Section 1

Darwin's Theory

Reading Preview

Key Concepts

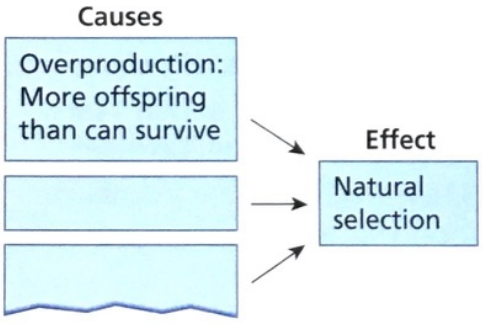
- What important observations did Darwin make on his voyage?
- What hypothesis did Darwin make to explain the differences between similar species?
- How does natural selection lead to evolution?

Key Terms

- species • fossil • adaptation
- evolution • scientific theory
- natural selection • variation

Target Reading Skill

Relating Cause and Effect In a graphic organizer, identify factors that cause natural selection.



Lab zone **Discover Activity**

How Do Living Things Vary?

1. Use a ruler to measure the length and width of 10 sunflower seeds. Record each measurement.
2. Now use a hand lens to carefully examine each seed. Record each seed's shape, color, and number of stripes.

Think It Over

Classifying In what ways are the seeds in your sample different from one another? In what ways are they similar? How could you group the seeds based on their similarities and differences?

In December 1831, the British ship HMS *Beagle* set sail from England on a five-year trip around the world. On board was a 22-year-old named Charles Darwin. Darwin eventually became the ship's naturalist—a person who studies the natural world. His job was to learn as much as he could about the living things he saw on the voyage. Darwin observed plants and animals he had never seen before. He wondered why they were so different from those in England. Darwin's observations led him to develop one of the most important scientific theories of all time: the theory of evolution by natural selection.

FIGURE 1
The Voyage of the *Beagle*
Charles Darwin sailed on the *Beagle* to the Galápagos Islands. He saw many unusual organisms on the islands, such as giant tortoises and the blue-footed booby.
Interpreting Maps *After leaving South America, where did the* Beagle *go?*

Replica of the *Beagle* ▶

Darwin's Observations

As you can see in Figure 1, the *Beagle* made many stops along the coast of South America. From there, the ship traveled to the Galápagos Islands. Darwin observed living things as he traveled. He thought about relationships among those organisms. **Darwin's important observations included the diversity of living things, the remains of ancient organisms, and the characteristics of organisms on the Galápagos Islands.**

Diversity Darwin was amazed by the tremendous diversity of living things that he saw. In Brazil, he saw insects that looked like flowers and ants that marched across the forest floor like huge armies. In Argentina, he saw sloths, animals that moved very slowly and spent much of their time hanging in trees.

Today scientists know that organisms are even more diverse than Darwin could ever have imagined. Scientists have identified more than 1.7 million species of organisms on Earth. A **species** is a group of similar organisms that can mate with each other and produce fertile offspring.

Fossils Darwin saw the fossil bones of animals that had died long ago. A **fossil** is the preserved remains or traces of an organism that lived in the past. Darwin was puzzled by some of the fossils he observed. For example, he saw fossil bones that resembled the bones of living sloths. The fossil bones were much larger than those of the sloths that were alive in Darwin's time. He wondered what had happened to the giant creatures from the past.

Reading Checkpoint What is a fossil?

Discovery CHANNEL SCHOOL

Changes Over Time

Video Preview
Video Field Trip
Video Assessment

▲ Giant tortoise

▲ Blue-footed booby

Galápagos Organisms

In 1835, the *Beagle* reached the Galápagos Islands. Darwin observed many unusual life forms on these small islands, such as giant tortoises, or land turtles. Some of these tortoises could look him in the eye! After returning to England, Darwin thought about the organisms he had seen. He compared Galápagos organisms to organisms that lived elsewhere. He also compared organisms on different islands in the Galápagos group. He was surprised by some of the similarities and differences he saw.

Comparisons to South American Organisms Darwin found many similarities between Galápagos organisms and those in South America. Many of the birds on the islands, including hawks, mockingbirds, and finches, resembled those on the mainland. Many of the plants were similar to plants Darwin had collected on the mainland.

However, there were important differences between the organisms on the islands and those on the mainland. The iguanas on the Galápagos Islands had large claws that allowed them to grip slippery rocks, where they fed on seaweed. The iguanas on the mainland had smaller claws. Smaller claws allowed the mainland iguanas to climb trees, where they ate leaves. You can see these differences in Figure 2.

