B will

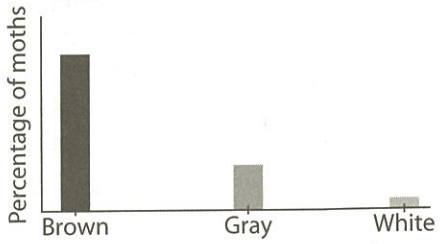
(1) migrate and intermix with population A
(2) become extinct
(3) have evolved more than population A
(4) have evolved less than population A

12. The organisms of population A and population B are now incapable of interbreeding and producing offspring. Which biological process most likely caused this situation to occur?

(1) artificial selection
(2) cloning
(3) natural selection
(4) asexual reproduction

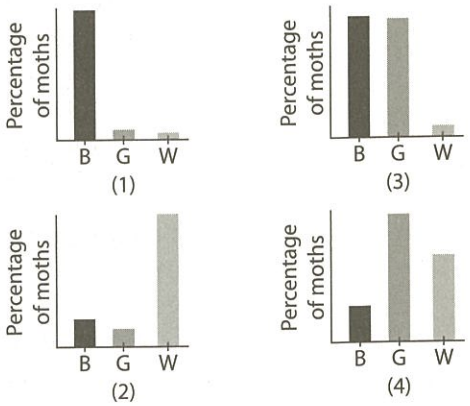
Base your answers to questions 13 and 14 on the information and graph below and on your knowledge of biology.

Scientists studying a moth population in a wooded area of New York State recorded the distribution of moth wing color as shown in the following graph. While observing the moths, scientists noted that the moths spent most of the day resting on trees and looking for food during the night. The woods contained trees with a bark color that was predominantly brown.



Distribution of moth wing color

13. A fungus infection affected nearly all trees in the woods so that the color of the tree bark was changed to a gray-white color. Which graph shows the most probable results that would occur in the distribution of wing color in this moth population after a long period of time?



14. As a result of the fungus infection, the change in moth wing color distribution would most probably occur by the

(1) production of sex cells by mitosis
(2) natural selection of favorable variations
(3) eating of pigments in fungus spores
(4) production of mutations as a result of eating the fungus

MemoryJogger

Recall that at the beginning of meiotic cell division, the chromosomes line up and can exchange parts. What ends up in each gamete is the result of chance, just as any hand of cards dealt to you after shuffling is the result of chance. As a result of this shuffling, the gametes (sperm and egg) each contain a unique combination of genetic information. Since any sperm may combine with an egg, the number of possible combinations becomes enormous.

Sources of Variation

As you may recall, the arrangement of an individual's DNA bases determines all the inherited characteristics of that individual. Any change in bases or their sequence may bring about a change in the individual. But not all of those changes can be passed on to the individual's offspring. In sexually reproducing organisms, only changes in the genes of sex cells can be passed on to the next generation and become the basis for evolutionary change. Other types of variation (such as changes to body cells) die with the individual. For example, a father who has built huge muscles due to exercise does NOT pass those large muscles to his offspring.

There are two major ways an organism can wind up with genes that differ from those of its parents. Some genetic variations arise because of mutations in the genes of an organism. Others are due to "genetic shuffling," the routine sorting and recombination of genes that occurs during sexual reproduction.

Mutation A **mutation** is a change in the base sequence of a DNA molecule. Mutations occur as random, chance events that cannot be predicted. Some mutations occur as errors in DNA as cells function. Radiation and some chemicals can also cause them. Mutations are an important source of totally new forms of genes.

When mutations occur in body cells, they affect only that individual. However, a mutation in a single-celled organism or in the sex cells of a multicellular organism can be passed on to the offspring. In organisms that reproduce sexually, only mutations in the genes of sex cells can become the basis for evolutionary change.

Nearly all mutations are harmful and may affect the offspring so severely that it cannot survive. A few mutations benefit the individual, however, and can increase its chance of surviving, reproducing, and passing the mutation to the next generation. A beneficial mutation may lead to the evolution of a new species. For example, the ancestors of polar bears probably had dark fur. If a mutation resulted in a bear with white fur, that bear probably would have died young. However, if the mutation occurred in a snowy environment, the white fur would be a useful mutation, allowing the bear to stalk its prey more effectively.

Genetic Shuffling The sorting and random recombining of genes during meiosis and fertilization results in new and different combinations of genes. These genes can be passed on to individual offspring. The process is similar to shuffling and dealing cards. The deck stays the same, but nearly every hand will be slightly different because of mixing and rearranging during shuffling. At fertilization, even more variety is introduced because now cards from "two decks" are combined. Although mutations provide new genetic instructions, genetic shuffling is the main source of the variation that exists among the members of any sexually reproducing species.

