Mechanisms of Speciation

In general, a species is a group of similar organisms that can breed and produce fertile offspring. The millions of species that live on Earth today emerged over time, with each new species arising from an already existing species. This diversification of one species from another is supported by genetic, developmental, and anatomical similarities among species. In addition, geological and fossil evidence show how species have changed over time.

Collaborate Kaibab and Abert's squirrels live on opposite sides of the Grand Canyon. Though closely related, they do not share all of the same characteristics. How did these differences come about? Make a list with a partner to explain your reasoning.

FIGURE 2: These squirrels are closely related but have different characteristics.

a Kaibab squirrel

b Abert's squirrel

Speciation

Where do new species come from? Speciation is the rise of two or more species from a single existing species. Experiments can be used to model speciation. In one such experiment, an existing population of fruit flies, *Drosophila melanogaster*, was divided into two groups. One group was given maltose-based food and the other was given starch-based food. The goal of the experiment was to determine what changes would occur from the isolation of species and the presence of different food sources.

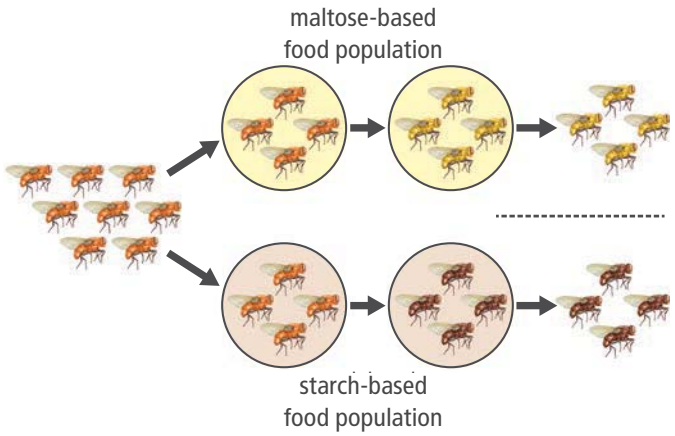

FIGURE 3: Changes in fruit flies can occur due to differing food sources.

Many generations later, the mating preference of the flies was analyzed. The scientists found that the flies raised on maltose-based food, called maltose flies, preferred to mate with other maltose flies. The flies raised on starch-based food, called starch flies, preferred to mate with other starch flies. However, cross-breeding between the two groups could still occur. This experiment shows a distinct mating preference and the beginning of reproductive isolation within a species. If the two groups of fruit flies were eventually unable to breed successfully, then speciation would occur.

Analyze What happened during the many generations that these flies were kept separated? How might this period of isolation have contributed to the mating preferences shown?

Reproductive Isolation

Predict How can reproductive isolation lead to speciation?

If gene flow is interrupted between two populations of the same species, the populations are said to be isolated. Isolated populations are prevented from mating and exchanging genes. This means natural selection acts upon a different gene pool for each population. Different mutations will accumulate, different variations will be selected for or against, and eventually adaptations will occur that prevent mating between the two populations. Isolated populations that are in different environments, and therefore exposed to different selective pressures, will diverge from one another more quickly. It becomes more likely that reproductive isolation will occur as the two populations become more different. Even isolated populations in similar environments can undergo speciation if genetic drift takes the two gene pools in opposite directions.

Reproductive isolation occurs when members of different populations can no longer mate successfully. Sometimes members of the two populations are not physically able to mate with each other. In other cases, they cannot produce offspring that survive and reproduce. Reproductive isolation is the final step of becoming a separate species.

Physical Separation

An isthmus is a strip of land with sea on both sides that links two larger landmasses. The Isthmus of Panama formed through a combination of volcanic island formation and uplift of the ocean floor. These two geological factors made solid land where there was once an open passage between the Atlantic and Pacific oceans.

Collaborate With a partner, make a list of other physical barriers that can lead to geographic isolation as happened with snapping shrimp.

Around 3 million years ago, the isthmus closed in, permanently separating populations of snapping shrimp. Once separated, each population of shrimp adapted to a different environment and became genetically different. Over time, the groups became different enough to be reproductively isolated and speciation occurred. The physical separation of two or more populations can lead to speciation through geographic isolation.

FIGURE 4: Speciation in snapping shrimp occurred due to geographic isolation.

Source: Carl Hansen and Nancy Knowlton, 2001, The Smithsonian Institution, as quoted by PBS, Evolution Library; Arthur Anker, 2016, Smithsonian Newsdesk

Behavior and Timing

Behavioral isolation is caused by differences in courting or mating behaviors. If two populations do not use the same courting or mating behaviors, then mating, and therefore gene flow, between the two groups is unlikely to occur. When gene flow is interrupted, natural selection acts upon the different gene pools. Reproductive isolation and speciation may eventually occur.

Male songbirds sing to defend their territories and attract mates. An eastern meadowlark and a western meadowlark are shown in Figure 5. As you can see, they look almost the same. The major difference between these species is their songs. The eastern and western meadowlarks use completely different songs to attract mates. This means eastern meadowlark males cannot successfully attract western meadowlark females, and western meadowlark females cannot give eastern meadowlark males the correct breeding cues. The two species have become behaviorally isolated.

