14.1 The origin of species is the source of biological diversity

- **Speciation** is the emergence of new species
- Every time speciation occurs, the diversity of life increases
- The many millions of species on Earth have all arisen from an ancestral life form that lived around 3.6 billion years ago
CONCEPTS OF SPECIES
14.2 There are several ways to define a species

- **Taxonomy** is the branch of biology that names and classifies species and groups them into broader categories.

- Carolus Linnaeus developed the binomial system of naming organisms using physical characteristics to distinguish over 11,000 species.

- Similarities between some species and variation within species can make defining species difficult.
14.2 There are several ways to define a species

- The **biological species concept** defines a species as a population or group of populations whose members have the potential to interbreed in nature and produce fertile offspring.

- Reproductive isolation prevents gene flow and maintains separate species.
14.2 There are several ways to define a species

- Can the biological species concept always distinguish species from each other?
14.2 There are several ways to define a species

- The **morphological species concept** classifies organisms based on observable phenotypic traits.

- It can be applied to asexual organisms, fossils, and in cases when we don’t know about possible interbreeding.

- There is some subjectivity in deciding which traits to use.
14.2 There are several ways to define a species

- The **ecological species concept** defines a species by its ecological role or niche
  
  Consider the cichlids, which are similar in appearance but feed at different depths in the lake.
The **phylogenetic species concept** defines a species as a set of organisms representing a specific evolutionary lineage.

- Morphological or DNA similarities or differences can be used to define a species.
- Defining the amount of difference required to distinguish separate species is a problem.
14.3 Reproductive barriers keep species separate

- **Reproductive barriers** serve to isolate a species gene pool and prevent interbreeding.

- Reproductive barriers are categorized as prezygotic or postzygotic, depending on whether they function *before* or *after* zygotes form.
<table>
<thead>
<tr>
<th>Prezygotic Barriers: Prevent Mating or Fertilization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temporal isolation:</strong> Mating or flowering occurs at different seasons or times of day.</td>
</tr>
<tr>
<td><strong>Habitat isolation:</strong> Populations live in different habitats and do not meet.</td>
</tr>
<tr>
<td><strong>Behavioral isolation:</strong> There is little or no sexual attraction between different species.</td>
</tr>
<tr>
<td><strong>Mechanical isolation:</strong> Structural differences in genitalia or flowers prevent copulation or pollen transfer.</td>
</tr>
<tr>
<td><strong>Gametic isolation:</strong> Male and/or female gametes die before uniting or fail to unite.</td>
</tr>
</tbody>
</table>

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<th>Postzygotic Barriers: Prevent the Development of Fertile Adults</th>
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<tr>
<td><strong>Reduced hybrid viability:</strong> Hybrids fail to develop or to reach sexual maturity.</td>
</tr>
<tr>
<td><strong>Reduced hybrid fertility:</strong> Hybrids fail to produce functional gametes.</td>
</tr>
<tr>
<td><strong>Hybrid breakdown:</strong> Offspring of hybrids are weak or infertile.</td>
</tr>
</tbody>
</table>
14.3 Reproductive barriers keep species separate

- **Prezygotic Barriers**
  - Prezygotic barriers prevent mating or fertilization between species
  - In *temporal isolation*, two species breed at different times (seasons, times of day, years)
  - In *habitat isolation*, two species live in the same general area but not in the same kind of place

Video:
- Blue-footed Boobies Courtship Ritual
- Albatross Courtship Ritual
- Giraffe Courtship Ritual

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14.3 Reproductive barriers keep species separate

- **Prezygotic Barriers**
  - In *behavioral isolation*, there is little or no sexual attraction between species, due to specific behaviors.
  - In *mechanical isolation*, female and male sex organs are not compatible.
  - In *gametic isolation*, female and male gametes are not compatible.
14.3 Reproductive barriers keep species separate