From his observations, Darwin hypothesized that a small number of different plant and animal species had come to the Galápagos Islands from the mainland. They might have been blown out to sea during a storm or set adrift on a fallen log. Once the plants and animals reached the islands, they reproduced. Eventually, their offspring became different from their mainland relatives.

FIGURE 2
Comparing Iguanas
Iguanas on mainland South America (above) have smaller claws than iguanas on the Galápagos Islands. **Comparing and Contrasting** *In what other ways are the iguanas different?*

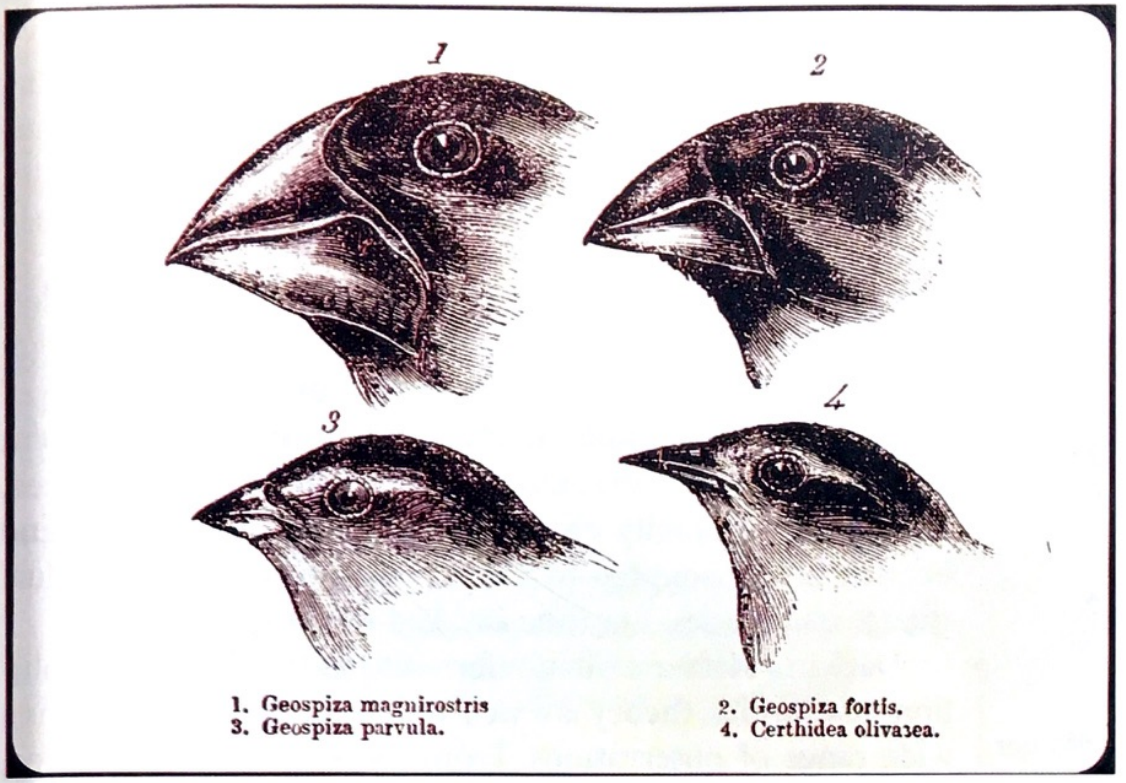


FIGURE 3
Galápagos Finches
Darwin made these drawings of four species of Galápagos finches. The structure of each bird's beak is an adaptation related to the type of food the bird eats. **Comparing and Contrasting** *Identify some specific differences in these finches' beaks.*

Comparisons Among the Islands As he traveled from one Galápagos island to the next, Darwin also noticed many differences among organisms. For example, the tortoises on one island had dome-shaped shells. Those on another island had saddle-shaped shells. A government official in the islands told Darwin that he could tell which island a tortoise came from just by looking at its shell.

Adaptations Like the tortoises, the finches on the Galápagos were noticeably different from one island to the next. The most obvious differences were the varied sizes and shapes of the birds' beaks, as shown in Figure 3. An examination of the different finches showed that each species was well suited to the life it led. Finches that ate insects had narrow, needle-like beaks. Finches that ate seeds had strong, wide beaks.

