Launch Lab

Are there variations within your class?
All populations contain variations in some characteristics of their members.
1. Read and complete a lab safety form.
2. Use a meterstick to measure the length from your elbow to the tip of your middle finger in centimeters. Record the measurement in your Science Journal.
3. Add your measurement to the class list.
4. Organize all of the measurements from shortest to longest.
5. Break the data into regular increments, such as 31–35 cm, 36–40 cm, and 41–45 cm. Count the number of measurements within each increment.
6. Construct a bar graph using the data. Label each axis and give your graph a title.

Think About This
1. What are the shortest and longest measurements?
2. How much do the shortest and longest lengths vary from each other?
3. Key Concept Describe how your results provide evidence of variations within your classroom population.

Charles Darwin

How many species of birds can you name? You might think of robins, penguins, or even chickens. Scientists estimate that about 10,000 species of birds live on Earth today. Each bird species has similar characteristics. Each has wings, feathers, and a beak. Scientists hypothesize that all birds evolved from an earlier, or ancestral, population of birdlike organisms. As this population evolved into different species, birds became different sizes and colors. They developed different songs and eating habits, but all retained similar bird characteristics.

How do birds and other species evolve? One scientist who worked to answer this question was Charles Darwin. Darwin was an English naturalist who, in the mid-1800s, developed a theory of how evolution works. A naturalist is a person who studies plants and animals by observing them. Darwin spent many years observing plants and animals in their natural habitats before developing his theory. Recall that a theory is an explanation of the natural world that is well supported by evidence. Darwin was not the first to develop a theory of evolution, but his theory is the one best supported by evidence today.

Key Concept Check Who was Charles Darwin?
Each island in the Galápagos has a different environment. Tortoises look different depending on which island environment they inhabit.

Visual Check What type of vegetation do domed tortoises eat?

Voyage of the Beagle
Darwin served as a naturalist on the HMS Beagle, a survey ship of the British navy. During his voyage around the world, Darwin observed and collected many plants and animals.

The Galápagos Islands
Darwin was especially interested in the organisms he saw on the Galápagos (guh LAH puh gus) Islands. The islands, shown in Figure 6, are located 1,000 km off the South American coast in the Pacific Ocean. Darwin saw that each island had a slightly different environment. Some were dry. Some were more humid. Others had mixed environments.

Tortoises Giant tortoises lived on many of the islands. When a resident told him that the tortoises on each island looked different, as shown in Figure 6, Darwin became curious.

Mockingbirds and Finches Darwin also became curious about the variety of mockingbirds and finches he saw and collected on the islands. Like the tortoises, different types of mockingbirds and finches lived in different island environments. Later, he was surprised to learn that many of these varieties were different enough to be separate species.

Reading Check What made Darwin become curious about the organisms that lived on the Galápagos Islands?
Darwin's Theory

Darwin realized there was a relationship between each species and the food sources of the island it lived on. Look again at Figure 6. You can see that tortoises with long necks lived on islands that had tall cacti. Their long necks enabled them to reach high to eat the cacti. The tortoises with short necks lived on islands that had plenty of short grass.

Common Ancestors

Darwin became convinced that all the tortoise species were related. He thought they all shared a common ancestor. He suspected that a storm had carried a small ancestral tortoise population to one of the islands from South America millions of years before. Eventually, the tortoises spread to the other islands. Their neck lengths and shell shapes changed to match their islands' food sources. How did this happen?

Variations

Darwin knew that individual members of a species exhibit slight differences, or variations. A variation is a slight difference in an inherited trait of individual members of a species. Even though the snail shells in Figure 7 are not all exactly the same, they are all from snails of the same species. You can also see variations in the zebras in the photo at the beginning of this lesson. Variations arise naturally in populations. They occur in the offspring as a result of sexual reproduction. You might recall that variations are caused by random mutations, or changes, in genes. Mutations can lead to changes in phenotype. Recall that an organism's phenotype is all of the observable traits and characteristics of the organism. Genetic changes to phenotype can be passed on to future generations.

Figure 7 The variations among the shells of a species of tree snail occur naturally within the population.

Visual Check
Describe three variations among these snail shells.
**Natural Selection**

Darwin did not know about genes. But he realized that variations were the key to the puzzle of how populations of tortoises and other organisms evolved. Darwin understood that food is a limiting resource, which means that the food in each island environment could not support every tortoise that was born. Tortoises had to compete with each other for food. As the tortoises spread to the various islands, some were born with random variations in neck length. If a variation benefited a tortoise, allowing it to compete for food better than other tortoises, the tortoise lived longer. Because it lived longer, it reproduced more. It passed on its variations to its offspring.

This is Darwin's theory of evolution by natural selection. **Natural selection** is the process by which populations of organisms with variations that help them survive in their environments live longer, compete better, and reproduce more than those that do not have the variations. Natural selection explains how populations change as their environments change. It explains the process by which Galápagos tortoises became matched to their food sources, as illustrated in Figure 8. It also explains the diversity of the Galápagos finches and mockingbirds. Birds with beak variations that help them compete for food live longer and reproduce more.

