

**Chapter 22: Descent with Modification: A Darwinian View of Life**

As you study this chapter, read several paragraphs at a time to catch the flow of ideas and understand the reasoning that is being described. In some places, the text describes a narrative or story of events that led to Darwin's theory of evolution. Therefore, first read the narrative to absorb the big picture and then return to answer the few questions that accompany this material.

**Overview**

1. Define *evolution* broadly and then give a narrower definition, as discussed in the overview.

**Evolution:** Descent with modification; the idea that living species are descendants of ancestral species that were different from the present-day ones; also defined more narrowly as the change in the genetic composition of a population from generation to generation

**Concept 22.1 The Darwinian revolution challenged the traditional view of a young Earth inhabited by unchanging species**

This section takes a look at the historical setting and influences on Darwin, and it sets the stage for our formal study of evolution.

2. How did each of the following sources view the origin of species?

**Aristotle and Scala Naturae:** Aristotle viewed species as fixed. Through his observations of nature, Aristotle recognized "affinities" among organisms. He concluded that life-forms could be arranged on a ladder, or scale, of increasing complexity, called the *scala naturae*. Each form, perfect and permanent, had its allotted rung on this ladder.

**The Old Testament:** The Old Testament holds that species were individually designed by God and therefore perfect.

**Carolus Linnaeus:** Linnaeus adopted a nested classification system, grouping similar species into increasingly general categories. Linnaeus, adhering to the Old Testament belief that all species were designed by God, did not ascribe the resemblances among species to evolutionary kinship, but rather to the pattern of their creation.

3. Explain the role of *fossils* in *rock strata* as a window to life in earlier times.

Many fossils are found in sedimentary rocks formed from the sand and mud that settle to the bottom of seas, lakes, swamps, and other aquatic habitats. New layers of sediment cover older ones and compress them into superimposed layers of rock called *strata*. The fossils in particular *strata* provide a glimpse of some of the organisms that populated Earth at the time that the layer formed.

4. How would Georges Cuvier have explained the appearance of the record of life shown in the rock *strata*?

Cuvier opposed the idea of evolution. He advocated *catastrophism*, the principle that events in the past occurred suddenly and were caused by mechanisms different from those operating in the present.

Cuvier speculated that each boundary between strata represented a catastrophe, such as a flood, that had destroyed many of the species living at that time.

5. James Hutton and Charles Lyell were geologists whose ideas strongly influenced Darwin's thinking. What were the ideas each of them contributed?

**James Hutton:** Hutton proposed that Earth's geologic features could be explained by gradual mechanisms still operating today, such as valley formed by rivers.

**Charles Lyell:** Lyell incorporated Hutton's thinking into his principle of uniformitarianism, which states that mechanisms of change are constant over time. Lyell proposed that the same geologic processes are operating today as in the past, and at the same rate.

6. What is the importance of the principle of *uniformitarianism*?

If geologic change results from slow, continuous actions rather than from sudden events, then Earth must be much older than the widely accepted age of a few thousand years.

7. Jean-Baptiste de Lamarck proposed a mechanism for how life changes over time. Explain the two principles of his mechanism.

**use and disuse:** The idea that parts of the body that are used extensively become larger and stronger, while those that are not used deteriorate.

**inheritance of acquired characteristics:** This idea states that an organism could pass these modifications of use and disuse to its offspring.

8. Although Lamarck's mechanism of evolution does not explain the changes in species over time, his thinking has been influential. What is considered to be the great importance of his ideas?

Lamarck recognized that the match of organisms to their environments can be explained by gradual evolutionary change rather than special creation.

***Concept 22.2 Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life***

9. Charles Darwin proposed that the mechanism of evolution is *natural selection* and that it explains how *adaptations* arise. What are *adaptations*? Give two examples of adaptations.

Adaptations are inherited characteristics of organisms that enhance their survival and reproduction in specific environments. Possible examples include the mottled coloration of a fawn that allows it to blend with its environment, or the sharp talons and beaks of birds of prey so well suited for predation.

10. Explain the process of *natural selection*.

In the process of natural selection, individuals that have certain inherited traits tend to survive and reproduce at higher rates than other individuals because of those traits.

11. Let's try to summarize Darwin's observations that drive changes in species over time:

Observation	Cite an Example
1. Variations in traits exist.	Variation in color and spot pattern of Asian ladybird beetles
2. These variations (traits) are heritable.	Variation in closely related species of elephants; offspring resemble close relatives more than other members of a population.
3. Species overproduce.	Dandelions produce thousands of seeds.
4. There is competition for resources; not all offspring survive.	Not all dandelion seeds germinate or survive to maturity

12. From these four observations, what two inferences did Darwin make?

1. Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals.
2. The unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations.

13. It is important to remember that differences in heritable traits can lead to *differential reproductive success*. This means that the individuals who have the necessary traits to promote survival in the current environment will leave the most offspring. How can this *differential reproductive success* affect the match between organisms and their environment?

When such advantages increase the number of offspring that survive and reproduce, the traits that are favored will likely appear at a greater frequency in the next generation.

14. To demonstrate your understanding of this section, complete the following sentences:

**Individuals do not evolve. Populations evolve.**

Now, take out your highlighter and mark the information in the box above. Hold these ideas firmly in your brain! Finally, if you are ever asked to explain Darwin's theory of evolution by natural selection (a common AP essay question), do *not* pull out the phrase "survival of the fittest." Instead, cite the points made in question 11 and explain the inferences that are drawn from them.