Beak shape is an example of an **adaptation,** a trait that helps an organism survive and reproduce. The finches' beak structures help in obtaining food. Other adaptations help organisms avoid being eaten. For example, some plants, such as milkweed, are poisonous or have a bad taste. A variety of adaptations aid in reproduction. The bright colors of some flowers attract insects. When an insect lands on a flower, the insect may pick up pollen grains, which produce sperm. The insect then may carry the pollen grains to another flower, enabling fertilization to take place.

Reading Checkpoint **How did the beaks of Galápagos finches differ from one island to another?**

Lab zone Try This Activity

Bird Beak Adaptations

Use this activity to explore adaptations in birds.

1. Scatter a small amount of bird seed on a paper plate. Scatter 20 raisins on the plate to represent insects.
2. Obtain a variety of objects such as tweezers, hair clips, and clothespins. Pick one object to use as a "beak."
3. See how many seeds you can pick up and drop into a cup in 10 seconds.
4. Now see how many "insects" you can pick up and drop into a cup in 10 seconds.
5. Use a different "beak" and repeat Steps 3 and 4.

Inferring What type of beak worked well for seeds? For insects? How are different-shaped beaks useful for eating different foods?

Evolution

After he returned to England, Darwin continued to think about what he had seen during his voyage on the *Beagle*. Darwin spent the next 20 years consulting with other scientists, gathering more information, and thinking through his ideas.

▲ Seattle Slew, great-grandfather of Funny Cide

Darwin's Reasoning Darwin especially wanted to understand the different adaptations of organisms on the Galápagos Islands. **Darwin reasoned that plants or animals that arrived on the Galápagos Islands faced conditions that were different from those on the mainland. Perhaps, Darwin hypothesized, the species gradually changed over many generations and became better adapted to the new conditions.** The gradual change in a species over time is called **evolution.**

Darwin's ideas are often referred to as the theory of evolution. A **scientific theory** is a well-tested concept that explains a wide range of observations. From the evidence he collected, Darwin concluded that organisms on the Galápagos Islands had changed over time. However, Darwin did not know how the changes had happened.

