

23.2

KEY CONCEPT

Species change over time.

BEFORE, you learned

- Fossils are evidence of earlier life
- More complex organisms have developed over time
- Mass extinctions contributed to the development of Earth's history

NOW, you will learn

- About early ideas and observations on evolution
- How Darwin developed his theory of natural selection
- How new species arise from older species

VOCABULARY

evolution p. 797
natural selection p. 801
adaptation p. 802
speciation p. 804

THINK ABOUT

How have telephones changed over time?



Today people across the world can communicate in many different ways. One of the most common ways is over the telephone. Looking at the two pictures, can you describe how this form of communication has changed over time?



Scientists explore the concept of evolution.

In a general sense, evolution involves a change over time. You could say that the way humans communicate has evolved. Certainly telephones have changed over time. The first telephones were the size of a shoebox. Today a telephone can fit in the palm of your hand and can send images as well as sound.

In biology, **evolution** refers to the process through which species change over time. The change results from a change in the genetic material of an organism and is passed from one generation to the next.

CHECK YOUR READING

What is evolution?

MAIN IDEA AND DETAILS

Make a chart for the main idea *scientists explore the concept of evolution*. Include details about scientists' observations.

Early Ideas

READING TIP

The word *acquire* comes from the root meaning “to add to.” Acquired traits are those that are “added” after an organism is born.

In the early 1800s, a French scientist named Jean Baptiste de Lamarck was the first scientist to propose a model of how life evolves. He became convinced that the fossil record showed that species had changed over time. He proposed an explanation for evolution based on the idea that an individual organism can acquire a new trait during its lifetime and then pass that trait on to its offspring. For example, Lamarck suggested that when giraffes stretched their necks to reach the leaves of tall trees, they passed the result of this stretching—a longer neck—to the next generation. Lamarck was a highly respected scientist, but he was unable to provide any evidence to support his idea.

CHECK YOUR READING

How did Lamarck explain the process of evolution?

