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CHAPTER 15 Origins of Biological Diversity

Summary of Key Concepts

Concept 15.1 The diversity of life is based on the origin of new species. (pp. 324–330)

The *biological species concept* defines a species as a population or group of populations whose members have the ability to breed with one another in nature and produce fertile offspring. Members of one species cannot successfully interbreed with members of other species. This concept helps biologists understand *speciation*, the origin of new species. Major evolutionary changes such as speciation are referred to as *macroevolution*. Macroevolution also includes extinction of species and evolution of new features such as wings.

The inability of different species to interbreed is called *reproductive isolation.* Barriers to interbreeding include different mating seasons and behaviors used to attract mates. The origin of these differences is the key to speciation. One event that can lead to speciation is geographic isolation. *Geographic isolation* occurs when a population becomes separated from the rest of the species due to geographic change or movement to an isolated place. The isolated population evolves new adaptations to its changed environment. Speciation occurs if the adaptations lead to reproductive isolation. When populations of a species evolve adaptations to a variety of different environments and form diverse new species, the process is called *adaptive radiation*.

Darwin thought macroevolution was a gradual process. Today, many biologists think that long periods of little change are broken by shorter times of more rapid change. This model is called *punctuated equilibrium.*

1. How does the biological species concept define a species? _____

_____

_____

_____

2. According to the punctuated equilibrium model, how does evolution occur?

_____

_____

_____

Concept 15.2 Evolution is usually a remodeling process. (pp. 331–334)

Some complex structures, such as the eyes of mammals, evolve in a series of small steps from simpler structures with the same basic function. Other structures evolved as adaptations for certain functions and later fulfilled a different function. For example, in penguins, wings evolved into flippers used for "flying" underwater. Scientists are searching for the genetic basis of such evolutionary changes in embryology. *Embryology* is the study of how multicellular organisms develop from fertilized eggs to adults. The changes may be due to mutations in the genes that control the early development of an organism.

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3. Give an example of evolution as a remodeling process. _____

_____

4. How can embryology contribute to an understanding of evolution? _____

_____

_____

Concept 15.3 The fossil record provides evidence of life's history. (pp. 335–340)

Bones and other hard parts of organisms may be preserved as fossils. Some fossils consist of footprints or other marks left in sediments. Rarely, an entire organism is preserved as a fossil. For example, mammoths have been preserved in ice. Younger sediments are usually layered over older ones. Therefore, a fossil's position in rock layers reveals whether it is older or younger than other fossils. This information is the fossil's relative age. Absolute age, or age in years, can be determined with *radiometric dating*. This method is based on the amount of radioactive isotopes a fossil contains. To calculate absolute age, scientists use an isotope's *half-life*, the time it takes for 50 percent of the original sample to decay.

The *geologic time scale* organizes Earth's history into the Precambrian, Paleozoic, Mesozoic, and Cenozoic eras. The boundaries between these eras are marked in the fossil record by major changes in life forms. Many of these changes can be explained by *continental drift*, the movement of Earth's continents on large plates of crust. Near the end of the Paleozoic Era, all the landmasses moved together into a "supercontinent" called Pangaea. This led to major environmental changes and competition between species that had been isolated. The result appears to have been an episode of great species loss called a *mass extinction*. Mass extinctions also occurred at the end of the other eras. Each mass extinction gave surviving organisms new opportunities and led to adaptive radiation. During the Mesozoic Era, the continents drifted apart. After that, species living on different continents evolved independently.

5. What are two ways of determining the age of fossils? _____

_____

_____

6. Name the four distinct eras of the geologic time scale. _____

_____

Concept 15.4 Modern taxonomy reflects evolutionary history. (pp. 341–349)

Taxonomy is a branch of biology that involves the identification, naming, and classification of species. One goal of taxonomy is to assign a universal scientific name to each known species. Another goal is to organize the diversity of life by classifying species into larger groups of related species. The most widely used system of classification was developed by Carolus Linnaeus. This system has a *binomial*, or two-part name, for each species. It also orders species into a hierarchy of broader groups.

In classifying organisms, biologists try to reflect evolutionary relationships among species. A diagram that shows hypothesized evolutionary relationships is called a *phylogenetic tree*. One clue about evolutionary relationships is

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homologous structures, such as bats' wings and whales' flippers. However, not all similar structures are homologous. *Convergent evolution* is a process in which unrelated species from similar environments have adaptations that seem very similar. These similar adaptations, such as the wings of insect and birds, are called *analogous structures*. Other clues about evolutionary relationships come from comparing genes and proteins of different species.

One way of thinking about classification is cladistics. Cladistics is based on *derived characters*, homologous characteristics that unite a group of organisms. To show these relationships, taxonomists use *cladograms*, which are phylogenetic trees constructed from a series of two-way branch points. Cladistic analysis led to revision of the traditional classification scheme, which had just two kingdoms: plants and animals. The revised scheme added three new kingdoms—monerans, protists, and fungi—to the original two. An even newer scheme added a taxonomic category above the kingdom level, called the domain. This scheme divides organisms into three domains: Bacteria, Archaea, and Eukarya.

7. State two goals of taxonomy. _____

_____

_____

8. What is cladistics? _____

_____

_____

Reading Skills Practice

Summarizing a key idea Write a paragraph describing in your own words how geographic isolation can lead to reproductive isolation and speciation.

In 1–7, write the letter of the correct definition on the line next to each term.

_____ **1.** biological species concept

_____ **2.** punctuated equilibrium

_____ **3.** geologic time scale

_____ **4.** radiometric dating

_____ **5.** phylogenetic tree

_____ **6.** convergent evolution

_____ **7.** derived character

a. scale that organizes Earth's history into four eras

b. model of evolution in which long periods of little change in a species are broken by shorter times of more rapid change

c. homologous character that unites organisms as a group

d. idea that a species is a population or group of populations whose members have the ability to breed successfully in nature but not to interbreed successfully with members of other species

e. process in which unrelated species from similar environments have adaptations that seem very similar

f. diagram that reflects evolutionary relationships

g. method of dating fossils based on radioactive isotopes

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Vocabulary Review and Reinforcement

In 8–12, fill in the blanks with the appropriate terms from the chapter.

A new species forms through the process of **8.** _____. This event occurs when some kind of reproductive barrier develops that prevents interbreeding—a condition known as **9.** _____. Huge numbers of species going extinct in a short period of time is called a(n) **10.** _____. This event creates opportunities for the surviving species. They become diverse as they adapt to new environments, a process that is called **11.** _____. This process occurred at the end of the Paleozoic Era, after **12.** _____ resulted in the formation of a supercontinent.

WordWise

Use the clues to complete the crossword puzzle using Key Terms from the chapter.

Across

1. This condition may be either geographic or reproductive.
4. An example of this is speciation.
6. This term means "two names."
7. This science classifies organisms.
8. This taxonomic category is broader than a kingdom.
9. Both homologous and analogous forms of these result from evolution.

Down

2. This process results in new species.
3. This science studies the development of organisms.
5. These diagrams are based on derived characters.