**Concept 22.3 Evolution is supported by an overwhelming amount of scientific evidence**

15. Use Figure 22.13 in your text to explain how research with soapberry bugs demonstrated observable evolutionary change.

Museum specimens showed that the average beak length of soapberry bugs was comparable to that of soapberry bugs feeding on native species in southern Florida. However, contemporary data suggest that a change in the size of the soapberry bug's food source, as seen with the introduction of the goldenrain tree, can result in evolution by natural selection for matching beak size.

16. *MRSA* is in the news today because it is becoming increasingly more common. What is it?

*MRSA* is methicillin-resistant *Staphylococcus aureus*, a flesh-eating strain of bacterium.

17. How did it become so dangerous? Explain the evolution of *MRSA*'s resistance to methicillin.

*MRSA* became dangerous because, over time, doctors used a variety of antibiotics, such as penicillin, to combat *MRSA*. Each time a new antibiotic was used to fight the disease, some *S. aureus* populations would develop resistance to the new drug. In 1959, doctors used the powerful antibiotic methicillin. Members of the *S. aureus* population that were resistant to methicillin reproduced at higher rates, leading to the spread of methicillin-resistant *S. aureus* (*MRSA*).

18. Do antibiotics *cause* bacteria to become resistant? Explain your response.

No. A drug does not create resistant pathogens; it selects for resistant individuals that are already present in the population.

19. Let's make a list of the four evidences for evolution that are described in this concept. Give an example of each.

Evidence for Evolution	Example
Direct observations of evolutionary change	Possible examples include the evolution of <i>MRSA</i> or the change in beak size in soapberry bugs.
Homology	Possible examples include the similarities between mammalian forelimbs.
Fossil record	Possible examples include fossils that show ancestors of cetaceans had hind limbs.
Biogeography	Possible examples include the creation of the evolutionary tree of horses, based on fossil locations.

20. How does the fossil record give evidence for evolution?

The fossil record documents the pattern of evolution, showing that past organisms differed from present-day organisms and that many species have become extinct.

21. What is meant by each of the following terms? Give an example of each.

Term	Explanation/Example
Homologous structures	Structures in different species that are similar because of common ancestry. For example, mammalian forelimbs.
Vestigial structures	A feature of an organism that is a historical remnant of a structure that served a function in the organism's ancestors. For example, skeletons of some snakes retain vestiges of the pelvis and leg bones.
Analogous structures (see p. 465)	Having characteristics that are similar because of convergent evolution, not homology. For example, the wing of a butterfly and wing of a bat both make flight possible.

22. How do *homologous structures* give evidence for evolution?

Homologous structures represent variations on a structural theme that was present in the common ancestors of a species.

23. What is summarized in an *evolutionary tree*?

An evolutionary tree reflects evolutionary relationships among groups of organisms.

24. Figure 22.17 in your text shows an evolutionary tree. What is indicated by each branch point in the following figure? Mark each branch point.

Each branch point represents the common ancestors of the lineage beginning there and to the right of it. Refer to Figure 22.17 on page 464.

25. What is indicated by the hatch marks in Figure 22.17?

A hatch mark represents a homologous characteristic shared by all the groups to the right of the mark.

26. Use the tree in question 24 to answer this question: Are crocodiles more closely related to lizards or to birds? Explain your response.

Based on this evolutionary tree, crocodiles are more closely related to birds than to lizards because they share a more common ancestor with the birds than with lizards.

27. On the evolutionary tree, label the vertical lines to the right, and annotate the key feature that marks each group.

See page 464 of your text for the labeled figure.

28. Organisms that are only distantly related can resemble each other. Explain *convergent evolution*, and describe how *analogous structures* can arise.

Convergent evolution is the independent evolution of similar features in different lineages. In such examples as the marsupials of Australia, in which species share features because of convergent evolution, the resemblance is said to be analogous. Analogous features share similar function, but not common ancestry.

29. *Convergent evolution* might be summarized like this: *Similar problem, similar solution*. Can you give two examples of convergent evolution?

Answers will vary but may include the sugar glider and the flying squirrel, and the evolution of wings in birds and bats.

### Study Tip

**Homologous structures** show evidence of relatedness (whale fin, bat wing).

**Analogous structures** are similar solutions to similar problems but do *not* indicate close relatedness (bird wing, butterfly wing).

30. What is *biogeography*? How is it affected by *continental drift* and the presence of *endemic species*?

Biogeography is the geographic distribution of species. The geographic distribution of organisms is influenced by many factors, including continental drift, the slow movement of Earth's movement over time, and the presence of endemic species, species that are found nowhere else in the world.

Let's wrap up all of these ideas with a final summary.

### ORGANIZE YOUR THOUGHTS

1. Evolution is change in species over time.
2. Heritable variations exist within a population.
3. These variations can result in differential reproductive success.
4. Over generations, this can result in changes in the genetic composition of the population.

*And remember:* Individuals do not evolve! *Populations* evolve.

### Test Your Understanding Answers

Now you should be ready to test your knowledge. Place your answers here:

1. b   2. d   3. d   4. c   5.a