Review Questions

15. Which statement is basic to the theory of evolution by natural selection?

(1) In general, living organisms maintain a constant population from generation to generation.
(2) Changes in living organisms are almost completely the result of mutations.
(3) Natural variations are inherited.
(4) There is little competition between species.

16. Which statement is *not* included as part of our modern understanding of evolution?

(1) Sexual reproduction and mutations provide variation among offspring.
(2) Traits are transmitted by genes and chromosomes.
(3) More offspring are produced than can possibly survive.
(4) New organs are formed when organisms need them.

17. The modern theory of evolution states that a basis for variation within a species is provided by

(1) mutations
(2) asexual reproduction
(3) cloning
(4) overproduction

18. Sexual reproduction is related to evolution because sexual reproduction

(1) occurs only in more recently evolved forms of animal life
(2) increases the chances of extinction of different species
(3) increases the chances for variations to occur
(4) is the more usual kind of reproduction

19. Mutations can be transmitted to the next generation if they are present in

(1) hormones
(2) gametes
(3) body cells
(4) muscle cells

20. A new chemical was discovered and introduced into a culture containing one species of bacteria. Within a day, most of the bacteria were dead, but a few remained alive. Which statement best explains why some of the bacteria survived?

(1) They had a genetic variation that gave them resistance to the chemical.
(2) They were exposed to the chemical long enough to develop a resistance to it.
(3) They mutated and became a different species after exposure to the chemical.
(4) They absorbed the chemical and broke it down in their digestive systems.

21. Which characteristics of a population would most likely indicate the lowest potential for evolutionary change in that population?

(1) sexual reproduction and few mutations
(2) sexual reproduction and many mutations
(3) asexual reproduction and few mutations
(4) asexual reproduction and many mutations

22. Which two factors provide the genetic basis for variation within many species?

(1) asexual reproduction and meiosis
(2) mutations and sexual reproduction
(3) competition and the synthesis of proteins
(4) ecological succession and mitosis

23. Which statement best describes a current understanding of natural selection?

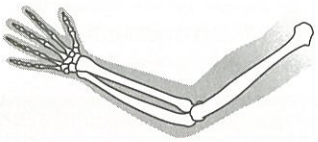
(1) Natural selection influences the frequency of an adaptation in a population.
(2) Natural selection has been discarded as an important concept in evolution.
(3) Changes in gene frequencies due to natural selection have little effect on the evolution of species.
(4) New mutations of genetic material are due to natural selection.

The Results of Genetic Variation

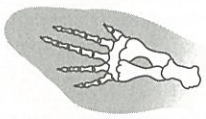
The changes that result from mutation or genetic shuffling in the sex cells may affect the offspring in several ways. Most of the changes can be categorized as structural, functional, or behavioral.

Structural Change The structure of any organism is the result of its species' entire evolutionary history. There are millions of examples of variations that have resulted in structural changes. For example, the polar bear (like other bears) has thick fur that keeps it warm in its cold environment.

Bird wing



Human arm



Whale flipper

Bat wing

Figure 5-6. Similar bone structure of different species: The limbs shown above are from different species and have different functions, but they share many structural similarities. They are all made of the same type of bones and are attached in a similar way. The whale flipper is actually much larger than the other limbs. Notice that the ulna and radius of the bat wing are almost fused.

Polar bears, however, have evolved an extra protection from the cold. The soles of their feet are also mostly covered with thick fur. This extra fur not only keeps their skin off the ice but also improves traction.

The theory of evolution has helped scientists explain many of the structural variations and similarities found in organisms. For example, in Figure 5-6, notice that each limb has one thick "long" bone, two thinner "long" bones, and a "hand" with five digits. The ancestor of these animals most likely had a similar limb structure. At one point, however, limbs began to vary, evolving into arms, legs, wings, or flippers.

Structures that are no longer used by modern organisms give scientists clues to the evolutionary history of a species. Some snakes, for example, have tiny, nonfunctional leg bones—an indication that they probably evolved from four-legged, lizard-like ancestors.

Functional Change Molecular or biochemical changes affect how an organism works. These are functional changes. For example, all working muscles emit an extremely tiny electrical output. In some eels, however, that electrical output has evolved into an adaptation that helps it find and capture food. The muscles of these eels can produce a massive shock that stuns or kills its prey.

Changes in DNA often lead to functional changes. One example is a mutation in the DNA of certain one-celled organisms that led to their ability to make enzymes that digest wood. Another is the evolution of the ability of some snakes to make a poisonous venom.