FIGURE 5: The eastern meadowlark and western meadowlark look almost identical but use different songs to attract mates.

Explore Online

a Eastern meadowlark

b Western meadowlark

The red-legged frog and the yellow-legged frog are closely related. The development of mating seasons that occur at different times caused these species to become temporally isolated. Temporal isolation occurs when timing prevents reproduction between populations. Red-legged frog populations breed from January to March while yellow-legged frog populations in the same area breed from late March to May. Speciation from a common ancestor occurred as the overlap in mating seasons shrank. The flow of genes between the two groups also shrank and the two groups diverged.

FIGURE 6: Red-legged frogs and yellow-legged frogs have different mating seasons.

a Red-legged frog

b Yellow-legged frog

Data Analysis Draw a graph to explain why different mating seasons were likely the cause of red-legged frog and yellow-legged frog speciation.

Adaptive Radiation

Speciation through the diversification of one ancestral species into many descendant species is called adaptive radiation. Adaptive radiation typically happens quickly as species benefit from less competition, new niches, or specializations that give a selective advantage.

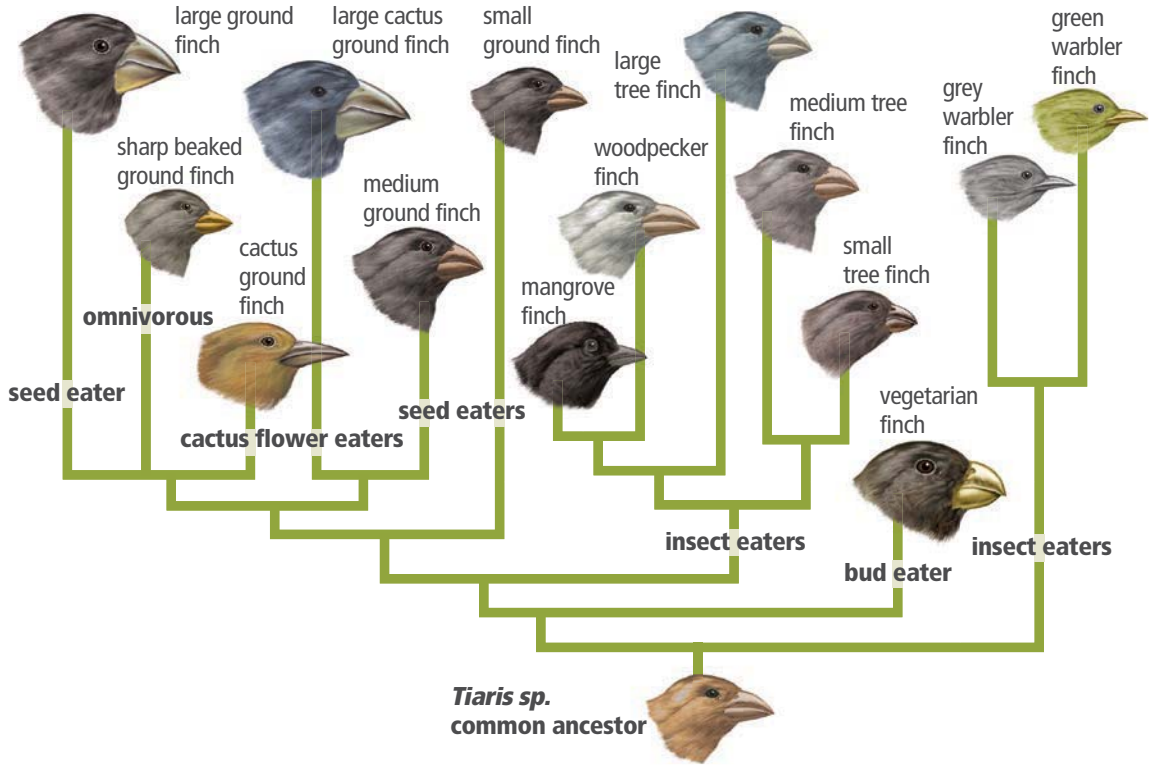

FIGURE 7: The diverse finches of the Galápagos Islands came from a common ancestor.

Darwin's finches are an example of adaptive radiation that occurred on an island system. The 14 species of finch found on the Galápagos Islands came from a common ancestor. The descendants have diversified and specialized to take advantage of different niches. The finch species minimize competition among themselves by specializing in different food sources. For example, populations of finches with larger beaks can crack harder and larger seeds. Populations of finches with smaller, pointy beaks can catch insects. Darwin's finches are a classic example of changes in environmental conditions driving the adaption and expansion of species.

Analyze What factors would support the idea that adaptive radiation occurred in the finches of the Galápagos Islands?

For adaptive radiation to take place, there must be adaptation by a species that leads to speciation. For example, dinosaur extinctions led to more resources and fewer predators for mammals. The open niches left by dinosaurs may have been the trigger for adaptive radiation of mammals after dinosaurs became extinct. Mammals diversified and adapted to new niches producing new species in many cases. This is an example of a catastrophic change in the environment leading to the expansion of an entire family of species.

Explain Which type of reproductive isolation could have led to the speciation of plants in the silversword alliance? Use evidence to support your claim.