CHAPTER 25
THE HISTORY OF LIFE ON EARTH

Learning objectives

The Origin of Life

1. Describe the four stages of the hypothesis for the origin of life on Earth by chemical evolution.
2. Describe the contributions that A. I. Oparin, J. B. S. Haldane, Stanley Miller, and Harold Urey made toward developing a model for the abiotic synthesis of organic molecules. Describe the conditions and locations where most of these chemical reactions likely occurred on the early Earth.
3. Describe the evidence that suggests that RNA was the first genetic material. Explain the significance of the discovery of ribozymes.
4. Describe how natural selection may have worked in an early RNA world.
5. Describe how natural selection may have favored the proliferation of stable protobionts with self-replicating, catalytic RNA.

Major Events in the History of Life on Earth

6. Explain why the fossil record provides an incomplete chronicle of evolutionary change.
7. Explain how radiometric dating can be used to determine the absolute age of rock strata. Explain how magnetism can be used to date rock strata.
8. Describe the major events in Earth's history from its origin until 2 billion years ago. In particular, note when Earth first formed, when life first evolved, and what forms of life existed in each eon.
9. Name the reactions that have produced O_2 on Earth. Describe the accumulation of atmospheric O_2 over time and the effects of this accumulation on living things.
10. Explain the endosymbiotic theory for the evolution of the eukaryotic cell. Describe the evidence that supports this theory.
11. State the evidence that suggests that the common ancestor of multicellular eukaryotes lived 1.5 billion years ago.
12. Explain the possible significance of Snowball Earth in the history of life on Earth.
13. Briefly describe the Cambrian explosion.
14. Explain how plants and fungi benefit from a mutualistic association, and how this symbiosis allowed them to colonize land together.
15. Describe the key evolutionary adaptations that arose as life colonized land.

Continental Drift, Mass Extinctions, and Adaptive Radiations

16. Describe the conditions in the interior of a supercontinent such as Pangaea.

17. Discuss, with a suitable example, how continental drift explains the current or former distribution of organisms.
18. Explain how continental drift led to Australia's unique flora and fauna.
19. Describe the mass extinctions that ended the Permian and Cretaceous periods. Discuss a hypothesis that accounts for each of these mass extinctions, and summarize the evidence for each hypothesis.
20. "A sixth mass extinction may be currently underway." Explain this statement.
21. Define adaptive radiation. Describe, with suitable examples, three circumstances under which adaptive radiation may occur.

Evo-Devo

22. Define evo-devo, heterochrony, and paedomorphosis.
23. Explain the function of *Hox* genes. Describe, with a suitable example, how changes in the number, sequence, or expression of *Hox* genes can lead to major morphological differences between species.
24. Explain how the evolution of changes in temporal and spatial developmental dynamics can result in evolutionary novelties.
25. Describe the significance of recent research on the differences between insect and crustacean *Ubx* genes.
26. Describe the significance of Kingley's research on the differences in *Pitx1* gene expression between marine and lake-dwelling threespine sticklebacks.

The Evolution of Complex Structures

27. Explain in general terms how a complex structure such as the human eye can be the product of gradual evolution.
28. Define exaptation and illustrate this concept with an example.
29. Explain why extracting a single evolutionary progression from a fossil record can be misleading.
30. Define and illustrate the concept of species selection.
31. Explain why evolutionary change is not goal-directed.