2 *Hiding in the Background*

MODELING

In the last activity, you explored how the presence of antibiotics in the environment affects the survival of bacteria depending on their resistance to antibiotics. In this activity, you will use a model to explore how an environment that includes predators affects the survival of individuals of an imaginary species, toothpick worms. You will focus on differences in just one feature, the color of the worms. The versions of a feature, such as color, are called **traits.** Differences in traits are called **variations**. The two possible color traits in worms are green and beige.

GUIDING QUESTION

How does the environment affect an individual's probability of survival and successful reproduction?

Camouflaged animals

MATERIALS

For each group of four students

2 paper bags

50 green toothpicks

50 beige toothpicks

For each student

1 clear plastic bag

1 Student Sheet 2.1, "Worm Populations"

1 piece of graph paper

The Toothpick Worm Model

Imagine that you are a bird that eats small worms. In this activity, toothpicks will represent the worms that you eat. There are two traits for worm color: beige and green. Different color toothpicks represent these two traits.

PROCEDURE

1. Label one of the paper bags "Worms" and the other "Reserve Toothpicks."
2. Each toothpick represents a worm. Count 25 green "worms" and 25 beige "worms," and place them into the paper bag labeled "Worms." This is the initial number of worms in the initial population, also called the *first generation*. These amounts are already marked for you in both tables on Student Sheet 2.1, "Worm Populations."
3. Place the rest of the toothpicks into the bag labeled "Reserve Toothpicks."
4. Shake the "Worms" bag to mix the worms.
5. As directed by your teacher, scatter the worms on the "ground."
6. You are going to play the role of a bird predator that preys upon worms. Your group must "eat" (pick up) 40 worms, so decide how many worms each member of your group will eat. You must pick up the first worms that you see, regardless of the color, and place them in the clear plastic bag, which represents the bird's stomach.

7. Count the total numbers of green and beige worms that survived in the habitat. Record these totals in Row 2 of the table for Generation 1 on Student Sheet 2.1.
8. Each surviving adult worm is reproducing, and each of them has 4 offspring that are identical to the parent. On Student Sheet 2.1, multiply the numbers of green and beige surviving adult worms by 4. For example, if you had 7 green worms still alive, there would be a total of 28 green offspring worms (7 x 4 = 28). Record this number in Row 3.
9. Add Rows 3 and 4 to get the total number of surviving adults and offspring for green worms and beige worms. Record this number in Row 4. This number represents the number of green worms and beige worms that are present in the habitat at the start of the second generation. Copy these numbers into Row 1 of the table for Generation 2.
10. Count out the number of green and beige toothpicks shown in Row 1 for Generation 2, and repeat Steps 6–8, but this time completing the table for Generation 2.
11. Repeat the steps again for Generation 3, the final generation in this simulation.
12. Create a graph showing the results from the start of Generation 1 through the end of Generation 3.

ANALYSIS

1. Look at your results.
   a. Compare the number of green worms to the number of beige worms using a ratio. For example, the ratio of green to beige worms in Generation 1 is 25:25, or 1:1.
   b. Calculate the percentage of green worms and beige worms in each generation.
   c. Describe how the percentage of green and beige worms changed over the three generations.
   d. Did any individual worm change color? Explain.
   e. Why do you think you observed this pattern?

      Hint: A **pattern** is something that happens in a repeated and predictable way. Provide a cause-and-effect explanation for this pattern.

2. Imagine that you performed this simulation for another generation. What do you predict the percentage would be of green and beige in the population of worms? Explain your prediction.
3. Due to a drought, grass begins to dry out and die, leaving only dead grass stalks. What is likely to happen to the percentage of green and beige worms? Explain.
4. Compare and contrast your findings with those from the previous activity, "The Full Course." How are they similar? How are they different?

