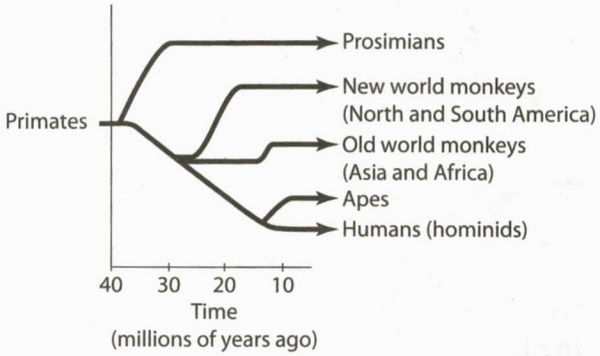
5. The diagram below represents possible lines of the evolution of primates.



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.

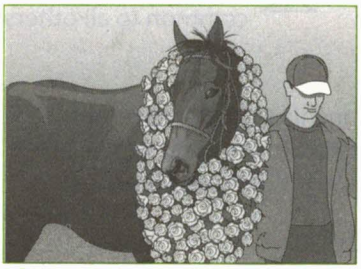


Figure 5-3. Racehorses are bred for speed and stamina: When humans breed plants or animals, they select specific traits, such as speed, flower color, or resistance to insects. In a similar way, "nature" selects any trait that increases an organism's ability to survive and reproduce.

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

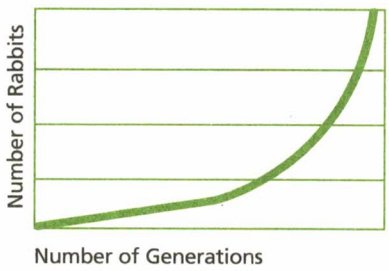


Figure 5-4. Overproduction: Rabbits are known for their high reproductive potential.

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,

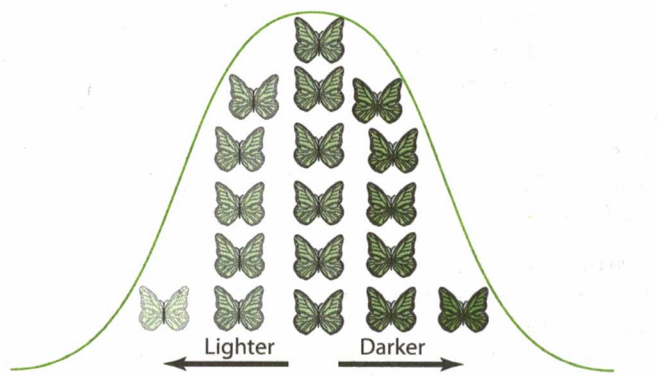


Figure 5-5. Genetic variation: In this example, a species of green butterflies might have individuals that vary in color from very dark green to very light green.

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.

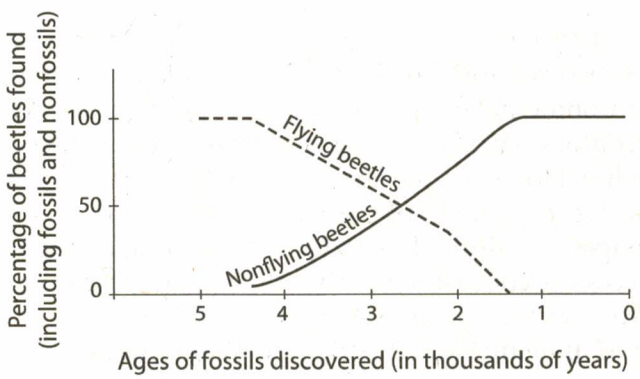
Review Questions

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?

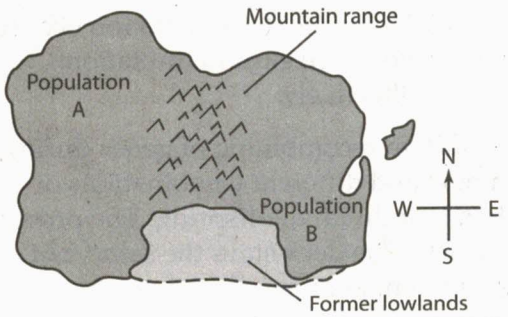
(1) asexual reproduction of the fittest
(2) isolation of the species
(3) survival of the best adapted
(4) new species development due to mutation

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

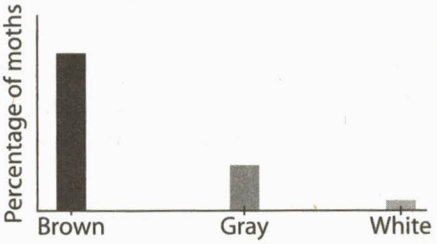
(1) migrate and intermix with population A
(2) become extinct
(3) have evolved more than population A
(4) have evolved less than population A

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

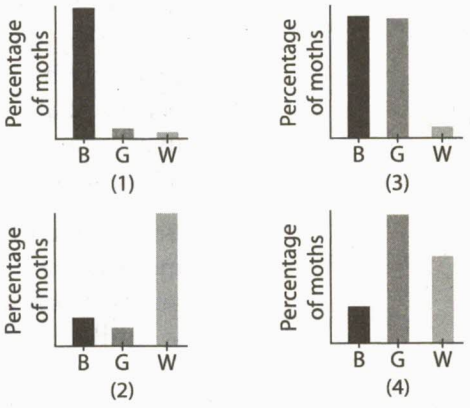
Base your answers to questions 13 and 14 on the information and graph below and on your knowledge of biology.

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