10 What Is a Species?

Think about the many different types of organisms you see in a typical day. In addition to humans, you might see mammals such as dogs and cats; birds such as robins and pigeons; insects such as ants and flies; and plants ranging from dandelions to oak trees. On a farm or at the zoo or aquarium, you would see even more examples.

The original idea of different types, or species, of organisms was based on the observable differences in their appearances. A species was defined as a group of organisms with similar physical characteristics. Beginning in the late 1700s, species became the basic unit of classification.

As scientists learned more about evolution and the causes of differences among groups of organisms, their ideas about species changed. Scientists now know that some populations of organisms that appear identical are in fact different species, and others that appear different are the same species. The original species concept was replaced by concepts that focus on evolutionary relationships.

There are now several alternative definitions for species. In this activity, you will explore the **biological species concept.** This method of defining a species is based on whether the organisms actually or can potentially breed with each other to produce fertile offspring. If they can, they are of the same species. This approach gives evolutionary biologists and conservationists a snapshot of where species are in the process of separation from one another. The classification of populations into the same or separate biological species may affect their conservation status. For example, if two populations are determined to be in separate species, it is more likely that both will be considered for protection.

The pickerel frog (a) and moor frog (b) are two species of frogs in the Rana *genus.*


a

b

Other species concepts are applied in other fields of biology. For example, evolutionary biologists use a phylogenetic species concept, which defines a species as a distinct lineage and reflects the evolutionary relationships among taxa.

Challenge

▶ How do new species separate from existing species?

MATERIALS

FOR EACH GROUP OF FOUR STUDENTS

- set of 14 Species Pair Cards
- set of eight Reproductive Barrier Cards

BACKGROUND INFORMATION

The Biological Species Concept

ACCORDING TO THE biological species concept, a **biological species** is all of the populations of individuals that actually or can potentially breed with each other in nature to produce fertile offspring. The result of this interbreeding is movement of genes, called **gene flow,** throughout the species. Members of the same species share a common group of genes—a **gene pool**—and a common evolutionary history. Should members of different populations mate but produce no or no fertile offspring or very rarely breed with each other even when present in the same location, they are considered different biological species.

OTHER WAYS TO CATEGORIZE SPECIES

The biological species concept is straightforward, but it turns out that there are a number of areas where it is not helpful. For example, many species, such as bacterial species, do not reproduce sexually. The concept also does not fit many plant species that crossbreed under natural or artificial conditions. Also, the concept cannot be applied to fossil organisms because their breeding cannot be observed.

Nevertheless, the biological species concept gives scientists a snapshot of the evolution of new species in many groups of plants and animals. As you review the examples on the following pages, keep in mind that the populations that share a common gene pool are most likely in the early stages of separation from one another. This is likely to be the case if individuals in the two populations meet the following two conditions:

- They usually breed together if they meet in the wild.
- Their breeding produces offspring able to produce their own offspring. ■

Procedure

Part A: Species Separation

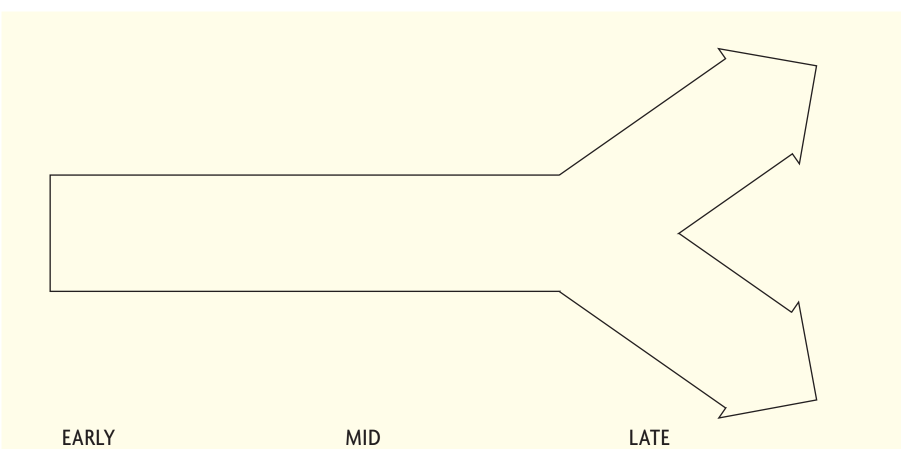
1. Read the information on the biological species concept in the box on the previous page.

2. In your science notebook, prepare an entry like the one below. It should take up about one-fourth of a notebook page.

Species Separation	
Example number/ organism name	
Claim	
Evidence to support the claim	
Reasoning	

3. On another page in your science notebook, across the entire page, draw and label an arrow like the one shown below. The arrow shows a continuum from early to late for the process of separation of new species from existing species.