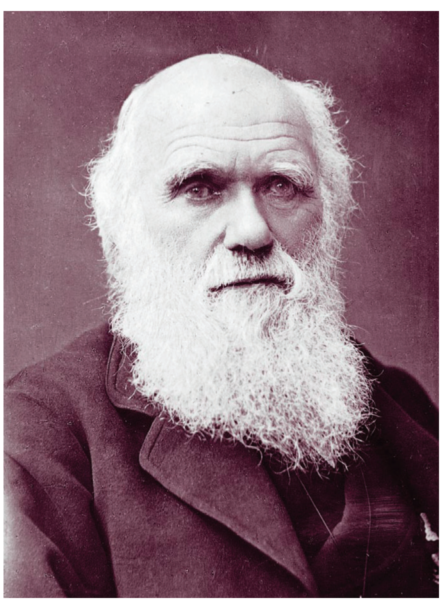
3 A Meeting of Minds

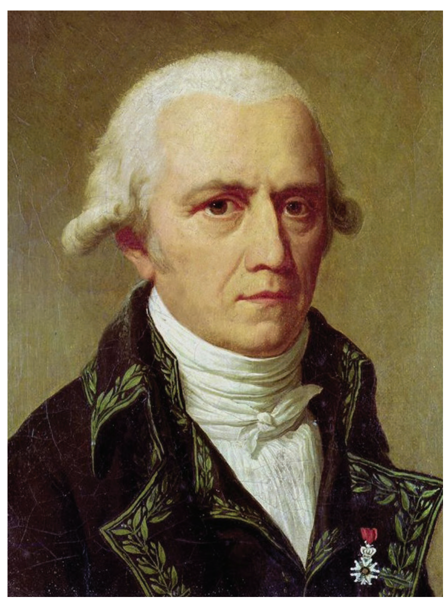
ROLE PLAY

IN THE PREVIOUS activities, you used models to explore how factors in the environment can influence the survival of organisms. In the first model, you explored how chemical substances in the environment affect bacteria. In the second model, you explored how predation affects toothpick worms. In your models, you explored what happens over a few generations. What happens when these environmental factors continue to affect a population of organisms for many more generations? In this activity, you will compare two different explanations for how species change over time.

GUIDING QUESTION

How does natural selection happen?





Charles Darwin (left) and Jean Baptiste Lamarck (right)

MATERIALS

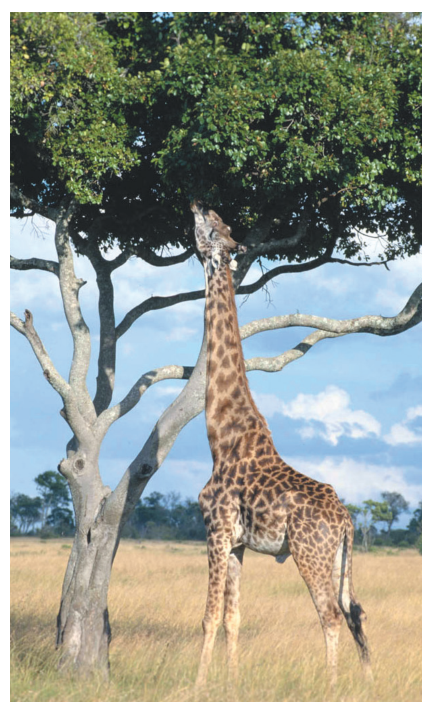
For each student

1 Student Sheet 3.1, "A Meeting of Minds"

PROCEDURE

1. Assign a role for each person in your group. Assuming there are four people in your group, each of you will read one role.
   - Charles Darwin, 19th-century scientist
   - Isabel Matos, science reporter for Station W-EVO
   - Jean-Baptiste Lamarck, 19th-century scientist
   - Wendy Chin, middle school student
2. Read the role play on the next pages aloud. As you read, think about what each character is saying.
3. Mark whether you think scientists today would agree or disagree with the statements on Student Sheet 3.1, "A Meeting of Minds."
4. Discuss the statements with your group.

HOW DO SPECIES CHANGE OVER TIME?