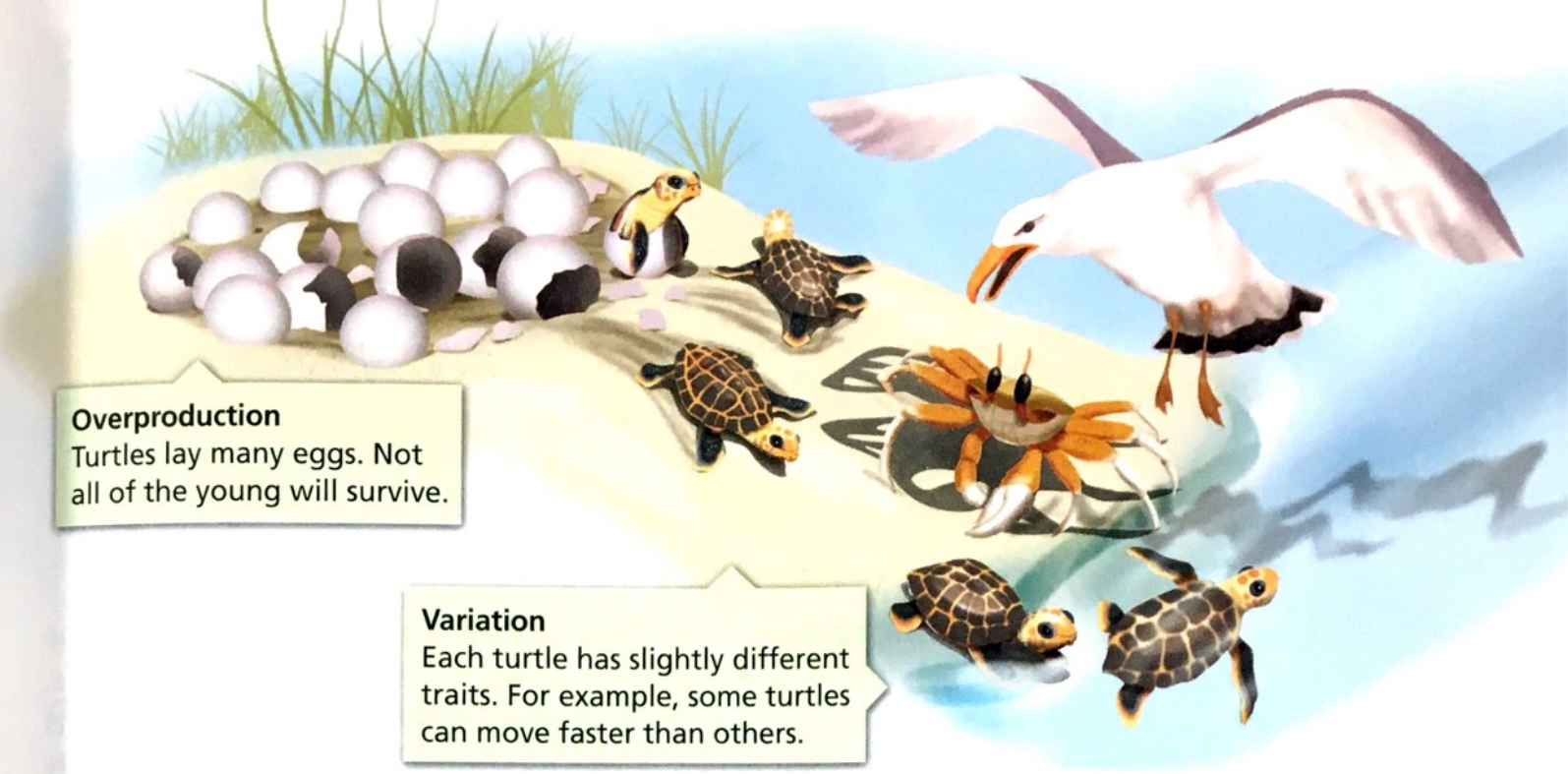
Distorted Humor, father of Funny Cide ▲

Selective Breeding Darwin studied other examples of changes in living things to help him understand how evolution might occur. One example that Darwin studied was the offspring of animals produced by selective breeding. English farmers in Darwin's time used selective breeding to produce sheep with fine wool. Darwin himself had bred pigeons with large, fan-shaped tails. By repeatedly allowing only those pigeons with many tail feathers to mate, breeders had produced pigeons with two or three times the usual number of tail feathers. Darwin thought that a process similar to selective breeding might happen in nature. But he wondered what process selected certain traits.

Reading Checkpoint **What is a scientific theory?**

Funny Cide ▶

FIGURE 4
Selective Breeding
Race horses are selectively bred to obtain the trait of speed. Funny Cide's father, Distorted Humor, and great-grandfather, Seattle Slew, were known for their speed.



Natural Selection

In 1858, Darwin and another British biologist, Alfred Russel Wallace, each proposed an explanation for how evolution could occur in nature. The next year, Darwin described this mechanism in a book entitled *The Origin of Species*. In his book, Darwin proposed that evolution occurs by means of natural selection. **Natural selection** is the process by which individuals that are better adapted to their environment are more likely to survive and reproduce than other members of the same species. Darwin identified factors that affect the process of natural selection: overproduction, competition, and variations. Figure 5 and Figure 6 show how natural selection might happen in a group of turtles.

FIGURE 5
Overproduction and Variation
Like actual sea turtles, the turtles in this illustration produce many more offspring than will survive. Some turtles are better adapted than others to survive in their environment.
Relating Cause and Effect *What adaptations might help young sea turtles survive?*

Overproduction Darwin knew that most species produce far more offspring than can possibly survive. In many species, so many offspring are produced that there are not enough resources—food, water, and living space—for all of them. Many female insects, for example, lay thousands of eggs. If all newly hatched insects survived, they would soon crowd out all other plants and animals. Darwin knew that this doesn't happen. Why not?

Variations As you learned in your study of genetics, members of a species differ from one another in many of their traits. Any difference between individuals of the same species is called a **variation.** For example, certain insects may be able to eat foods that other insects of their species avoid. The color of a few insects may be different from that of most other insects in their species.

Lab zone Skills Activity

Making Models

Scatter 15 black buttons and 15 white buttons on a sheet of white paper. Have a partner time you to see how many buttons you can pick up in 10 seconds. Pick up the buttons one at a time. Did you collect more buttons of one color than the other? Why? How can a variation such as color affect the process of natural selection?

