Name Date Class

Section 15.2

Mechanisms of Evolution

North Carolina Objectives **Objective 3.05** Examine the development of the theory of evolution by natural selection including: Mechanisms of evolution

Before You Read

In this section you will learn about different ways that evolution occurs. For example, evolution can occur when a physical barrier divides a population into smaller groups that can no longer interact. What barriers might divide a population? Write examples on the lines below.

Read to Learn

Population Genetics and Evolution

In the previous section you learned about Darwin's theory of evolution by natural selection. Since Darwin's time, scientists have learned about genes and have modified Darwin's theories. Today, scientists look at the way genes act in plant and animal populations. This study is called population genetics. It is based on the thought that evolution happens when the genes in a population change over a long period of time.

Individuals in a population do not evolve—populations do. Individuals' genes do not change during their lifetime. But within a population, genes and their frequencies change over time. This is what causes evolution.

What is genetic equilibrium?

How can a population's genes change over time? Picture all the alleles (the alternate forms of a gene) of a population's genes in a large group called a **gene pool.** The percentage of times any allele is in the gene pool is called **allelic frequency.** When this frequency stays the same over generations, **genetic equilibrium** exists. A population in genetic equilibrium is not evolving. Once a change happens, though, the population's genetic equilibrium is disrupted and evolution takes place.

What can change genetic equilibrium?

One way genetic equilibrium is disturbed is by mutation. A mutation is any change or random error in a DNA sequence. Some mutations simply occur by chance. Radiation and chemicals can also cause mutation.

STUDY COACH

Mark the Text **Identify Main Ideas** Highlight the main idea of each paragraph.

Think it Over

1. **Analyze** Which of the following is an example of genetic equilibrium? (Circle your choice.)
   a. Generation after generation of a population of roses are red.
   b. A mutation in a population of red roses results in some yellow offspring.

Think it Over

2. **Analyze** On what population would genetic drift most likely have the greatest impact? (Circle your choice.)
   a. a population of twelve turtles on a small, isolated island
   b. the population of humans in the United States
   c. a population of 5000 woodpeckers in western Canada

Genetic drift is another way that a population's genetic equilibrium can be disrupted. **Genetic drift** is the change of allelic frequencies by chance events. This change can greatly affect small populations made up of descendants of a small number of organisms.

For example, in Pennsylvania, there is a small Amish population of about 12 000 people. The Amish marry only other members of their community. Of the original 30 settlers in this community, at least one carried a recessive allele that resulted in offspring with short arms and legs and extra fingers and toes. Today, the frequency of this allele in this population is high—1 in 14. But, in the rest of the United States, the frequency is lower, only 1 in 1000.

Gene flow also can upset genetic equilibrium. Gene flow occurs when an individual leaves or enters a population. This individual's genes either leave or enter the gene pool as a result.

Mutation, genetic drift, and gene flow primarily affect small and isolated gene pools. The impact is much smaller in larger, less isolated gene pools.

The Evolution of the Species

How do changes in a gene pool bring about evolution of a new species? Remember that a species is a group of living things that look alike and can mate with each other to produce fertile offspring. The evolution of a new species is called **speciation** (spee shee AY shun). Speciation occurs when members of similar populations no longer mate with each other to produce fertile offspring. A new species could develop when part of a population has been geographically cut off from the rest of its population. The figure on page 171 illustrates this idea.

An example would be when a river forms a physical barrier and divides a population in two. This is called **geographic isolation.** The separated parts of the population can no longer mate. Over time, the gene pools of the now separate populations become very different. In this way, natural selection results in new species.

What happens in reproductive isolation?

As populations become increasingly different from each other, **reproductive isolation** occurs. This happens when organisms that at one time mated with each other and produced fertile offspring are no longer able to do so. This can be because the genetic material of the populations becomes so different that fertilization cannot occur. Reproductive isolation also occurs if the mating seasons of similar populations are at different times of year.

Reading Check

3. What is one way that reproductive isolation can occur?

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Section 15.2 Mechanisms of Evolution, *continued*

A Tree frogs are a single population.

B The formation of a river may divide the frogs into two populations. A new form may appear in one population.

C Over time, the divided populations may become two species that may no longer interbreed, even if reunited.

What role do chromosomes play in the development of a new species?