Behavioral Change Behaviors have also evolved through natural selection. Many of the specific behaviors we find in species today have become common because they resulted in greater reproductive success.

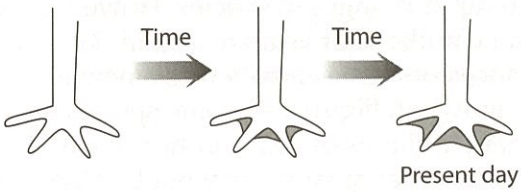
- Fighting among the males of a walrus population for a harem of females is one evolved behavior. Because of the fighting, the stronger, healthier male mates with the most females.
- The correct rate of "blinking" allows males and females of firefly species to find each other. A different pattern or rate of blinking would isolate the individual from potential mates.

The Importance of Variation

If environmental conditions change, organisms that have adapted to those conditions may die. If all the members of the species had exactly the same combination of characteristics, an environmental change could be disastrous, wiping out the entire species. The variation of organisms within a species increases the likelihood that at least some members of the species will survive in a changed environment. Once the diversity present in a species is lost, it is next to impossible to get it back. Today's endangered species have such small populations that biologists worry that they may not have the genetic diversity to adapt to even slight changes in their environment.

Review Questions

24. The changes in the foot structure in a bird population over many generations are shown in the diagram below.



These changes can best be explained by the concept of

(1) natural selection
(2) extinction
(3) stable gene frequencies
(4) cloning

25. Explain how the lack of genetic diversity found in populations of endangered species might hinder their recovery. [1]

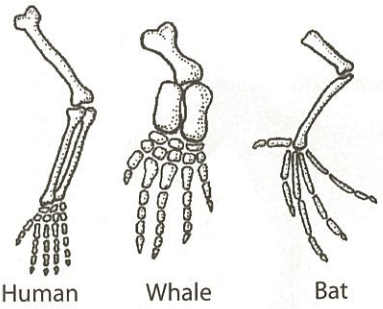
26. The Florida panther, a member of the cat family, has a population of fewer than 100 individuals and has limited genetic variation. Which inference based on this information is valid?

(1) These animals will begin to evolve rapidly.
(2) Over time, these animals will become less likely to survive in a changing environment.
(3) These animals are easily able to adapt to the environment.
(4) Over time, these animals will become more likely to be resistant to disease.

27. Which statement could be used as evidence to show that two different species of organisms most likely developed from a single, common ancestor?

(1) They eat the same types of food.
(2) They have different digestive enzymes.
(3) They lived during the same time period.
(4) They contain similar amino acid sequences.

28. The diagrams below show the bones in the forelimbs of three different organisms.



Differences in the bone arrangements support the hypothesis that these organisms

(1) are members of the same species
(2) may have descended from the same ancestor
(3) have adaptations to survive in different environments
(4) all contain the same genetic information

29. In most populations, the individuals that produce the greatest number of offspring are

(1) always the strongest
(2) usually the best adapted
(3) those that have only inheritable traits
(4) those that are the most intelligent

30. The best scientific explanation for differences in structure, function, and behavior found in different species of organisms is provided by

(1) carbohydrate electrophoresis
(2) population chromatography
(3) the theory of carrying capacity
(4) the theory of evolution

Patterns of Change

Evolution appears to follow certain patterns that appear repeatedly in the fossil record. For example:

- Changes in species are often related to environmental change.
- Species with short reproductive cycles that produce many offspring tend to evolve more quickly than species with long lifespans and few offspring.
- The failure to adapt to a changing environment may result in the death of the species.

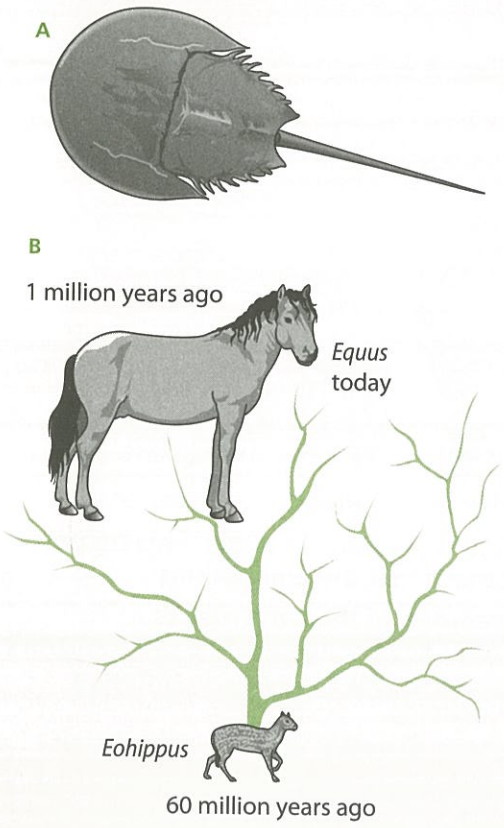


Figure 5-7. The rate of evolution: For some species, the rate of evolutionary change has been very slow. For example, the horseshoe crab (A) has shown little change from fossils of its ancestors that lived 300 million years ago. However, the horse (B) has evolved tremendously over the past 60 million years.