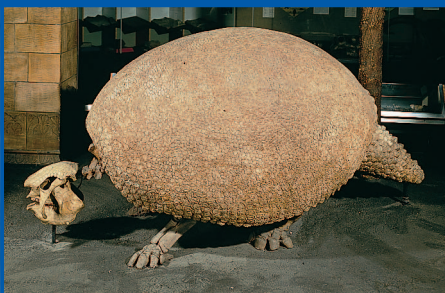
Darwin's Voyage

The Beagle

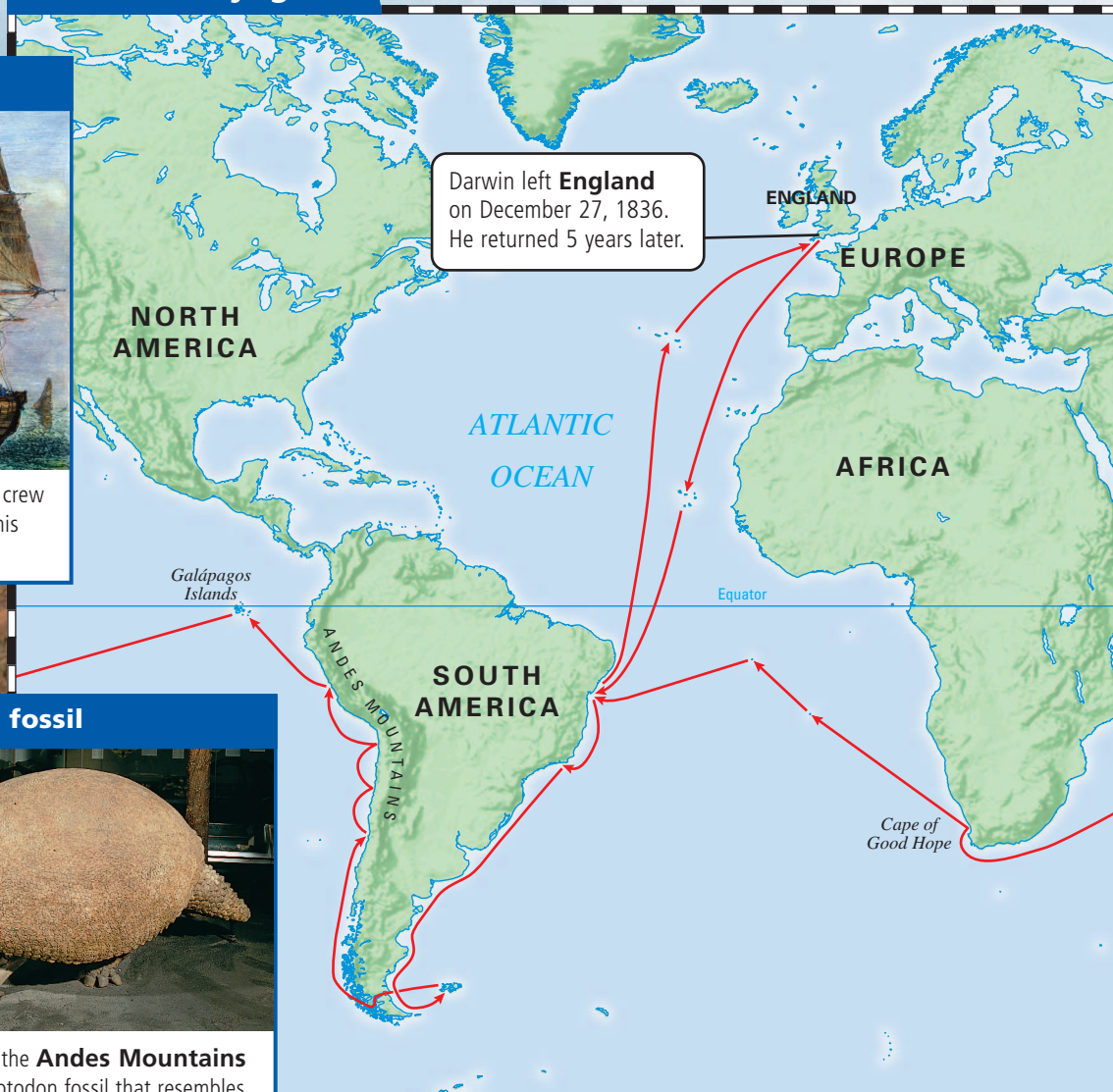


Darwin traveled with a crew of over 70 people on this 90-foot-long vessel.

Glyptodon fossil



Darwin hiked in the **Andes Mountains** and found a glyptodon fossil that resembles the modern armadillo.