**Key Concept Check** What role do variations have in the theory of evolution by natural selection?

---

**Figure 8** A beneficial variation in neck length spreads through a tortoise population by natural selection.
Adaptations

Natural selection explains how all species change over time as their environments change. Through natural selection, a helpful variation in one individual can be passed on to future members of a population. As time passes, more variations arise. The accumulation of many similar variations can lead to an adaptation (a'dapt a shun). An adaptation is an inherited trait that increases an organism's chance of surviving and reproducing in its environment. The long neck of certain species of tortoises is an adaptation to an environment with tall cacti.

Key Concept Check How do variations lead to adaptations?

Types of Adaptations

Every species has many adaptations. Scientists classify adaptations into three categories: structural, behavioral, and functional. Structural adaptations involve color, shape, and other physical characteristics. The shape of a tortoise's neck is a structural adaptation. Behavioral adaptations involve the way an organism behaves or acts. Hunting at night and moving in herds are examples of behavioral adaptations. Functional adaptations involve internal body systems that affect biochemistry. A drop in body temperature during hibernation is an example of a functional adaptation. Figure 9 illustrates examples of all three types of adaptations in the desert jackrabbit.

Figure 9 The desert jackrabbit has structural, behavioral, and functional adaptations. These adaptations enable it to survive in its desert environment.

Structural adaptation The jackrabbit's powerful legs help it run fast to escape from predators.

Behavioral adaptation The jackrabbit stays still during the hottest part of the day, helping it conserve energy.

Functional adaptation The blood vessels in the jackrabbit's ears expand to enable the blood to cool before re-entering the body.
Environmental Interactions

Have you ever wanted to be invisible? Many species have evolved adaptations that make them nearly invisible. The seahorse in Figure 10 is the same color and has a texture similar to the coral it is resting on. This is a structural adaptation called camouflage (KAM uh flahj). **Camouflage** is an adaptation that enables a species to blend in with its environment.

Some species have adaptations that draw attention to them. The caterpillar in Figure 10 resembles a snake. Predators see it and are scared away. **The resemblance of one species to another species is mimicry** (MIH mih kree). Camouflage and mimicry are adaptations that help species avoid being eaten. Many other adaptations help species eat. The pelican in Figure 10 has a beak and mouth uniquely adapted to its food source—fish.

**Reading Check** How do camouflage and mimicry differ?

Environments are complex. Species must adapt to an environment's living parts as well as to an environment's nonliving parts. Nonliving things include temperature, water, nutrients in soil, and climate. Deciduous trees shed their leaves due to changes in climate. Camouflage, mimicry, and mouth shape are adaptations mostly to an environment's living parts. An extreme example of two species adapting to each other is shown in Figure 11.

Living and nonliving factors are always changing. Even slight environmental changes affect how species adapt. If a species is unable to adapt, it becomes extinct. The fossil record contains many fossils of species unable to adapt to change.
Artificial Selection

Adaptations provide evidence of how closely Earth's species match their environments. This is exactly what Darwin's theory of evolution by natural selection predicted. Darwin provided many examples of adaptation in *On the Origin of Species*, the book he wrote to explain his theory. Darwin did not write this book until 20 years after he developed his theory. He spent those years collecting more evidence for his theory by studying barnacles, orchids, corals, and earthworms.

Darwin also had a hobby of breeding domestic pigeons. He selectively bred pigeons of different colors and shapes to produce new, fancy varieties. *The breeding of organisms for desired characteristics is called selective breeding.* Like many domestic plants and animals produced from selective breeding, pigeons look different from their ancestors, as shown in Figure 12. Darwin realized that changes caused by selective breeding were much like changes caused by natural selection. Instead of nature selecting variations, humans selected them. Darwin called this process artificial selection.

Artificial selection explains and supports Darwin's theory. As you will read in Lesson 3, other evidence also supports the idea that species evolve from other species.

MiniLab

Who survives?

Camouflage helps organisms blend in. This can help them avoid predators or sneak up on prey. Camouflage helps organisms survive in their environments.

1. Read and complete a lab safety form.
2. Choose an area of your classroom where your moth will rest with open wings during the day.
3. Use scissors, paper, markers, and a ruler to design a moth that measures 2–5 cm in width with open wings and will be camouflaged where it is placed. Write the location where the moth is to be placed. Give the location and your completed moth to your teacher.
4. On the following day, you will have 1 minute to spot as many moths in the room as you can.
5. In your Science Journal, record the location of moths spotted by your team.
6. Find the remaining moths that were not spotted. Observe their appearance.

Analyze and Conclude

1. Compare the appearances and resting places of the moths that were spotted with those that were not spotted.
2. **Key Concept** Explain how camouflage enables an organism to survive in its environment.