The Rate of Evolution

Most of the diversity of life on Earth today is believed to be the result of natural selection occurring over a vast period of geologic time. The amount of change seems to be linked to changes in the environment. Minimal environmental change often results in stable populations. Rapid environmental change often leads to rapid changes in species. However, for any species, it may take millions of years to accumulate enough differences from its ancestors to be classified as a new or different species. As shown in Figure 5-7, some species have hardly changed in many millions of years. Others have changed so much that the relationships may not be obvious.

The rate of evolutionary change may also be influenced by the number of offspring produced by a species. Those that have few offspring and live a long time generally evolve quite slowly. Those that have brief lifespans and numerous offspring can change so quickly that evolution may occur in just a few years.

One example of rapid change involves the evolution of antibiotic resistance by pathogenic bacteria. When a population of millions of bacteria is exposed to an antibiotic, there is a chance that a few might have a gene that makes them resistant to the antibiotic. (This gene probably occurred as a chance mutation at some earlier time. It was most likely present in some of the bacteria before the antibiotic was used, and its appearance was totally unrelated to the presence of the antibiotic.) The antibiotic could kill almost all of the bacteria except for a few that escape exposure to the antibiotic. The ones with the resistance gene would also survive.

Because the antibiotic eliminated most of the competition, the few survivors, including the resistant ones, reproduce quickly, giving rise to a new population of the bacteria. In this new population, a higher proportion of individuals is now resistant to the drug. When the same antibiotic is used on the descendants of this new population, even more resistant bacteria will survive. Now the proportion of resistant bacteria is even higher. In this case, the antibiotic has become an agent of selection. The antibiotic did not cause the original mutation that made the bacteria resistant to the antibiotic. It merely determined which bacteria would live to reproduce. Figure 5-8 shows the process.

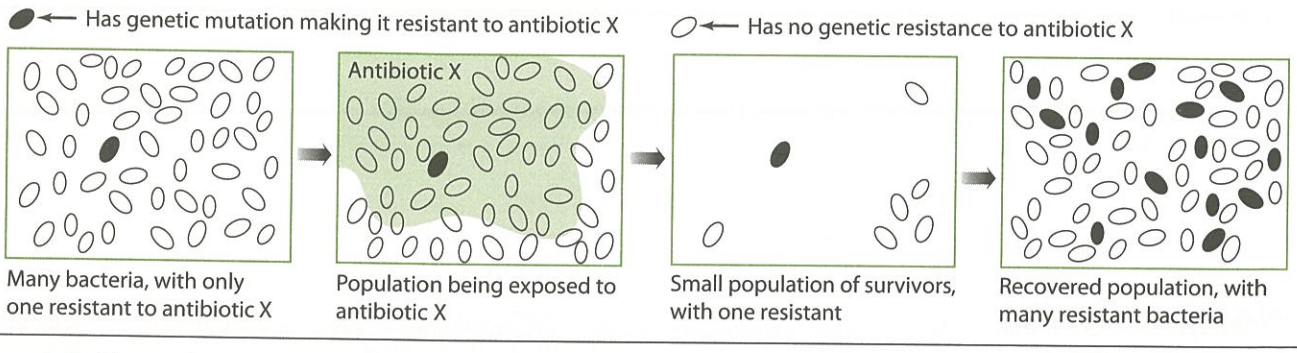


Figure 5-8. How resistance to antibiotics can develop

Insects also have short reproductive cycles and produce many offspring. Many insect species have changed significantly in response to pesticide use. For example, the widespread use of the pesticide DDT led to insect species becoming resistant in just a few years. As was the case with bacteria and antibiotics, there may have been a few DDT-resistant insects in the population before the chemical was ever used. They probably had a random mutation that had no adaptive value before the use of DDT. Once the DDT was sprayed, nearly all of the nonresistant insects were killed, leaving a high proportion of resistant insects to repopulate the area. Later, if DDT was sprayed again, it was less effective against the resistant offspring of the survivors of the earlier spraying.