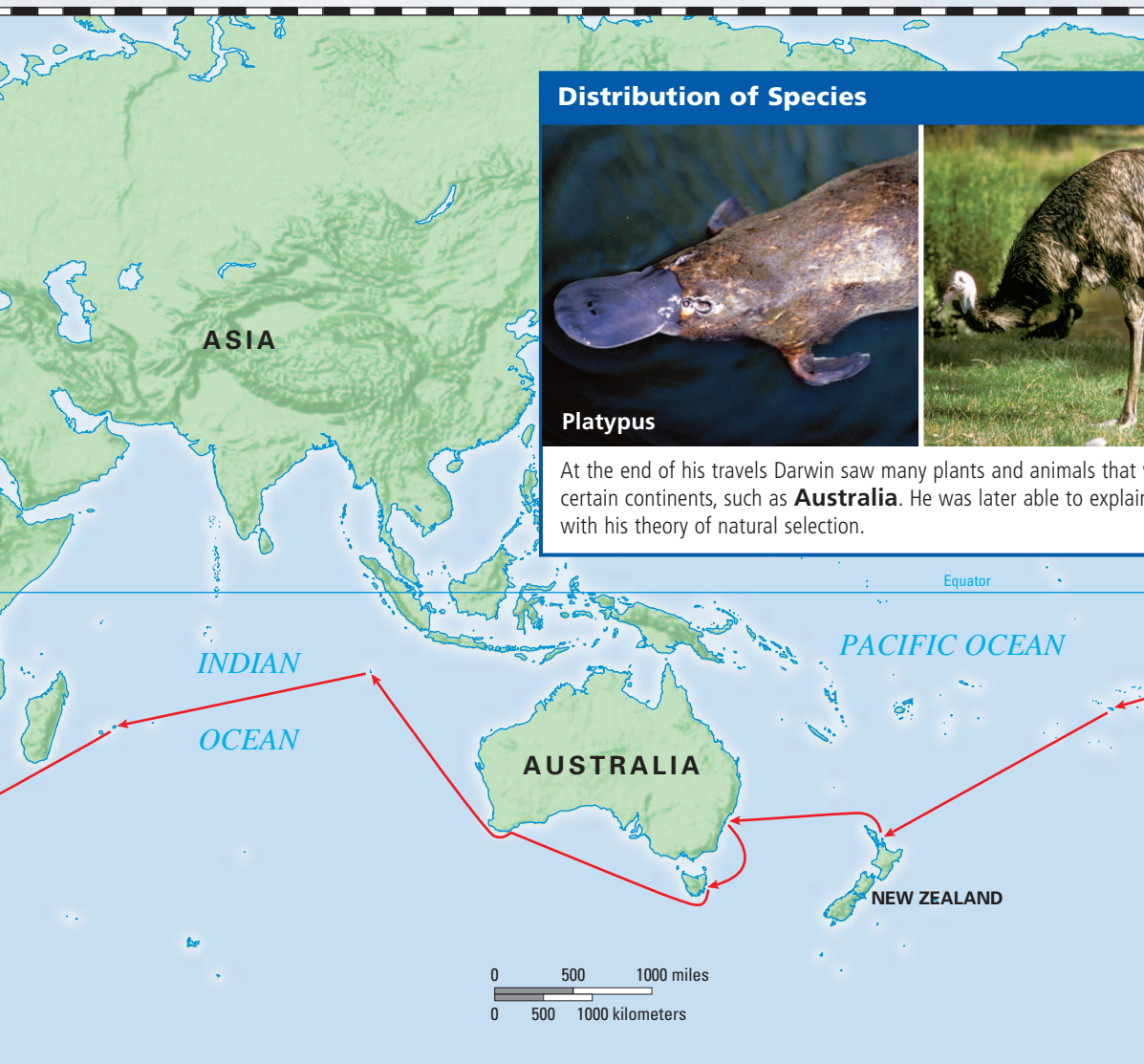
Darwin's Observations

About 50 years after Lamarck, the British naturalist Charles Darwin published what would become the basis of the modern theory of evolution. As a young adult, Darwin spent 5 years as a naturalist aboard the *Beagle*, a ship in the British navy. The map below shows the route Darwin traveled. As he sailed along the coast of South America, he studied rock formations and collected fossils. He also began to compare the new animals he was seeing with ones from his own country.

The differences he saw in animals became more obvious when he visited the Galápagos Islands, a chain of volcanic islands about 950 kilometers (600 mi) off the South American coast. On the 798 Galápagos Islands, plants and animals not only differed from those he saw on the mainland, but some differed from island to island.



Darwin was only 20 in 1831 when he joined H.M.S. *Beagle*.



Distribution of Species



Platypus



Emu

At the end of his travels Darwin saw many plants and animals that were specific to certain continents, such as **Australia**. He was later able to explain this pattern with his theory of natural selection.

Darwin observed several types of tortoises on the islands. Tortoises with short necks were living in damp areas with abundant plant life that grew close to the ground. Longer-necked tortoises were living in dry areas with cacti. He considered whether the length of their necks made it possible for the tortoises to live in different environments.

Darwin also found many different types of birds called finches living on the islands. Some finches were common in the treetops, while others lived in the lower shrubs of a neighboring island. Among the different islands he noticed a variety of beak shapes and sizes. Some finches had heavy, short beaks useful for pecking trees or seeds, while others had small, thin beaks that could be used for capturing insects. These observations caused Darwin to wonder if the birds had evolved from similar species.

Darwin's Finches

On the Galápagos Islands, Darwin observed similar-looking birds with very different beaks. These birds are closely related finch species that are suited to different habitats on the island.

Woodpecker Finch



The woodpecker finch is able to hold a twig in its long pointed beak, which it uses to pull the larvae of insects from a tree. The vegetarian finch has a curved beak, ideal for taking large berries from a branch.

Vegetarian Finch



Large Ground Finch



The large ground finch has a large beak that it uses to crack open the hard shells of the seeds it feeds on. The cactus finch has a narrow beak that it uses to cut into a cactus and eat the tissue inside.