Chromosomes can also be important in the development of new species. Many new types of plants and some types of animals evolve as a result of what is called polyploidy (PAH lih ploy dee). Any individual or species with a multiple (an extra set) of the normal set of chromosomes is known as a **polyploid.** Mistakes during mitosis or meiosis result in polyploid individuals. Some polyploids cannot produce offspring capable of reproducing. But still others develop into adults that can interbreed and a new species results. Many flowering plants and some important crops—such as wheat, cotton, and apples—originated by polyploidy.

How much time does it take to develop a new species?

Although the developing of new species by polyploidy takes only one generation, most other types of speciation take much

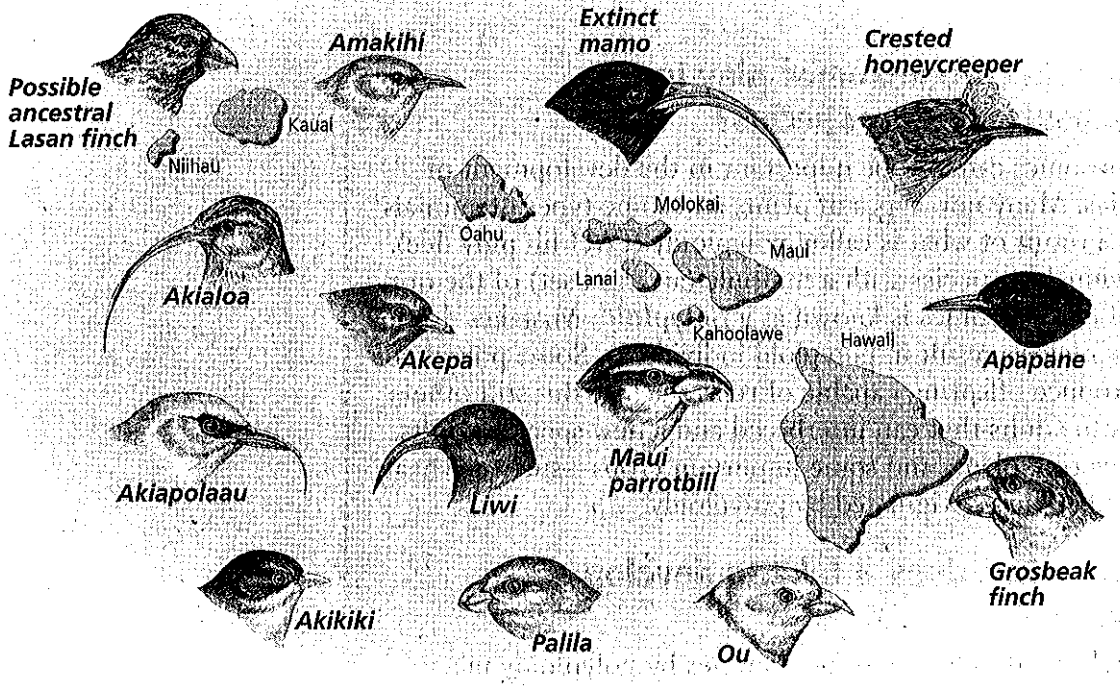
longer. **Gradualism** is the idea that species originate through a gradual change of adaptations. For example, fossil evidence shows that sea lilies evolved slowly and steadily over time.

Punctuated equilibrium is a theory that speciation occurs quickly, in rapid bursts. There are long periods of genetic equilibrium between the bursts. In this theory, environmental changes like higher temperatures or a competitive species moving into a population's habitat lead to fast changes in the population's gene pool. Fossil evidence shows several elephant species may have evolved by punctuated equilibrium.

Patterns of Evolution

Biologists have observed that different patterns of evolution occur in different environments. These patterns support the idea that natural selection is important for evolution. An example of this occurs in the Hawaiian honeycreepers.

Hawaiian honeycreepers are all similar in body size and shape, but they differ in color and beak shape. They also live in different habitats. Despite their differences, scientists hypothesize that these birds evolved from a single species that lived on the



Hawaiian Islands long ago. When a single ancestral species evolves into many different species that fit a number of different habitats, the result is called adaptive radiation. **Adaptive radiation** is a type of divergent evolution. **Divergent evolution** occurs as populations that were once similar to an ancestral species change and adapt to different living conditions. These populations eventually become new species.