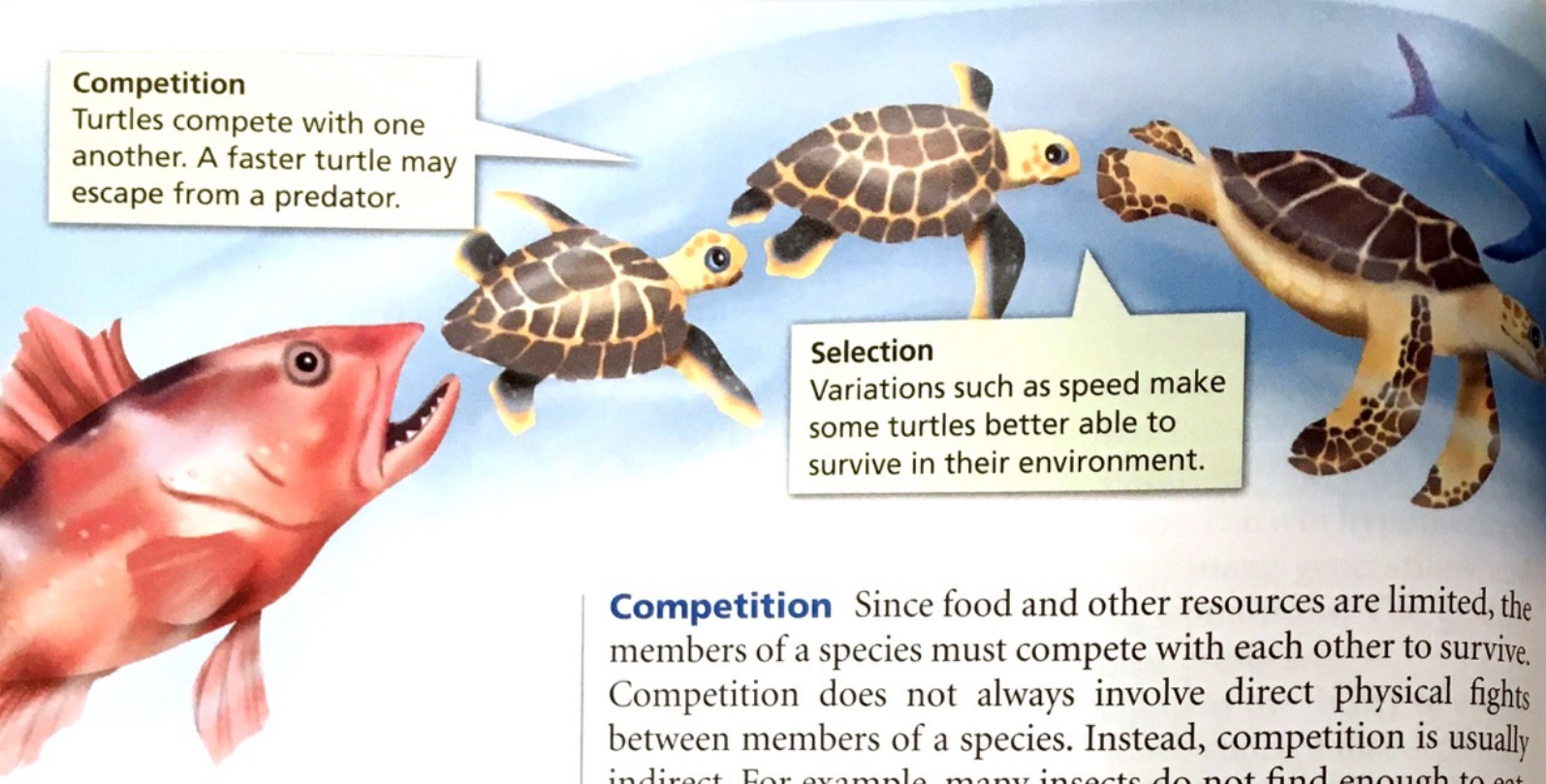


FIGURE 6
Competition and Selection
Variations among turtles make some of them better able to survive. Turtles that survive to become adults will be able to reproduce.
Applying Concepts *What are some variations that sea turtles might exhibit?*

Competition Since food and other resources are limited, the members of a species must compete with each other to survive. Competition does not always involve direct physical fights between members of a species. Instead, competition is usually indirect. For example, many insects do not find enough to eat. Others are caught by predators. Only a few insects will survive.

Selection Darwin observed that some variations make individuals better adapted to their environment. Those individuals are more likely to survive and reproduce. Their offspring may inherit the helpful characteristic. The offspring, in turn, will be more likely to survive and reproduce, and thus pass on the characteristic to their offspring. After many generations, more members of the species will have the helpful characteristic.

