

***Reproductive isolating mechanisms***

- *Prezygotic barriers*: Anything that prevents mating and fertilization is a prezygotic mechanism.

Habitat isolation, behavioral isolation, temporal isolation, mechanical isolation and gametic isolation are all examples of prezygotic isolating mechanisms. Some species of fruit flies in the genus *Rhagoletis* provide an example of habitat and behavioral isolating mechanisms. Different species are reproductively isolated because each species lays its eggs on different host species. Adults return to lay eggs on the hosts from which they emerged. Some species of fruit flies in the genus *Drosophila* are reproductively isolated because of mechanical incompatibility of their genitalia.

- *Postzygotic barriers*: Postzygotic barriers prevent a hybrid zygote from developing into a viable, fertile adult. The mule is a typical example.

Reduced viability or fertility of hybrid individuals or reduced viability or fertility of the offspring of hybrid individuals are evidence of postzygotic reproductive isolation. Differences in chromosome number or arrangement of genes on chromosomes usually result in postzygotic isolation because chromosomes may not pair normally during mitosis or meiosis.

***The formation of new species requires some initial reduction of gene flow***

Two processes of speciation are thought to be important: allopatric speciation and sympatric speciation.

- *Allopatric speciation*: The first step in allopatric speciation is the restriction of dispersal between two or more populations that would otherwise freely interbreed.

One possibility is that a geographic barrier such as a river or desert forms. The separation of two populations by such a barrier is called a vicariant event.

A second possibility is that individuals from a source population colonize a new geographic area that is separated from the source population by a nearly complete barrier to gene flow. The establishment of a new population is a founder event.

Both vicariant and founder events may reduce gene flow sufficiently that reproductive isolating mechanisms can evolve afterwards.

Whether a geographic barrier leads to allopatric speciation or not depends on dispersal ability. A barrier may lead to speciation in some groups but not in others. For example, a river may be a barrier for a snake but not a bird.

In the *Origin*, Darwin emphasized that isolation led to the evolution of separate species. The neo-Darwinian theory is essentially the same. If there is no gene flow between two populations, they will evolve independently under the combined

effects of mutation, natural selection, and genetic drift and will eventually be recognized as different species. Reproductive isolating mechanisms will eventually evolve in the absence of gene flow.

Female choice can play an important role in species formation, as illustrated by the cichlid fishes and birds of paradise. Accidental differences in female preference can lead to rapid evolution of reproductive isolation. Cichlid fishes have evolved into hundreds of species in a relatively short time.

- *Founder events*: Founder events are thought to be important for species formation because they create opportunities for rapid changes in allele frequencies both because of natural selection and genetic drift.

If the founder group is small, genetic drift alone can cause substantial changes in allele frequencies in the new population, and some of those changes can result in morphological change and reproductive isolation. In the extreme case of a population founded by a single individual capable of self-fertilization, a gene can become homozygous for an allele that is in low frequency in the source population.

A population arriving in a new area may experience new environmental conditions that lead to rapid evolution as the population adapts to the new conditions.

- *Adaptive radiation*: An adaptive radiation is the evolution of numerous species from a common ancestor in an environment that presents new opportunities. Cactuses are the result of an adaptive radiation in the deserts of North and South America.

Many adaptive radiations occur on remote islands or in island-like habitats such as lakes because there are many opportunities for founder events. Both natural selection and genetic drift may lead to rapid evolution.

Hawaiian honeycreepers and cichlid fishes found in African lakes are good examples of adaptive radiations in restricted areas.

- *Laboratory experiments*: Reproductive isolation between two groups can evolve in a laboratory experiment. In two groups of fruit flies, a prezygotic barrier evolved in a laboratory experiment when flies were raised on starch or maltose, illustrated in Fig. 24.7 in the textbook.

### ***Sympatric speciation can occur.***

Other processes can reduce gene flow and lead to the evolution reproductive isolation of sympatric populations without an initial restriction in dispersal.

- *In plants, polyploidy can lead to immediate reproductive isolation*: Mutations can create polyploid plants that have either one parent (autopolyploid) or two parents (allopolyploid). A polyploid self-fertile plant is likely to be reproductively isolated by a postzygotic mechanism from its parent(s) because it has a different

number of chromosomes, as illustrated in Fig. 24.8. The genus *Clarkia* provides several examples of allopolyploid and autopolyploid species.