As a result of these kinds of rapid evolutionary events, we are finding more and more bacteria that are resistant to antibiotics and more and more insect species that are resistant to our pesticides. This has created many problems in the fields of medicine and agriculture and will continue to be a problem in the future.

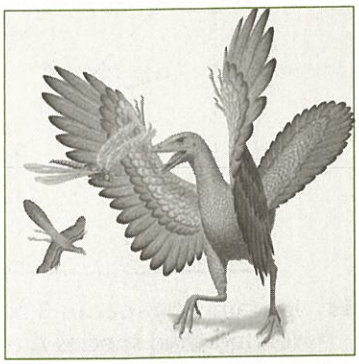


Figure 5-9. An artist's conception of how the extinct *Archaeopteryx* might have looked, and the fossilized skeleton of this animal.

Extinction

Extinction is the disappearance of an entire species. Any time the death rate of individuals within a species is greater than the birth rate, extinction is a possibility. Generally, extinction occurs when the environment changes. Temperatures change; sea levels rise and fall. Grasslands become deserts; clear lakes become polluted. The variation of organisms within a species increases the likelihood that at least some members of the species will survive the changing environmental conditions. However, when the adaptive characteristics of a species are insufficient to allow its survival in a new environment, the species will become extinct.

The fossil record shows that throughout geologic time, millions of species have evolved, survived for a while, then failed to adapt successfully, and finally became extinct. It is a surprisingly common process. In fact, from the number of fossils of extinct organisms found, it is apparent that a majority of the species that ever lived on Earth is now extinct. Figure 5-9 shows a fossil of the extinct *Archaeopteryx*, an ancestor of modern birds.

Review Questions

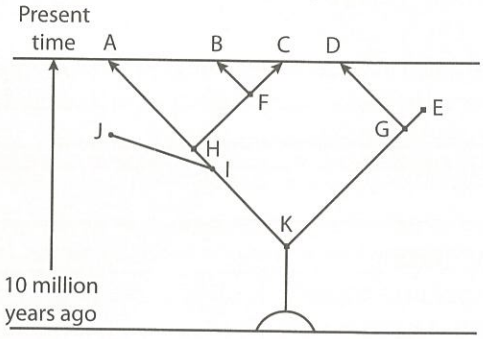
31. The shark has changed very little in the last 50 million years. Which statement best explains why this is the case?

(1) The shark is well adapted to its relatively unchanged environment.
(2) Sharks have a high reproductive rate and show little change in their genetic makeup from one generation to the next.
(3) Sharks need to change only if humans are present in their environment.
(4) Sharks have a high mutation and genetic recombination rate.

32. Many animals exist today in a form that is almost identical to the form they had a million years ago. What is the most probable explanation for this lack of evolutionary change?

(1) Genetic mutations have occurred among these animals.
(2) The environment of these animals remained about the same.
(3) These animals reproduce by sexual reproduction.
(4) Complex organisms evolved into simpler ones.

Base your answers to questions 33 through 35 on the diagram below and on your knowledge of biology. The diagram shows an interpretation of relationships based on evolutionary theory. The letters represent different species.



33. Explain why species B and C are more closely related than species A and C are.

34. The diagram indicates that a common ancestor for species C and E is species

(1) F (2) G (3) H (4) K

35. Which species are least likely to be vital parts of a present-day ecosystem?

(1) A and E
(2) C and D
(3) E and J
(4) B and F

Base your answers to questions 36 and 37 on the information below and on your knowledge of biology.

Joshua Lederberg discovered that, in a large population of Escherichia coli (E. coli) about 1 in 10 million of the offspring was naturally resistant to the antibiotic streptomycin. When these naturally resistant bacteria were isolated and grown separately, they soon formed a larger population. The entire population so formed was also naturally resistant to streptomycin.

36. The formation of the large streptomycin-resistant population is based on

(1) variations and survival of the fittest
(2) mutations and asexual reproduction
(3) sexual reproduction and no mutations
(4) survival of the fittest and cloning

37. According to modern evolutionary theory, the resistance to streptomycin probably resulted directly from

(1) culturing the *E. coli*
(2) changes in temperature under which *E. coli* are grown
(3) a change in the DNA of *E. coli*
(4) the presence of streptomycin in the environment of *E. coli*

38. A large population of cockroaches was sprayed with a newly developed, fast-acting insecticide. The appearance of some cockroaches that are resistant to this insecticide supports the concept that

(1) species traits tend to remain constant
(2) variation exists within a species
(3) insecticides cause mutations
(4) the environment does not change

39. Compounds like the pesticide DDT may bring about the evolution of new strains of organisms by

(1) destroying food producers
(2) acting as a natural selecting agent
(3) mixing two different sets of genes
(4) creating new ecological niches

40. A population of mosquitoes is sprayed with a new insecticide. Most of the mosquitoes are killed, but a few survive. In the next generation, the spraying continues, but still more mosquitoes hatch that are immune to the insecticide.