In effect, the environment has "selected" organisms with helpful traits to become parents of the next generation. **Darwin proposed that, over a long time, natural selection can lead to change. Helpful variations may gradually accumulate in a species, while unfavorable ones may disappear.**

Environmental Change A change in the environment can affect an organism's ability to survive. The environmental change can therefore lead to selection. For example, monkey flowers are a type of plant. Most monkey flowers cannot grow in soil that has a high concentration of copper. However, because of genetic variation, some varieties of monkey flower now grow near copper mines, in spite of the copper in the soil.

Here is how natural selection might have resulted in monkey flowers that can grow in copper-contaminated soil. When the soil around a mine first became contaminated, a small number of monkey-flower plants may have been able to survive in the high level of copper. These plants grew and reproduced. After many generations, most of the seeds that sprouted in the soil produced monkey flowers that could withstand the copper.

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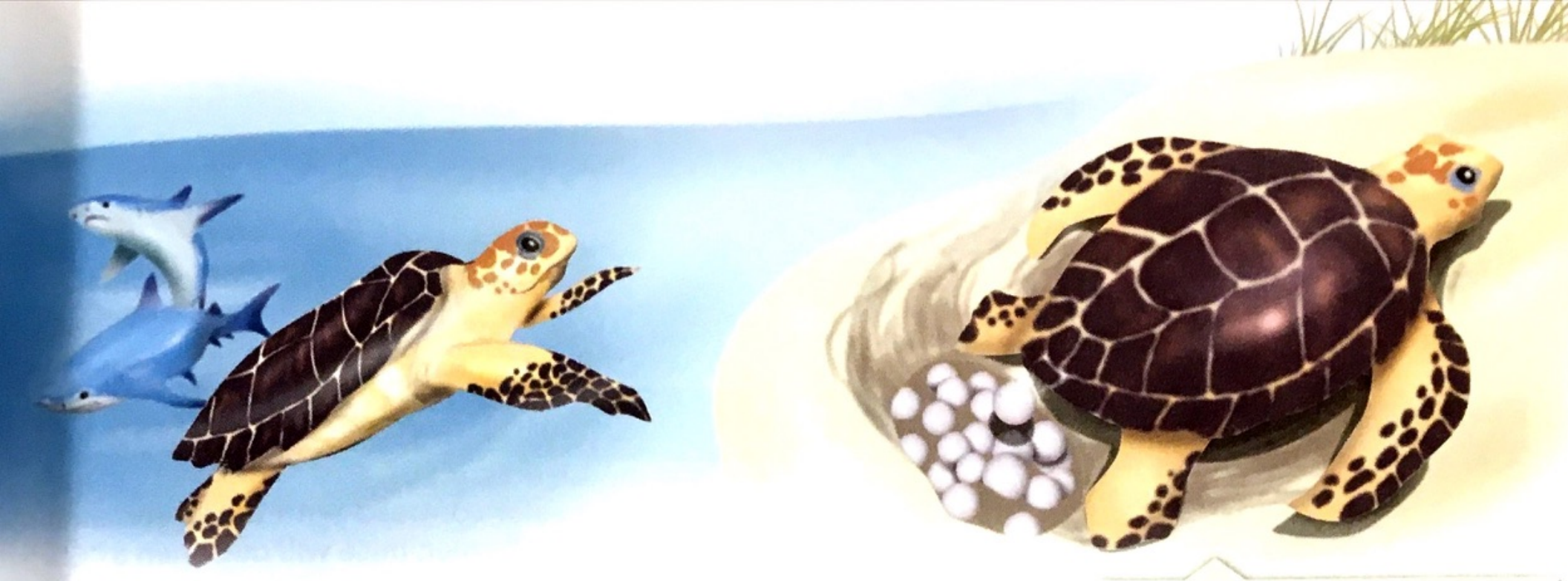

Survival and Reproduction Only a few turtles survive long enough to reproduce. The offspring may inherit the favorable traits of the parents.

Genes and Natural Selection Without variations, all the members of a species would have the same traits. Natural selection would not occur because all individuals would have an equal chance of surviving and reproducing. But where do variations come from? How are they passed on from parents to offspring?

Darwin could not explain what caused variations or how they were passed on. As scientists later learned, variations can result from mutation and the shuffling of alleles during meiosis. Genes are passed from parents to their offspring. Because of this, only traits that are inherited, or controlled by genes, can be acted upon by natural selection.