

Chapter 4

Biodiversity and Evolution

Summary

1. 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.
2. 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.
3. Extinction of species and formation of new species constantly change the biodiversity of the earth.
4. 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. Some sharks play the role of keystone species in their environments. Nevertheless, about 32% of shark species are threatened with extinction. In addition to the roles sharks play in their environments, science stands to learn many things from these species. Many people argue that they should be saved simply because they have the right to exist.

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

1. Species are individuals that can make and produce viable offspring.
2. Species diversity, genetic diversity, ecosystem diversity, and functional diversity.
 - a. Biomes are large regions with distinct climates and certain species that are adapted to them.

Individuals Matter: E.O Wilson has been a large influence on conservation efforts. His early work included discovering how ants communicate and developing the theory of island biogeography.

SCIENCE FOCUS: Insects often have a bad reputation and are considered pests. However the ecological roles they play in pollinating flowering plants and controlling other insect populations make them invaluable to humans.

2. How does the earth's life change over time?

A. Most of what we know of the history of life comes from the fossil record.

B. Evolution is the change in a population's genetic makeup over time.

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

1. In 1858 Charles Darwin and Alfred Russel Wallace independently proposed natural selection as the mechanism of evolution.
2. Natural selection occurs when members of a population have genetic traits that improve their ability to survive and produce offspring with those specific traits.
3. For natural selection to work on a population, three steps occur:
 - a. The development of genetic variability.
 - i. Mutations are random changes in the structure/number of DNA molecules in a cell.
 - ii. 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.
 - b. Natural selection: environmental conditions favor some individuals over others by virtue of adaptive traits.
 - c. populations evolve such that they are better adapted to survive and reproduce under existing 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.

4. Natural selection can only act on existing genes and is limited by reproductive capacity.
5. Three common misconceptions about evolution.
 - a. Fitness is a measure of strength.
 - b. Organisms develop certain traits because they need them.
 - c. Evolution works according to some grand plan.

4-3 How do geological 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: Earth is uniquely suited to support life because of its average temperature, distance from the sun, size and atmospheric composition.

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.
 1. Endemic species (those found in only one place) are especially vulnerable.
- 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, 25–95% of species are lost. There appear to have been at least three and perhaps five mass extinctions on earth.

SCIENCE FOCUS: Artificial selection involves crossbreeding between genetic varieties of the same species to give rise to populations with desirable traits. Now, scientists can use genetic engineering to produce desirable traits or eliminate undesirable ones.

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 and its isolation affect 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.
- 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. They can survive extreme conditions and have a wide variety of adaptations that allow them to avoid predation.

- 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, an 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 effect on maintaining balance within an ecosystem.
 1. Can be, but are not necessarily, pollinators and top predators.

CASE STUDY: Alligators act as a keystone species, yet their numbers were seriously compromised by overhunting. 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.

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

Teaching Tips

Large Lecture Courses:

Pick two species that students would be familiar with from the local environment (perhaps something from the urban edge, such as coyotes or raccoons). One should be a generalist and one a specialist. Allow them to brainstorm ideas as you record them on the board. What are the characteristics of each? Which one are they more familiar with? Are humans more similar to the specialist or generalist?

Smaller Lecture Courses

Have students work in small groups researching a species that is an ecosystem engineer prior to this lecture. As an introduction, they can briefly present their species to the rest of the course, covering the ways in which the species alters its environment, and what advantages this has. Conclude with a compare/contrast discourse on the ways in which humans are similar or different from ecosystem engineers.

Key Terms

adaptation
adaptive trait
background extinction
biological diversity
biological evolution
differential reproduction
ecological niche
endemic species
extinction
fossils
foundation species
generalist species
geographic isolation
indicator species

keystone species
mass extinction
mutations
native species
natural selection
niche
nonnative species
reproductive isolation
specialist species
speciation
species
species diversity
theory of evolution