How could these results be explained according to the present concept of evolution?

(1) The insecticide caused a mutation in the mosquitoes.
(2) The mosquitoes learned how to fight the insecticide.
(3) A few mosquitoes in the first population were resistant and transmitted this resistance to their offspring.
(4) The insecticide caused the mosquitoes to develop an immune response, which was inherited.

41. Throughout the history of Earth, which factor has probably been the chief cause of the extinction of various species?

(1) people's interference with nature
(2) failure to adapt to environmental changes
(3) warfare within the species
(4) volcanic eruptions

42. Fossil evidence indicates that many species have existed for relatively brief periods of time and have then become extinct. Which statement best explains the reason for their short existence?

(1) These organisms lacked the energy to produce mutations.
(2) Humans modify plant and animal species through the knowledge of genetics.
(3) These organisms lacked variations having adaptive value.
(4) Within these species, increasing complexity reduced their chances of survival.

Practice Questions for the New York Regents Exam

TOPIC 5

Directions

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully and answer with a correct choice or response.

Part A

1 How does natural selection operate to cause change in a population?
(1) The members of the population are equally able to survive environmental change.
(2) The members of the population differ so that only some survive when the environment changes.
(3) The members of the population cause environmental changes and adapt to them.
(4) All the members of the population adapt to environmental changes.

2 Which mutation could be passed on to future generations?
(1) a gene change in a liver cell
(2) cancer caused by excessive exposure to the sun
(3) a chromosomal alteration during gamete formation
(4) random breakage of a chromosome in a leaf cell of a maple tree

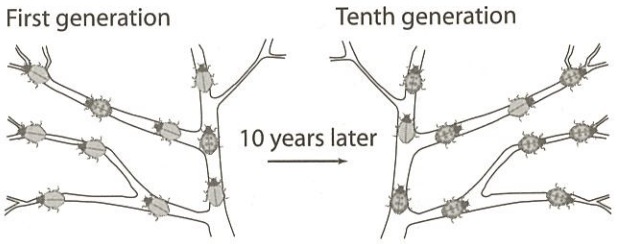
3 A trait with low survival value to the members of a population will most likely
(1) undergo a series of mutations in succeeding generations
(2) cause the reproductive rate of the individual to increase
(3) decrease in frequency from one generation to the next
(4) remain unchanged in frequency through many generations

4 A change in the genetic material that produces variation in a species may be the result of
(1) the struggle for survival
(2) the overproduction of a species
(3) a mutation
(4) competition

5 The DNA sequences found in two different species are 95% the same. This suggests that these species
(1) are evolving into the same species
(2) contain identical proteins
(3) may have similar evolutionary histories
(4) have the same number of mutations

6 The process by which a species passes out of existence is known as
(1) endangerment
(2) deforestation
(3) extinction
(4) adaptation

7 The diagram below illustrates the change that occurred in the frequency of body pattern traits shown by an insect population over ten generations.



A probable explanation for this change would be that over time there was
(1) a decrease in the adaptive value of the spotted trait
(2) an increase in the adaptive value of the spotted trait
(3) an increase in the population of the insect
(4) a decrease in the mutation rate of the gene for body pattern

8 The fact that a healthy deer can outrun a timber wolf is an example of
(1) mutation
(2) isolation
(3) non-random mating
(4) natural selection

9 A maple tree releases hundreds of seeds in a single season. This is an example of
(1) a mutation
(2) isolation
(3) overproduction
(4) non-random mating