Cactus Finch



Natural selection explains how living things evolve.

After Darwin returned home to England in 1836, he spent several years analyzing the observations and specimens he had collected on his voyage. He struggled to develop an explanation that would account for the amazing diversity of species he saw and for the relationships between them. By 1844 he had developed a hypothesis based in part on an insight from one of his hobbies—breeding pigeons.

Darwin knew from personal experience that breeders can produce new varieties of an animal over time. The process breeders use is called artificial selection. For example, breeders produce a new breed of dog by selecting dogs that have certain desired traits and then allowing only those individuals to mate. From the resulting litters, they again selectively breed only the individual dogs with the desired traits. By repeating this process generation after generation, a new breed is produced.



Learn more about natural selection.



CHECK YOUR
READING

What is artificial selection?

Artificial Selection



Cairn



Airedale



Tibetan

COMPARE AND CONTRAST These dogs are all terriers, but they have been bred through artificial selection to show very specific traits. How are the dogs similar? How are they different?

Darwin's insight was that a similar process might be going on in nature. He proposed that, through a process he called **natural selection**, members of a species that are best suited to their environment survive and reproduce at a higher rate than other members of the species. Darwin based this idea on a few key principles. These are overproduction, variation, adaptation, and selection.

Overproduction

Take a look at how Darwin's ideas are useful for the study of salmon. When a plant or an animal reproduces, it usually makes more offspring than the environment can support, as you can see in the diagram on page 803. A female salmon may lay several thousand fertile eggs, but not all of them will hatch. Only a few hundred of the salmon that hatch from the eggs will survive disease and avoid fish-eating predators. Several dozen of these survivors will live to adulthood. An even smaller number will successfully reproduce.

Variation

READING TIP

As you read about the principles of natural selection, refer to the diagrams on page 803.

Within a species there are natural differences, or variations, in traits. For example, if you looked very closely at thousands of salmon, you might see slight differences among individuals. Some might have larger fins. Others might have distinct patterns of spots on their scales. Many of the differences among individuals result from differences in the genetic material of the fish.

Sometimes the genetic material itself changes, causing a new variation to come about. A change in the genetic material is referred to as a mutation. As the fish with the new variation reproduces, the trait gets passed on to its offspring. Therefore, genetic variations are passed on from one generation to the next.

Adaptation

Sometimes a mutation occurs that makes an individual better able to survive than other members of the group. An **adaptation** is any inherited trait that gives an organism an advantage in its particular environment. For example, a slight change in the shape of a tail fin may increase a fish's chance of survival by helping it swim faster and avoid predators.

Selection

Darwin reasoned that individual organisms with a particular adaptation are most likely to survive long enough to reproduce. As a result, the adaptation becomes more common in the next generation of offspring. As this process repeats from generation to generation, more members of a species show the adaptation. Consider the shape of the salmon. If a change in the tail fin makes the salmon better able to move upstream and lay eggs, scientists say this trait has been selected for in this environment. In other words, the species is evolving through natural selection.

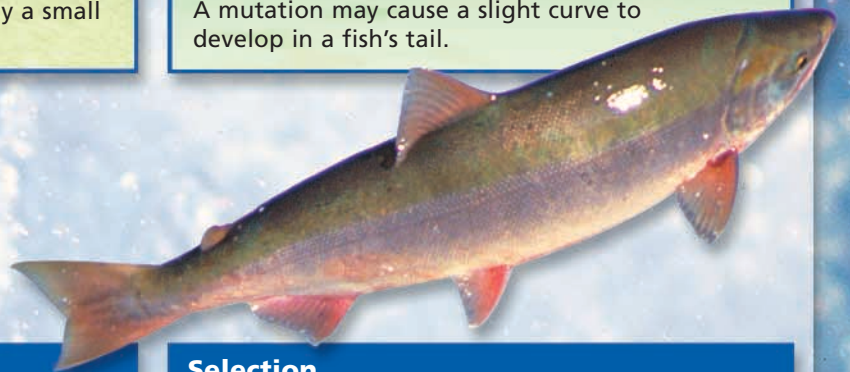
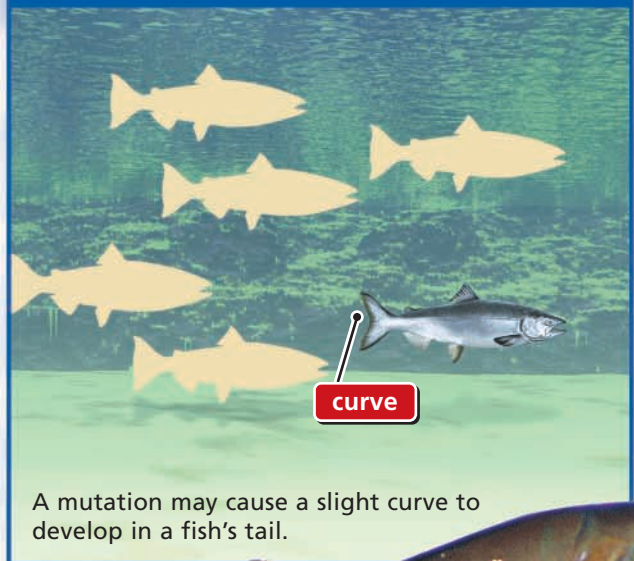
Natural Selection