Postzygotic Barriers

- Postzygotic barriers operate after hybrid zygotes are formed
  - In reduced hybrid viability, most hybrid offspring do not survive
  - In reduced hybrid fertility, hybrid offspring are vigorous but sterile
  - In hybrid breakdown, the first-generation hybrids are viable and fertile, but the offspring of the hybrids are feeble or sterile

- The process of speciation depends on whether reproductive barriers prevent gene flow between populations
14.3 Reproductive barriers keep species separate

- If two related species live in the same area, would natural selection favor the evolution of *prezygotic* or *postzygotic* reproductive isolating mechanisms?
MECHANISMS OF SPECIATION
14.4 In allopatric speciation, geographic isolation leads to speciation

- In **allopatric speciation**, populations of the same species are geographically separated, separating their gene pools.

- Changes in the allele frequencies of each population may be caused by **natural selection, genetic drift**, and **mutation**, unaffected by gene flow from other populations.
14.4 In allopatric speciation, geographic isolation leads to speciation

- Gene flow between populations is initially prevented by a geographic barrier
  - The Grand Canyon and Colorado River separate two species of antelope squirrels
14.4 In allopatric speciation, geographic isolation leads to speciation

- Likelihood of allopatric speciation increases when a population is small and isolated
  - A small population may have a different gene pool due to the founder effect
  - Genetic drift and natural selection may have a greater effect in a small population in a new habitat
14.5 In sympatric speciation, speciation takes place without geographic isolation

- In **sympatric speciation**, new species may arise within the same geographic area as a parent species.
14.9 TALKING ABOUT SCIENCE: Peter and Rosemary Grant study the evolution of Darwin’s finches

- Peter and Rosemary Grant have worked on medium ground finches on tiny, isolated, uninhabited Daphne Major in the Galapágos Islands for 35 years.

- Medium ground finches and cactus finches occasionally interbreed.
  - Hybrid offspring have intermediate bill sizes and survive well during wet years, when there are plenty of soft, small seeds around.
  - During dry years, hybrids are outcompeted by both parental types.
14.9 TALKING ABOUT SCIENCE: Peter and Rosemary Grant study the evolution of Darwin’s finches

- The occasional hybridization between finch species introduces new genes into both populations.

- During drought years, hybrids die out.
  - This keeps medium ground finches and cactus finches on separate evolutionary paths.
Cactus-seed-eater (cactus finch)

Seed-eater (medium ground finch)

Tool-using insect-eater (woodpecker finch)
Cactus-seed-eater (cactus finch)
Seed-eater
(medium ground finch)
Tool-using insect-eater
(woodpecker finch)
14.10 Adaptive radiation may occur when new opportunities arise

- In **adaptive radiation**, many diverse species evolve from a common ancestor.

- Adaptive radiations occur
  - When a few organisms colonize new unexploited areas
  - After a mass extinction

- Adaptive radiations are linked to new opportunities: lack of competitors, varying habitats and food sources, evolution of new structures.
14.11 Speciation may occur rapidly or slowly

- What is the total length of time between speciation events (between formation of a species and subsequent divergence of that species)?
  - In a survey of 84 groups of plants and animals, the time ranged from 4,000 to 40 million years
  - Overall, the time between speciation events averaged 6.5 million years and rarely took less than 50,000 years
Prezygotic barriers
- Temporal isolation
- Habitat isolation
- Behavioral isolation
- Mechanical isolation
- Gametic isolation

Postzygotic barriers
- Reduced hybrid viability
- Reduced hybrid fertility
- Hybrid breakdown
You should now be able to

1. Compare the definitions, advantages, and disadvantages of the different species concepts

2. Describe five types of prezygotic barriers and three types of postzygotic barriers that prevent populations belonging to closely related species from interbreeding
You should now be able to

4. Explain how geographical processes can fragment populations and lead to speciation

5. Explain how sympatric speciation can occur, noting examples in plants and animals

6. Explain how reproductive barriers might evolve in isolated populations of organisms

7. Explain the conditions that can lead to adaptive radiation