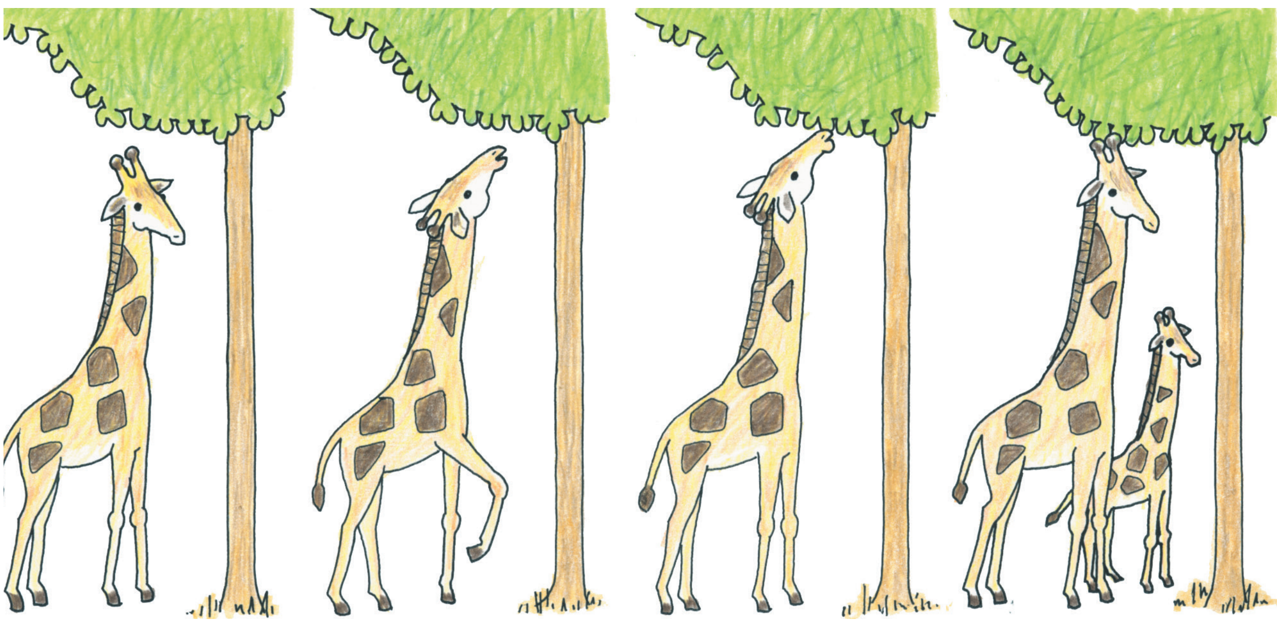
Isabel Matos: In today's episode of "Time Travel News," we have brought together two of the first scientists to publish ideas on how species **evolve**, or change over time. Visiting us from the 19th century are Jean-Baptiste Lamarck and Charles Darwin. Monsieur Lamarck, let's start with you.

Jean-Baptiste Lamarck: I was one of the first to recognize that species change over time. In 1809, I proposed the first theory of how species change over time. Allow me to explain my theory. Let's begin by talking about giraffes. Wendy, why do you think giraffes have such long necks?

Wendy Chin: To reach leaves at the tops of trees, I guess. They have to be able to get food.

Lamarck: Quite right. I began to wonder how giraffes' necks became so long. My theory was that giraffes stretched their necks by reaching for leaves that were higher and higher on the trees. This made their necks longer. Then, when they had babies, their babies had longer necks too. Look—this sketch helps explain my ideas.

Lamarckian Evolution



This is an adult giraffe. *The giraffe reaches for leaves slightly out of reach.* *The use of the neck causes it to lengthen slightly.* *The offspring of the giraffe also has a longer neck.*

Wendy: Shouldn't a theory be based on evidence?

Matos: Mr. Lamarck, did you ever see an adult giraffe grow its neck longer?

Lamarck: Of course not. My idea was that the growth was very small, too small to measure in one generation.

Charles Darwin: I'd like to explain another theory, called *natural selection*. Alfred Russel Wallace and I constructed this theory at about the same time. We also noticed that not all animals of the same type have the same features. Take horses, for instance.

Wendy: Oh, I know what you mean! There are horses of different sizes and colors, but they are all one species and can interbreed.

Darwin: Exactly—and the same is true of giraffes. Have you noticed that animals in the same species look different, or varied? This is important because in the wild, some animals in each species usually die every year. Only animals that survive can give birth to offspring. Now, what feature of a giraffe might help it to survive and live to reproduce?

Lamarck: Its neck, of course! As I said before, it must stretch from being used so vigorously. Giraffes can then pass on the longer necks to their children.

What differences do you observe in these giraffes of the same species?

Matos: But Mr. Lamarck, modern scientists have found no evidence for your hypothesis that parents can pass acquired traits to their offspring. Consider professional wrestlers. They build muscles by lifting weights. But their babies are no stronger than other babies. If these babies want to have muscles like their parents, they have to pump a lot of iron, too!

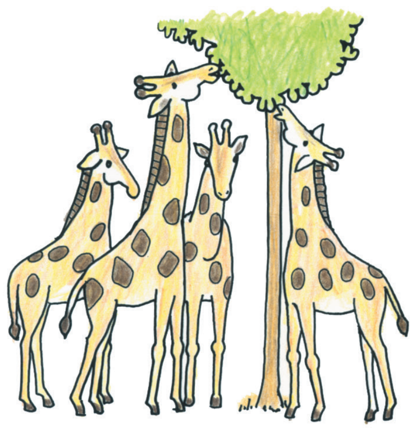
Darwin: But just like human babies, not all giraffes are the same. They have slight differences in all their characteristics, including neck length.

Lamarck: So you're saying any giraffe that happens to have a slightly longer neck can eat leaves that are higher in a tree than a shorter-necked giraffe can and, therefore, is more likely to survive.