Many domesticated plants are polyploid, including oats, wheat, barley, potatoes, bananas, and tobacco. It is likely that polyploid individuals were selected early in the process of domestication of plants, both because they had unusual properties and because they were reproductively isolated from their wild relatives. Gene flow from wild plants would tend to make domestication more difficult.

- *In animals, sympatric speciation can occur because of differences in habitat or food preference:* Host shifts combined with extreme habitat fidelity can lead to rapid speciation, as has occurred in fig wasps, discussed already by Dr. Feldman. Each species of fig has its own wasp species. New species in the genus *Rhagoletis* have evolved when new host species were colonized.

### ***Macroevolution and microevolution***

Microevolution is the process of change in individual species. Macroevolution is evolutionary change above the species level, including the formation of species, the diversification of species, and the appearance of major evolutionary developments.

One of the important questions in evolutionary biology is how well macroevolutionary patterns can be predicted from our understanding of microevolution.

### ***The punctuated equilibrium theory***

- *Pattern:* The punctuated equilibrium theory is a generalization about the pattern of evolution as seen in the fossil record. The pattern is the stasis of established wide-spread lineages and morphological change when new species appear. The two are compared in Fig. 24.13.

What is not seen very often in the fossil record is gradual and continuous change in widespread species. Darwin's explanation for not seeing this pattern was the imperfection of the fossil record. Even when the fossil record of some groups is more complete, the punctuated equilibrium pattern instead of a gradual pattern is often found. The fossil record of humans and their immediate ancestors, which will be reviewed later, is an example of the punctuated equilibrium pattern.

- *Consistent with neo-Darwinism:* Rapid changes can be explained by the effects of natural selection. What appears to be very rapid in the fossil record may have taken 50,000 years or longer, which is plenty of time for natural selection and genetic drift to cause substantial morphological change.

Stasis can result from selection and from habitat choice. Species tend to remain in those environments to which they are well adapted. During the Pleistocene, glaciers covered much of the northern Europe, Asia and North America. Many species, including oak and spruce trees, that previously lived in the north shifted their ranges to the south and then returned to the north as the climate changed.

*Example test questions*

Q1. Mules are sterile because they cannot produce functional gametes. This is evidence that

- A. horses and donkeys are members of the same species.
- B. horses and donkeys are separated by genetic drift.
- C. horses and donkeys are separated by a founder event.
- D. horses and donkeys are separated by a prezygotic barrier.
- E. horses and donkeys are separated by a postzygotic barrier.

Q2. Which one of the following is a necessary step in the process of species formation?

- A. The appearance of a new morphological structure.
- B. A change in the number of chromosomes
- C. A change in geographic location.
- D. A reduction in gene flow.
- E. The formation of a new genus.

Q3. Which pair of words best completes the following sentence: In the \_\_\_\_\_ theory of speciation, a barrier to \_\_\_\_\_ is the initial step.

- A. allopolyploid, autopolyploid.
- B. sympatric, dispersal.
- C. allopatric, dispersal.
- D. allopatric, selection.
- E. sympatric, selection.

Q4. What has favored the evolution of many species of fig wasps?

- A. Fig wasps are very small.
- B. Fig wasps can fly long distances.
- C. Fig wasp species are very different in size.
- D. Each fig wasp species lays eggs on only one species of fig.
- E. Fig wasp species are hermaphroditic.

Q5. Snapdragons are plants capable of self-fertilization. Flower color is controlled by a single gene with two alleles: RR individuals have red flowers; RW individuals have pink flowers; WW individuals have white flowers. A new population of snapdragons is established by a seed from a source population in which the frequency of R is 0.2. If the source population has genotypes in the Hardy-Weinberg frequencies, what is the chance that the first plant in the newly founded population will have red flowers?

- A. 0.01
- B. 0.04
- C. 0.2
- D. 0.36
- E. 0.64

Q6. Which pair of words best fills the blanks in the following sentence? The punctuated equilibrium theory is a generalization about the \_\_\_\_\_ of evolution seen in \_\_\_\_\_.

- A. mechanism, Paleozoic
- B. theory, The Origin of Species.
- C. pattern, fossil record.
- D. fact, fossil record.
- E. repeatability, plants and animals.

Correct answers: E, D, C, D, B, C