Certain traits become more common in a group of organisms through the process of natural selection.

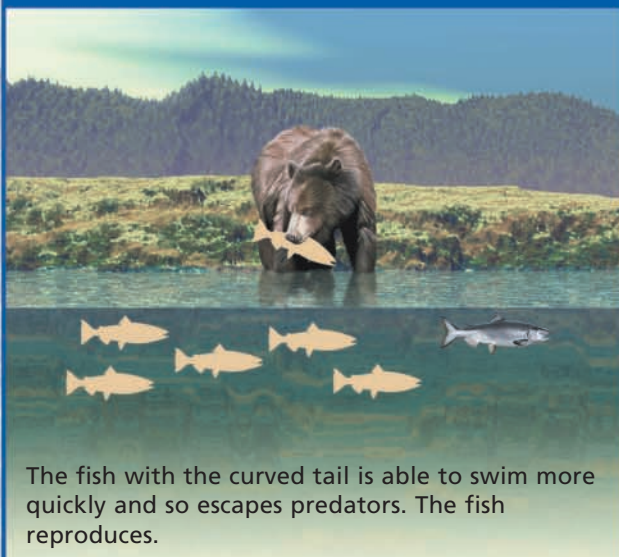
Overproduction



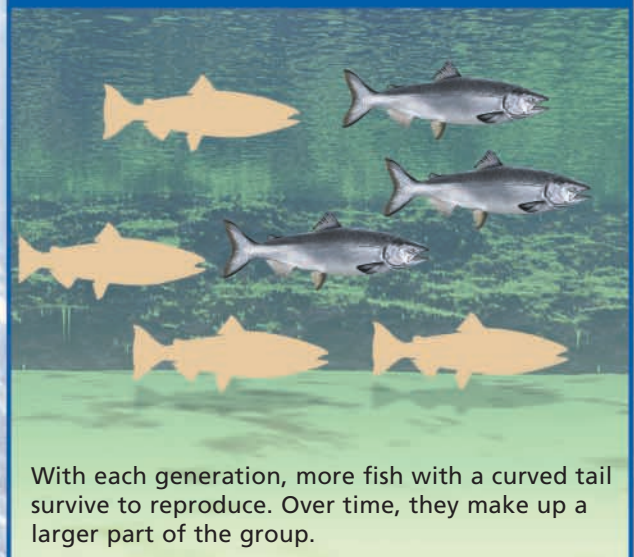
Variation



Adaptation



Selection



How does natural selection occur for an individual salmon?

New species develop from earlier species.

Darwin's personal observations and the work of another scientist, Alfred Wallace, led Darwin to write about this new concept of evolution. In 1859, after more than twenty years of work, Darwin published his ideas in his book *On the Origin of Species*. This work led the way for our modern understanding of how new species arise.

Speciation

Speciation is the evolution of new species from an existing species. Speciation may occur when the environment changes dramatically, or when the environment changes gradually. The Galápagos finch populations Darwin studied showed evidence of speciation.