4. Work as a class with your teacher to complete some of the examples on the following pages.



5. Following your teacher's instructions, complete some of the following examples with your group and some on your own.

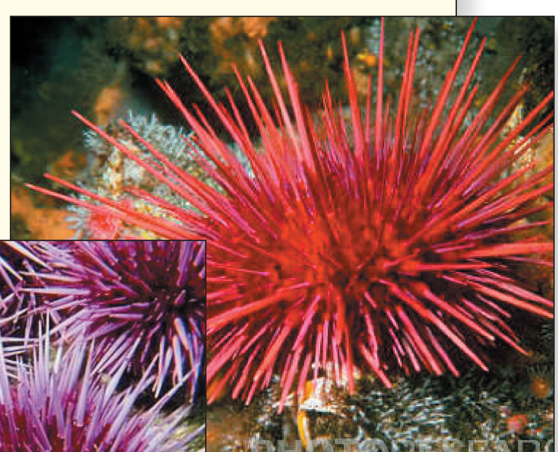
6. In your science notebook, record each of the following:
   - The example number and the name of the organisms
   - Your claim: a statement about what stage of separation the species are in
   - Place the names of the organisms at the appropriate stage of separation (early, mid, late) along the arrow you drew in Step 3.
   - Your evidence: the information about the mechanism of the separation between species
   - Your reasoning: an explanation of the mechanism of separation that supports your claim. Refer to the biological species concept to explain each species' stage in the separation process.
7. Repeat Step 6 for all of your assigned examples.

The Separation of Species

EXAMPLE 1

Red and Purple Sea Urchins

Red and purple sea urchins live in shallow ocean waters along the eastern Pacific coast from Alaska to Mexico. The sperm of one of these organisms fertilizes the eggs of the other only in the laboratory, where scientists mix the eggs with much higher concentrations of sperm than are likely in the wild. The embryos produced, however, do not survive beyond the very early stages of development. ■



Red sea urchins

Purple sea urchins

EXAMPLE 2

Eastern and Great Plains Narrowmouth Frogs

The eastern narrowmouth frog's range extends along the east coast of the United States from the Carolinas to Florida and west into parts of Oklahoma and Texas, where it lives in moist areas. The Great Plains narrowmouth frog's range is from Baja California in Mexico to eastern Texas, eastern Oklahoma, and northern Missouri, where it lives in drier regions. These two types of frogs occasionally breed naturally in the areas where they overlap, but the fertility of their offspring is not known. Most of the time the frogs select mates of their own type, perhaps because of differences in their mating calls. The two groups of frogs are distinguished by their colors. ■

Great Plains narrow mouth frog (top), Eastern narrow mouth frog (bottom)

EXAMPLE 3

Northern and California Spotted Owls

Northern spotted owls range from northwestern California to western Oregon, Washington, and Canada. California spotted owls are found in the Sierra Nevada from northern to southern California. The two owl populations overlap in parts of northern California. Field observations and genetic evidence suggest that when birds of each type come into contact they have bred and produced fertile offspring. These offspring have a hybrid (mixed) genetic makeup. However, this cross-breeding is rare. Northern and California spotted owls show some differences in appearance and genetics. ■

EXAMPLE 4

Horses and Donkeys

A female horse and a male donkey can mate to produce a mule. Horses have 64 chromosomes, while donkeys have 62. The mule is born with 63 chromosomes that cannot divide evenly, and this makes mules sterile. Although there are some cases of female mules breeding successfully with male horses or donkeys to produce live but infertile offspring, there are no known cases of male mules breeding successfully with female mules, donkeys, or horses. ■

The mule is the sterile offspring of a horse and a donkey.