Part B

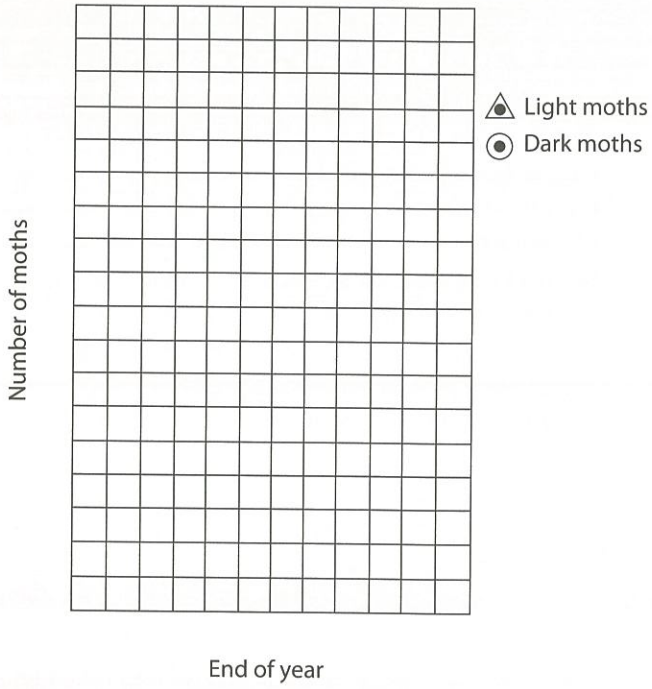
Base your answers to questions 10 through 15 on the information below and on your knowledge of biology.

The bark of trees around Manchester, England, was mostly light in color before the Industrial Revolution. Light-colored peppered moths that rested on the trees were camouflaged from bird predators, while dark-colored peppered moths were easily preyed upon. After a few years of industrialization, the tree bark became darkened from pollution. The table below represents a change in the number of light- and dark-colored moths within the peppered moth population over a period of six years from the beginning of industrialization.

End of Year	Number of Light Moths	Number of Dark Moths
1	556	64
2	237	112
3	484	198
4	392	210
5	246	281
6	225	357

Using the information in the data table, construct a line graph on the grid provided. Follow the instructions below.

Changes in Peppered Moth Population



10 Mark an appropriate scale, without any breaks, on each axis. [1]

11 Plot the data for the number of dark moths on the grid. Surround each point with a small circle and connect the points. [1]

Example: 

12 Plot the data for the number of light moths on the grid. Surround each point with a small triangle and connect the points. [1]

Example: 

13 At the end of which year of study was the number of dark-colored moths closest to the number of light-colored moths?
(1) 1 (2) 2 (3) 5 (4) 6

14 Which aspect of the evolutionary process is suggested by the information provided?
(1) The light-colored moths will eventually increase in number.
(2) The darker moths appeared when the tree trunks became lighter.
(3) The changing environment caused a darkening of the pigments of the moths.
(4) The darker moths increased in number when the environment became more favorable for their traits.

15 The biological concept that is most closely associated with the changes in the peppered moth population in England is known as
(1) natural selection (3) asexual reproduction
(2) positive feedback (4) homeostatic control

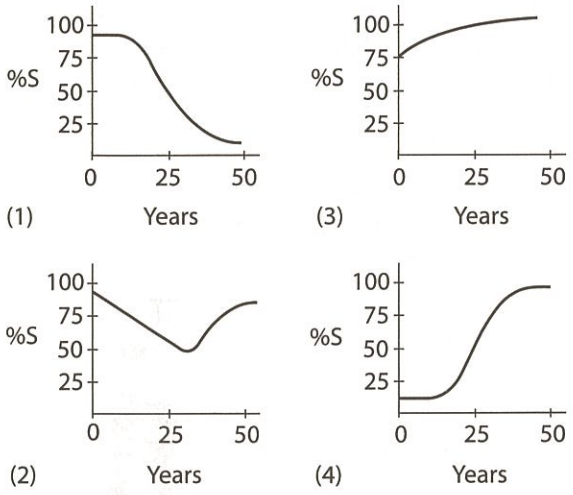
Base your answers to questions 16 through 19 on the paragraph below and on your knowledge of biology.

Two different species of crickets inhabited a meadow. One species of cricket had a straw-colored body and made up 90% of the total cricket population.The other species of cricket had a dark red body and made up 10% of the population.This proportion between the species had been constant for many years.

A new variety of grass with purple blades appeared in the meadow. The purple grass was better adapted to the meadow environment than the native green grass and replaced the green grass within a period of 50 years.

16 The appearance of the purple grass was most likely the result of
(1) asexual reproduction (3) cloning
(2) genetic engineering (4) mutation

17 Which graph most likely indicates the percentages of the straw-colored crickets (%S) over the 50-year period after the appearance of purple grass?



18 The evolutionary concept that would explain the changes taking place during the 50-year period in both the crickets and grasses is called
(1) common ancestry
(2) natural selection
(3) homeostatic balance
(4) selective breeding

19 What is the most likely reason for the large proportion of straw-colored crickets in the original population?
(1) The straw-colored crickets were larger and killed off most of the red crickets.
(2) Few natural enemies of the straw-colored crickets lived in the meadow.
(3) More straw-colored crickets than red were able to survive in the green grass.
(4) Red-colored crickets were not a part of the fossil record for the meadow.