Isolation

Darwin's trip to the Galápagos Islands showed him an important point about speciation. Many new species had evolved after populations were separated from the mainland and were not able to breed with their mainland relatives. Darwin reasoned that isolation of populations by geographical or other barriers could contribute to the process of speciation. A species of fish called cichlids shows how a physical barrier contributes to speciation.

Speciation

In this African lake, new species of cichlids have evolved.



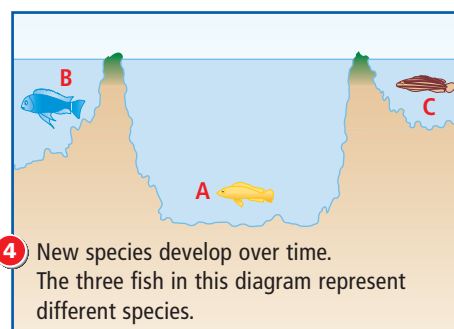
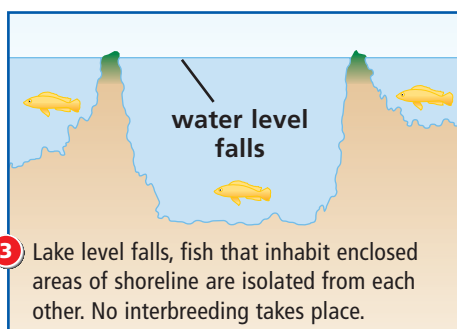
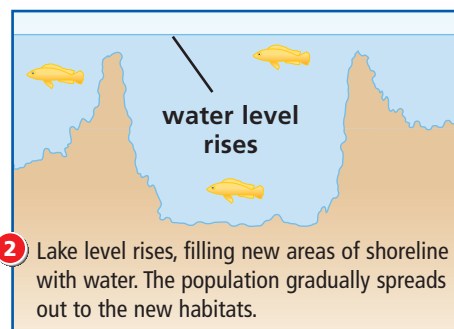
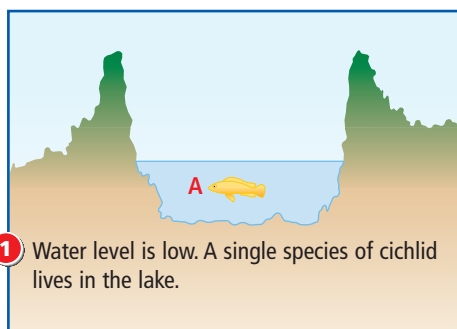
Species A



Species B



Species C



In Lake Tanganyika, one of the largest lakes in the world, there are over 150 species of cichlids. Members of one particular genus, *tropheus*, originally lived along the rocky shore and couldn't cross the open water. The climate and geology of the area caused the lake's water level to rise and fall many times over thousands of years. As the water level changed, a new, rocky habitat was formed, and some populations of cichlids became isolated from each other.

The isolated populations were unable to interact with each other because they couldn't cross open waters. As a result, genetic differences began to add up in these populations. The cichlid populations now represent distinct species. They have developed unique characteristics and cannot breed with each other. See diagram on page 804.

Today scientists understand that isolation is essential to speciation. For a species to separate, two populations must be prevented from reproducing with each other. A geographic boundary like an ocean or mountain range can result in isolation. Two populations of a species can also be isolated if they feed on different things or reproduce at different times of the year.

As the cichlids in Lake Tanganyika show, the mutations in one isolated group may differ from another. Two or more populations may evolve differently from each other. The result is speciation, which has contributed to the biodiversity on Earth.

The Rocky Mountains are an example of a barrier that can isolate populations.



What is a key factor that can lead to speciation?

23.2 Review

KEY CONCEPTS

1. How did Lamarck's ideas differ from Darwin's?
2. What did Darwin observe in the finch populations that supported his idea of natural selection?
3. Explain how isolation helps speciation.

CRITICAL THINKING

4. **Hypothesize** Two species of grasses are separated by a tall mountain range. A third species of grass shares some characteristics with each of the other two species. It inhabits a small valley, surrounded on all sides by mountains. Form a hypothesis for the origin of the third species.

CHALLENGE

5. **Predict** The Arctic hare lives in snow-covered mountains in Canada. The hare is hunted by foxes, wolves, and owls. Which trait is more likely to be inherited by new generations of hares: white fur or black fur?