EXAMPLE 5

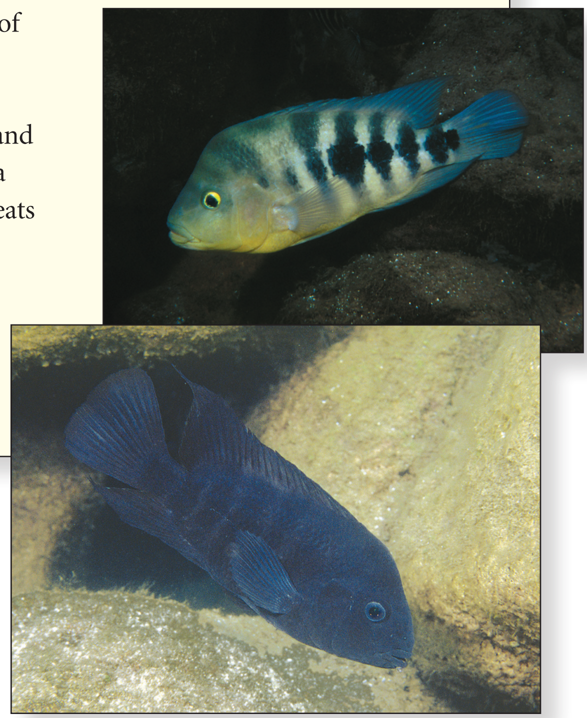
Dogs and Wolves

There is great variety among domesticated dogs, which were bred from wolves approximately 10,000 years ago. Most dogs can breed with one another and have puppies that show a mix of the traits of the parent dogs. For example, a breeder of designer dogs can mate a boxer and a poodle to produce a boxerdoodle. Dogs from different breeds often mate to produce a mixed breed dog, commonly called a mutt. Dogs can also breed with wolves to produce fertile offspring. These mixed offspring can reproduce with similar dogs, other dog breeds, or wolves. Genetic analysis reveals very little difference between dogs and wolves. Wolves are much more similar genetically to dogs than to coyotes. ■

EXAMPLE 6

Midas Cichlid and Arrow Cichlid Fish

Scientists are studying two types of cichlid fish in a volcanic lake in Nicaragua. The Midas cichlid is a bottom-feeder, has a wide body, and eats algae. The arrow cichlid has a slender body for swimming and eats winged insects. The two types of fish select mates of their own kind, and fail to reproduce live offspring when people try to breed them. ■



Arrow cichlid (top), Midas cichlid (bottom)

EXAMPLE 7

Blue and Red Cichlid Fish

Two very similar types of cichlid fish live in Lake Victoria in Africa. One is blue, and the other is red. Females of these two types prefer mates of the same color, and in nature these two types of fish do not breed. However, in a lab, when they are put in lighting conditions where they cannot see the color of the other fish, they will freely mate with fish of the other color. In these lab conditions, the females would now mate with either color male, and produce fully fertile offspring. ■

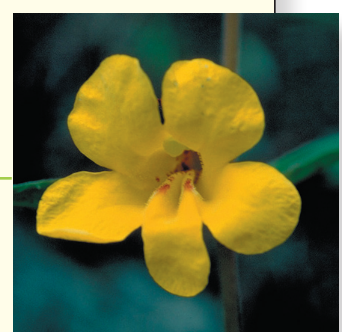
EXAMPLE 8

Green Lacewings

Two populations of lacewings that look identical and live in the same locations do not mate in the wild because they have different mating signals. Female lacewings exhibit a strong preference in the wild for males with a similar mating call. Genetic analysis suggests that the changes in mating call result from changes in just a small number of genes, but that these changes prevent the mating of males and females with different mating calls. When mated in the laboratory, offspring of these two types of lacewings are fertile. ■

EXAMPLE 9

Copper-resistant and Copper-tolerant Yellow Monkey Flower



Copper is toxic to most plants. However, scientists have observed a few plants that have developed a tolerance for copper. One of those is the yellow monkey flower. When scientists crossed copper-tolerant plants with plants sensitive to copper, many of the hybrid plants did not survive. In early growth stages, their leaves turned yellow and they died soon after. ■

EXAMPLE 10

Orchids

Three populations of orchids each flower at different times of the year for just a single day. Therefore, even though these orchids grow in the same tropical forest area, there is no chance that members of one population will fertilize the other in the wild. ■

Part B: The Formation of New Species

Evolutionary biologists focus on the question of how new species and other taxa arise. As you have learned, two populations that have different physical characteristics might still belong to the same species if they can interbreed to produce fertile offspring and do so in nature. This interbreeding allows gene flow, with the two populations sharing a common gene pool.

How do new species evolve? According to the biological species concept, two populations must be reproductively isolated. Reproductive isolation is caused by several kinds of barriers. Once they become reproductively isolated, the two populations will no longer share a common gene pool. Each population will change independently of the other as a result of selection by the different environments. Eventually the two populations could evolve into two separate species.

8. With your group, spread the Species Pair Cards out on a table.
9. Examine the information on each card carefully, noting the barriers to reproduction between the two species described on the card.
10. Sort the cards into groups based on the barriers to reproduction. Work with your group to agree on a name that describes each kind of barrier. While doing so,
    - listen to and consider the explanations of your group members.
    - if you disagree, explain how and why you disagree.
11. In your science notebook, write the title: Our Groupings. Beneath this title, list the groups that you created and the names you picked to describe each group. Be sure to record which species pairs belong to each group.
12. Following your teacher's instructions, your team will present your groupings to the class. As you look at other students' groupings, observe the similarities and differences between their systems and yours. Discuss your observations with your team members.
13. Your group will receive eight Reproductive Barrier Cards from your teacher. Each card represents a barrier that leads to reproductive isolation of related species. Based on the information described on the Reproductive Barrier Cards, place each Species Pair Card under one of the Reproductive Barrier Cards.
14. Record this new set of groupings in your science notebook under the title Scientific Groupings.
15. List the isolating mechanisms you examined in this activity. Write a definition for each mechanism in your own words.
16. List the two types of reproductive isolation in this section, and describe them in your own words.

