# Chapter 4

# Evolution and Biodiversity

### Summary

1. Life emerged on the earth through two phases of development: a chemical evolution of the organic molecules, biopolymers, and systems of chemical reactions to form the first cells and the biological evolution from single-celled prokaryotic bacteria to single-celled eukaryotic creatures, and then to multicellular organisms.

2. Evolution is the change in a population’s genetic makeup over time. Evolution forces adaptations to changes in environmental conditions in a population. The diversity of life on earth reflects the wide variety of adaptations necessary and suggests that environmental conditions have varied widely over the life of the earth.

3. An ecological niche is a species’ way of life or its functional role in a community. Everything that affects its survival and reproduction (temperature tolerance, water needs, space needs, interactions with other organisms, etc.) is a part of that niche. The ecological niche helps a population survive by the adaptive traits that its organisms have acquired.

4. Extinction of species and formation of new species constantly change the biodiversity of the earth.

5. In the future, evolution will continue to influence our environment. Man’s use of artificial selection and genetic engineering to evolve species may have unintended consequences because evolution is a long, slow process and is unpredictable.

### Key Questions and Concepts

* 1. **What is biodiversity and why is it important?**

**CORE CASE STUDY**. Alligators act as a keystone species, yet their numbers were seriously compromised by over-hunting. Their activities provide important habitat for fish and avian species. They also control populations by their feeding behaviors. In 1967 the alligator was placed on the endangered species list and has made a dramatic recovery.

1. Biodiversity is the variety of species, genes, ecosystems, and ecosystem processes.

1. Species diversity, genetic diversity, ecosystem diversity, and functional diversity.

**4-2 Where do species come from?**

A. Evolution is the change in a population’s genetic makeup over time.

B. Populations evolve by becoming genetically different.

C. All species descend from earlier, ancestral species—theory of evolution.

1. Over time, a population’s gene pool changes when mutations (beneficial changes) in DNA molecules are passed on to offspring.

a. Mutations are random changes in the structure/number of DNA molecules in a cell.

b. Mutations occur in two ways.

1) Gene DNA is exposed to external agents like X-rays, chemicals (mutagens), or radioactivity.

2) Random mistakes that occur in coded genetic instructions.

D. Natural selection occurs when members of a population have genetic traits that improve their ability to survive and produce offspring with those specific traits.

1. For natural selection to evolve in a population, three conditions are necessary:

a. The population must have genetic variability.

b. The trait must be heritable, capable of being passed from one generation to another.

c. The trait must enable individuals with the trait to produce more offspring than individuals without the trait; this is differential reproduction.

2. Adaptation or adaptive traits are heritable traits that help organisms to survive and reproduce better under prevailing environmental conditions.

**CASE STUDY**. Humans have thrived so well as a species because of their strong opposable thumbs, ability to walk upright, and complex brain. These adaptations may not prove as beneficial as the environment continues to change, though our powerful brain may allow us to live more sustainably in the future.

E. Natural selection can only act on existing genes and is limited by reproductive capacity.

**4-3 How do geologic processes and climate change affect evolution?**

A. Processes such as the shifting of tectonic plates, volcanic eruptions, and earthquakes influence earth’s climate and in turn affect evolution by removing and/or isolating habitats and species.

B. Long-term climate changes relocate ecosystems, thus determining where certain species can live.

C. Asteroids and meteorites have caused environmental stress and mass extinctions.

**SCIENCE FOCUS**: the conditions that make Earth suitable for life.

**4-4 How do speciation, extinction, and human activities affect biodiversity?**

A. Natural selection can lead to development of an entirely new species.

In speciation, two species arise from one when some members of a population cannot breed with other members to produce fertile offspring. Speciation occurs in two phases:

1. Geographic isolation, physical separation for long time periods.

2. Reproductive isolation.

B. When population members cannot adapt to changing environmental conditions, the species becomes extinct.

C. When local environmental conditions change, some species will disappear at a low rate; this is called background extinction.

D. Mass extinction is a significant rise in extinction rates above the background extinction level. Usually, 25–70% of species are lost. Recent evidence suggests that there have been two mass extinctions on earth. There appear to have been three mass extinctions on earth.

**SCIENCE FOCUS**: Artificial ways to control population genetics include artificial selection and genetic engineering.

**4-5 What is species diversity and why is it important?**

A. Species diversity is the number of species (richness) combined with their relative abundance (evenness).

B. Species rich communities tend to be more stable and more productive.

**SCIENCE FOCUS**: the size of a habitat affects the species richness of that habitat island

**4-6 What roles do species play in ecosystems?**

A. Ecological niche is a species’ way of life in an ecosystem, everything that affects its survival and reproduction.

1. The niche includes the members’ adaptations; its range of tolerance for physical and chemical conditions, its interactions with other components of the ecosystem, and its role in energy flow and matter recycling.

2. The fundamental niche is the full potential range of conditions and resources a species could potentially use. Its realized niche is the part of the potential niche that allows a species to survive and avoid competition with other species for the same resources.

B. Some species have broad ecological roles and are termed generalist species.

C. Some species have narrow ecological roles and are termed specialist species.

**CASE STUDY**. Cockroaches are the ultimate generalists. The can survive extreme conditions and have a wide variety of adaptations that allow them to avoid predation. By contrast, many species are narrow specialists, though they sometimes have an advantage in their environment because they have few competitors.

D. Niches can be occupied by native or non-native species.

E. Indicator species provide early warning of ecosystem damage because they have a narrow range of tolerance.

**CASE STUDY**. Amphibians are indicator species that are declining globally. Factors affecting their survival include habitat loss, drought, pollution, increase in UV radiation, parasites, fungal diseases, climate change, overhunting, and introduction of non-native species. Their role as indicator species is cause for alarm on a global scale.

H. Keystone species have a large affect on maintaining balance within an ecosystem.

1. Can be, but are not necessarily, pollinators and top predators.

2. Foundation species create and enhance habitats that benefit other species.

**CASE STUDY**. Sharks are keystone species that have been overlooked by conservation efforts because of human bias. They tend to be considered dangerous and have gone without protection despite being heavily fished for their valuable fins. They also commonly drown in fishing nets. Shark populations have been declining since the 1970s, and scientists are now calling for a ban on shark finning in international waters.

### Key Terms

**adaptation** (p. 82)

**adaptive trait** (p. 82)

**background extinction** (p. 87)

**biological evolution** (p. 80)

**differential reproduction** (p. 82)

**ecological niche** (p. 91)

**endemic species** (p. 87)

**extinction** (p. 87)

**fossils** (p. 81)

**gene splicing** (p. 88)

**generalist species** (p. 91)

**geographic isolation** (p. 86)

**mass extinction** (p. 88)

**mutations** (p. 82)

**niche** (p. 91)

**reproductive isolation** (p. 86)

**specialist species** (p. 92)

**speciation** (p. 86)

**Discussion Topics**

1. To what extent should humans take evolution into their own hands?

2. Should there be limits on genetic engineering?

3. How does the change that humans create through cultural evolution compare to the process of evolution by natural selection?