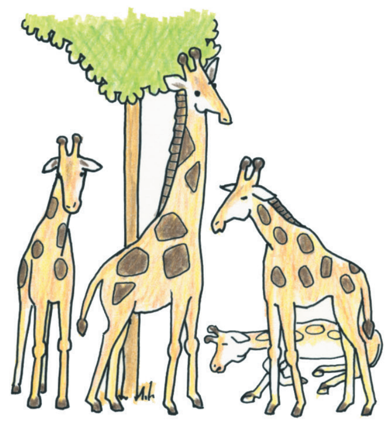
Wendy: So the longer-necked giraffes are more likely to live longer because they can reach more food. If more of these giraffes live longer, they can produce more offspring!

Darwin: That's right. Animals with certain features, such as giraffes with longer necks, are more likely to live to adulthood and have more babies. We call that process *natural selection*. Here's a sketch of how it works:

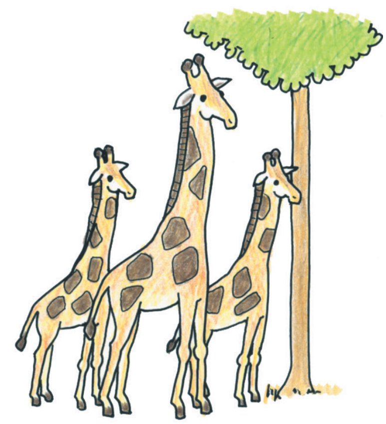
Darwinian Evolution (Natural Selection)



Giraffes with longer necks tend to reach leaves more easily.



Longer-necked giraffes are more likely to eat enough to survive . . .



. . . and reproduce. The offspring inherit their parents' longer necks.

Wendy: But why will the offspring of longer-necked giraffes have longer necks, too?

Matos: Well, tall parents are more likely to have tall children, aren't they? The same is probably true of giraffes.

Darwin: According to my theory, each new generation of giraffes has, on the average, slightly longer necks than the generation before.

Lamarck: But not because they stretched their necks? Only because the longer-necked giraffes were more likely to survive and reproduce?

Wendy: I get it. Individual animals don't change, but over very long periods of time, the population of an entire species does.

Lamarck: But, Mr. Darwin, can your theory of natural selection explain why extinction occurs?

Darwin: I believe so. Consider the mammoth, which became extinct a few thousand years ago. Why didn't mammoths keep changing and continue to survive?

Wendy: There are several theories about that. They became extinct during a time when the global climate was warmer than it had been before. The changing climate may have affected the mammoth's food supply, and human hunters may have contributed to the extinction.

Matos: So a species becomes extinct when it doesn't survive an environmental change. No individuals in the population have the traits necessary to survive.

Darwin: That's all it is. The variation in the population isn't enough to withstand environmental changes. In fact, sooner or later, most species become extinct.

Wendy: Let me get this straight. As time passes, species change. The way this occurs is by natural selection—some individuals in a population happen to be better suited to the environment and they're more likely to survive and reproduce.

Lamarck: As a result, the population as a whole over many generations comes to have the trait, such as a giraffe's long neck, that increases survival. A trait that becomes more common because it increases survival and reproduction is called an **adaptation.**

Matos: Today, we know that we pass on characteristics like longer necks to our offspring through genes. Genes don't change because you exercise your neck.

Darwin: Tell us more about these genes.

Wendy: I learned about genes in school. **Genes** are parts of our cells that we inherit from our parents. They determine our traits, like hair color and eye color.

Lamarck: Fascinating. I would like to learn more about this.

Darwin: Without this modern evidence, I hesitated to publish my theory for years, until Wallace sent me a brief paper containing the same ideas. Within a few years of our publications, our ideas were widely accepted.

Matos: So scientists now understand that **natural selection** is the process that results in the survival and reproductive success of individuals that have inherited traits that are adapted to their current environment. Thank you, Mr. Lamarck and Mr. Darwin. Viewers, I hope you've enjoyed meeting people from our past. Join us next week for a scintillating conversation with Marie Curie, the first woman scientist to receive a Nobel Prize.

ANALYSIS

1. Compare and contrast Lamarck's and Darwin's theories of change over time.
   a. What are the similarities? What are the differences?
   b. Why do scientists find Darwin's theory more convincing?
2. Explain why earthworms are beige or brown and not green
   a. using Darwin's theory of natural selection.
   b. using Lamarck's theory of change.
3. Explain whether Darwin's theory or Lamarck's theory is a better explanation for your results in the previous activity, "Hiding in the Background."

   Hint: Be sure to cite evidence from the activity.