Another pattern that can occur is convergent evolution. **Convergent evolution** occurs when unrelated species live in similar environments in different parts of the world. Because they have similar environmental pressures, they share similar pressures of natural selection. As a result, they have similarities. For example, there is an organ pipe cactus that grows in the deserts of North and South America and a plant that looks similar and lives in African deserts. These plants are not related, but their environments are similar. Both plants have fleshy bodies and no leaves. Convergent evolution has apparently occurred.

Reading Check

4. What features do unrelated species that develop similar traits in different parts of the world demonstrate?

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After You Read

Mini Glossary

adaptive radiation: divergent evolution in which ancestral species evolve into a variety of species that fit diverse habitats

allelic frequency: percentage of any specific allele found in a population's gene pool

convergent evolution: evolution in which unrelated organisms evolve similar traits; occurs when unrelated species occupy similar environments

divergent evolution: evolution in which species that once were similar to an ancestral species diverge; occurs when populations change as they adapt to different environmental conditions, eventually resulting in new species

gene pool: all of the alleles available in a population

genetic drift: alteration of allelic frequencies in a population by chance events; disrupts a population's genetic equilibrium

genetic equilibrium: condition in which the frequency of alleles in a population remains the same over generations; no evolution occurs

geographic isolation: occurs whenever a physical barrier such as a river divides a population; results in individuals of the population no longer being able to mate; can lead to the formation of new species

gradualism: idea that species originate through a gradual change of adaptations

polyploid: any species with multiple sets of the normal set of chromosomes; results from errors during mitosis or meiosis

punctuated equilibrium: idea that periods of speciation occur relatively quickly with long periods of genetic equilibrium between

reproductive isolation: occurs when formerly interbreeding organisms can no longer produce fertile offspring due to an incompatibility of their genetic material or by differences in mating behavior

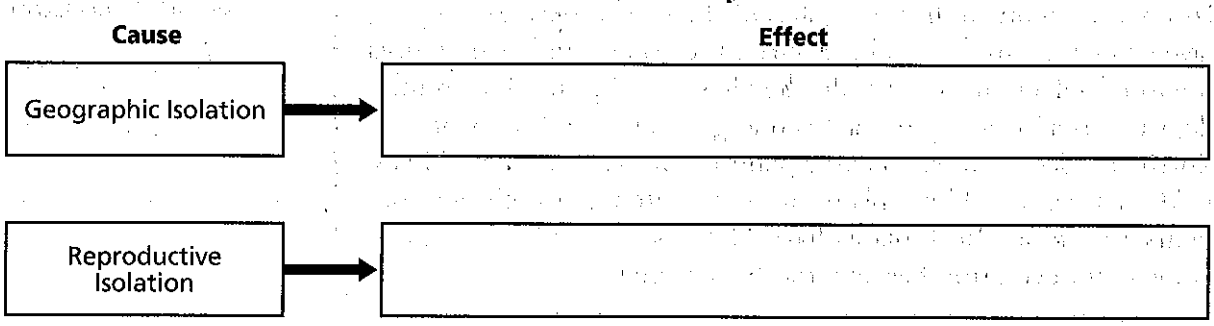
speciation (spee shee AY shun): process of evolution of new species that occurs when members of similar populations no longer interbreed to produce fertile offspring within their natural environment

Section 15.2 Mechanisms of Evolution, *continued*

1. Read the terms and their definitions from the Mini Glossary on page 173. Circle the two terms that refer to different ideas about the rate in which speciation occurs. Then, choose one of these terms and use it correctly in a sentence.

2. Use the statements under the diagram to fill in the results of each type of isolation.

The Evolution of a New Species



- Members of the same species no longer mate because they cannot reach each other.
- The genetic material of the populations becomes so different that fertilization cannot occur.
- A barrier divides a population.
- Populations have different mating seasons.

3. Review the section, then fill in the blanks below using the following terms: **punctuated equilibrium, speciation, genetic equilibrium, polyploid, mutation.**

1. When the frequency of alleles for a specific trait remains the same for generations, it is called _____.
2. One of the factors that can interrupt genetic equilibrium is _____.
3. _____ occurs when members of similar populations can no longer interbreed to produce fertile offspring within their natural environment.
4. The idea that a sudden environmental change can cause rapid changes in a population's gene pool is called _____.
5. A _____ is an individual with a multiple of the normal set of chromosomes.

Visit the Glencoe Science Web site at **science.glencoe.com** to find your biology book and learn more about the mechanisms of evolution.