20 State what could happen to a species in a changing environment if the members of that species do not express any genetic variations. [1]

Part C

21 Genetic variation is the raw material of evolution. Identify two different sources of genetic variation in a plant or animal population. [1]

Base your answers to questions 22 through 24 on the information below and on your knowledge of biology.

Humans have modified some animal species by breeding only those that possess certain desirable traits. As a result, we have racehorses and greyhounds that are faster than their ancestors.

In a similar way, many animals have been modified naturally. The giraffe has long forelegs and a long neck, head, and tongue, which make it well adapted for browsing (feeding) in the higher branches of trees. Therefore, the giraffe can obtain food that is beyond the reach of other animals, especially during droughts.

Ancient populations of giraffes varied in the relative lengths of their body parts. Those giraffes that were able to browse the highest were more likely to survive. They mated, and their offspring often inherited the structural characteristics suitable for high browsing. The giraffes that could not reach the food supply most likely died of starvation and therefore did not produce as many offspring as those that could reach higher.

22 Describe how the type of selection for traits in animals such as greyhounds and racehorses is different from the type of selection for traits that is occurring in animals such as giraffes. [1]

23 Describe two specific events of sexual reproduction that can be the source of the variations selected for in both giraffes and racehorses. [1]

24 Variation, a struggle for existence, and the survival of the fittest are all important to the evolution of species. Provide an example of each of these from the passage above. [3]

Base your answers to questions 25 and 26 on the information below and on your knowledge of biology.

Scientists have observed thousands of female leatherback turtles during egg laying. Every female leatherback exhibits the same remarkable behavior. When she first comes up on the beach to lay her eggs, she digs a deep hole, lays her eggs in the hole, and then covers the eggs with sand. She then travels about 100 meters away from the first hole and digs another. She doesn't lay any eggs in this hole, but goes through the same process of covering the hole just as if there had been eggs present.

25 Write a hypothesis to explain why the female leatherback digs two holes. [1]

26 In the past, some leatherbacks may have only dug one hole and laid their eggs in it. In terms of evolution, how can this modern behavior of digging two holes be explained? [1]

Base your answers to questions 27 and 28 on the information below and on your knowledge of biology.

Cockroaches that are resistant to many common household insecticides are more numerous than those that are killed by these same insecticides. Scientists explain the increased numbers of insecticide-resistant cockroaches with the following statement: Variations that have a high survival value tend to be passed on to the next generation of organisms in greater number than those variations that have low survival value.

27 Identify the variation that is present in the cockroach population and describe how this variation most likely came about. [1]

28 Explain how the use of insecticides is associated with the fact that the resistant cockroaches outnumber the nonresistant cockroaches. [1]

Base your answer to questions 29 through 31 on the paragraph below and on your knowledge of biology.

A scientist discovered that in a large population of pathogenic bacteria, a few were resistant to the antibiotic penicillin. By adding penicillin to the population, she soon obtained a large population that was resistant to penicillin.

29 Explain how this experiment supports the concept of evolution by natural selection. Your explanation should include the concepts of
- selective agent [1]
- reproduction [1]
- resistance [1]
- offspring [1]

30 Identify the chemical substance in the bacteria that provides the resistance to penicillin and makes this resistance inheritable. [1]

31 The evolutionary changes described here occurred in a relatively short period of time rather than requiring millions of years. State one reason why it is possible for bacteria to evolve so rapidly. [1]

Base your answers to questions 32 and 33 on the information below and on your knowledge of biology.

Over a period of 28 million years, various genera (related groups) of hoofed mammals called *Titanotheres* showed a continuous change in body and horn size before they eventually became extinct.

32 Describe how gradual changes in the environment might have resulted in the changes observed in *Titanotheres*. [1]

33 Explain how environmental changes could have led to the extinction of *Titanotheres*. [1]

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34 Growers of fruit trees have always had problems with insects. Insects can cause visible damage to fruits, making them less appealing to consumers. As a result of this damage, much of the fruit cannot be sold. Insecticides have been useful for controlling these insects, but, in recent years, some insecticides have been much less effective. In some cases, insecticides do nothing to stop the insect attacks.

Provide a biological explanation for this loss of effectiveness of the insecticides. In your answer, be sure to:
- identify the original event that resulted in the evolution of insecticide resistance in some insects [1]
- explain why the percentage of resistant insects in the population has increased [1]
- describe one alternative form of insect control, other than using a different insecticide, that fruit growers could use to protect their crops from insect attack [1]