Analysis

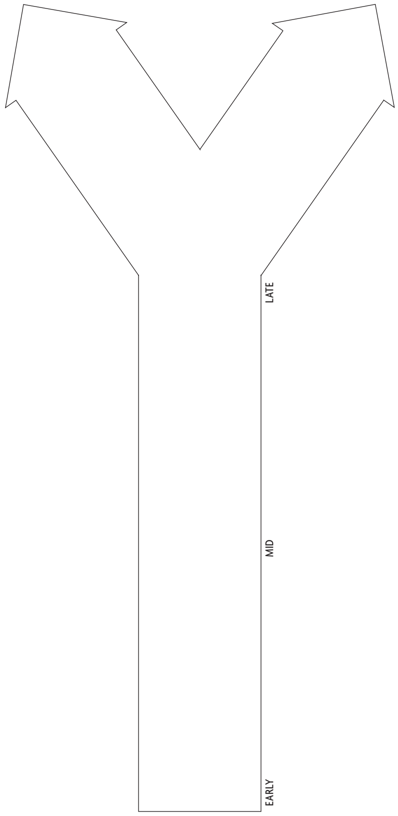
1. Why is appearance alone no longer considered sufficient evidence for classifying organisms?
2. Explain how geographic isolation can lead to speciation.
3. Lions and tigers do not overlap in range and do not breed in nature. In captivity, a male lion may mate with a female tiger and produce offspring. Although more rare, a male tiger may also mate with a female lion to produce offspring. In both cases, the male offspring are sterile, while the females might or might not be fertile. Explain where lions and tigers are on the speciation continuum, according to the biological species concept. Support your answer with evidence and reasoning.
4. How did your groupings of the reproductive barriers in Part B resemble or differ from those used by scientists as shown by the cards in Step 13?
5. Why do you think you came up with a different set of groups in Part B than scientists do in their groupings?
6. Did any of the species pairs in Part B show more than one barrier to reproduction? List examples, and describe the barriers they display.
7. Describe the barriers that are causing reproductive isolation for each of the following from Part A:
   a. Red and purple sea urchins
   b. Eastern and Great Plains narrowmouth frogs
   c. Northern and California spotted owls
8. Two related species of frogs appear to be very similar, but they have different mating calls. In addition, one species breeds in the fall, and the other breeds in the spring. What mechanisms contribute to reproductive isolation of these species?
9. Two related species of birds appear to be similar, but when they breed, their offspring rarely survive past a few days old. What mechanism leads to reproductive isolation of these species?
10. A genetic change occurs in the gene pool of a population of a single flower species with large white tubular flowers. This species is normally pollinated by a species of large bee that is attracted to large white tubular flowers. Pollination is essential for these flowers to produce seeds. In some individuals, one genetic change leads to the production of much smaller flowers. Explain how this could lead to speciation in the population.

KEY VOCABULARY

biological species	**gene pool**
biological species concept	
gene flow	species

NAME *Sample Student Response* ____________________ DATE ____________________

Supporting a Scientific Argument



Example 1: ____________________

Claim: ____________________

Evidence to support the claim: ____________________

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Reasoning: ____________________

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Example 2: ____________________

Claim: ____________________

Evidence to support the claim: ____________________

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Reasoning: ____________________

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Example 3: ____________________

Claim: ____________________

Evidence to support the claim: ____________________

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Reasoning: ____________________

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NAME *Sample Student Response* ______________________ DATE ______________

Supporting a Scientific Argument continued

Name: ______________________ Date: __________

Example 4: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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Example 5: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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Example 6: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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NAME *Sample Student Response* ____________________ DATE ____________

Supporting a Scientific Argument continued

Name: ______________________ Date: ________

Example 7: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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Example 8: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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Example 9: ______________________

Claim: ______________________

Evidence to support the claim: ______________________

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Reasoning: ______________________

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NAME *Sample Student Response* DATE

Supporting a Scientific Argument continued

Name: ______________________________ Date: __________

Example 10: ______________________________

Claim: ______________________________

Evidence to support the claim: ______________________________

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Reasoning: ______________________________

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