

1.2

Unifying Themes of Biology

KEY CONCEPT Unifying themes connect concepts from many fields of biology.

▶ MAIN IDEAS

- All levels of life have systems of related parts.
- Structure and function are related in biology.
- Organisms must maintain homeostasis to survive in diverse environments.
- Evolution explains the unity and diversity of life.

VOCABULARY

- system**, p. 7
- ecosystem**, p. 7
- homeostasis**, p. 9
- evolution**, p. 10
- adaptation**, p. 10



REVIEW AT
CLASSZONE.COM

Connect What do you think about when you hear the term *theme*? Maybe you think about the music at the start of your favorite TV show. Maybe you think about the colors and organization of a computer desktop. In both cases, that theme shows up over and over again. In biology, you will see something similar. That is, some concepts come up time after time, even in topics that might seem to be completely unrelated. Understanding these themes, or concepts, can help you to connect the different areas of biology.

▶ MAIN IDEA

All levels of life have systems of related parts.

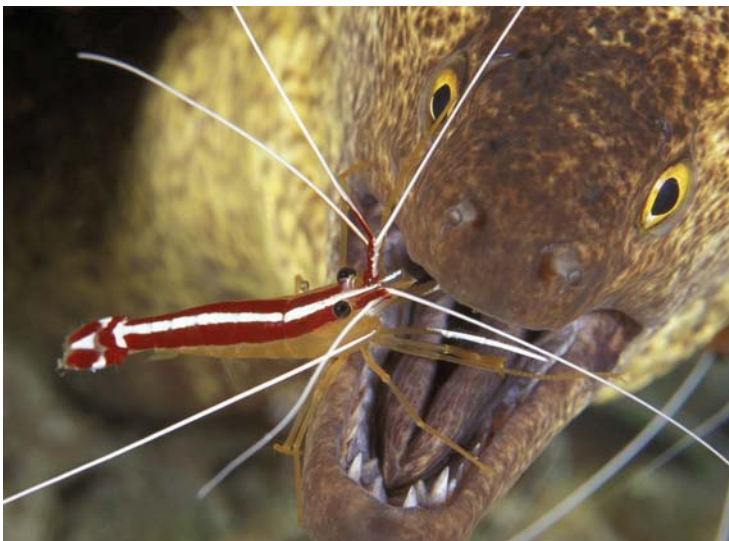
Think about the separate parts of a car—tires, engine, seats, and so on. Even if you have a complete set of car parts, you might not have a functioning car. Only when all of the parts that make up a car are put together in the correct way do you have a working car. A car is a system. A **system** is an organized group of related parts that interact to form a whole. Like any other system, a car's characteristics come from the arrangement and interaction of its parts.

Systems exist on all scales in biology, from molecules that cannot be seen, to cells that can be seen only with a microscope, to the entire biosphere. In just one heart muscle cell, for example, many chemicals and processes interact in a

precise way so that the cell has energy to do its work. Moving up a level, heart muscle, valves, arteries, and veins help form a system in your body—the circulatory system.

Two organisms that interact can also be a system, as you can see in **FIGURE 1.4**. On a larger scale, you are a part of a biological system—an ecosystem—that has living and nonliving parts. An **ecosystem** is a physical environment with different species that interact with one another and with nonliving things. When you hear the term *ecosystem*, you might think about a large region, such as a desert, a coral reef, or a forest. But an ecosystem can also be a very small area, such as an individual tree.

FIGURE 1.4 The moray eel and the cleaner shrimp are parts of a system in which both organisms benefit. The shrimp cleans the eel's mouth and gets food and protection in return.



Often, different biologists study different systems. For example, a person studying DNA might focus on very specific chemical interactions that take place in a cell. A person studying behavior in birds might focus on predator-prey relationships in an ecosystem. However, more and more biologists are working across different system levels. For example, some scientists study how chemicals in the brain affect social interactions.

Connect Describe how your biology class could be considered a system.

▶ MAIN IDEA

Structure and function are related in biology.

Think about a car again. In a car, different parts have different structures. The structure of a car part gives the part a specific function. For example, a tire's function is directly related to its structure. No other part of the car can perform that function. Structure and function are also related in living things. What something does in an organism is directly related to its shape or form. For example, when you eat, you probably bite into food with your sharp front teeth. Then you probably chew it mostly with your grinding molars. All of your teeth help you eat, but different types of teeth have different functions.

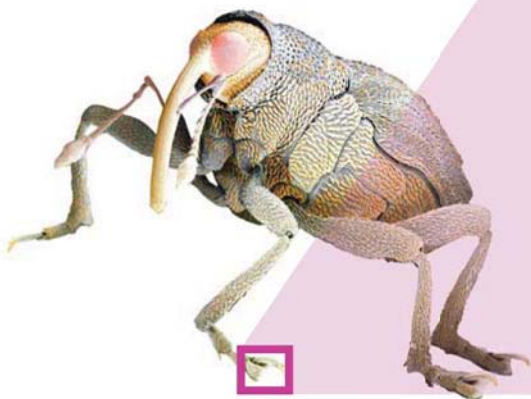
Structure and function are related at the level of chemicals in cells. For example, membrane channels and enzymes are both proteins, but they have very different structures and functions. A channel is a protein molecule that extends through the membrane, or outer layer, of a cell. It has a structure like a tube that allows specific chemicals to pass into and out of a cell. Enzymes are protein molecules that make chemical processes possible in living things. These proteins have shapes that allow them to attach to only certain chemicals and then cause the chemicals to react with each other.

Different types of cells also have different functions that depend on their specialized structures. For example, cells in your brain process information. They have many branches that receive information from other cells. They also have long extensions that allow them to send messages to other cells. Red blood cells are very different. They are much smaller, disk-shaped, and are

Connecting CONCEPTS

Biochemistry Proteins are a type of molecule found in all living things. Proteins have many different functions, which you will read about in **Chapter 2**.

FIGURE 1.5 The snout beetle (below) has specialized prongs and pads on its tarsi (right) that allow it to easily walk on both smooth and rough surfaces. (colored SEMs; magnifications: beetle 20×; tarsus 100×)



specialized to carry oxygen. Their structure allows them to fit through even the smallest blood vessels to deliver oxygen throughout your body. Of course, a cell from your brain cannot take the place of one of your red blood cells.

Structure and function are also related on the level of the organism. For example, your foot structure allows you to walk easily on rough, fairly level surfaces. Walking on a surface such as ice is more difficult, and walking up a wall is impossible for you. The beetle in **FIGURE 1.5** is different. Its tarsi, or “feet,” have sharp prongs that can grip smooth or vertical surfaces, as well as soft pads for walking on rough surfaces. The beetle’s tarsus has a different structure and function than your foot has, but both are specialized for walking.

Infer Do you think heart muscle has the same structure as arm muscle? Explain.

▶ MAIN IDEA

Organisms must maintain homeostasis to survive in diverse environments.

Temperature and other environmental conditions are always changing, but the conditions inside organisms usually stay quite stable. How does the polar bear in **FIGURE 1.6** live in the arctic? How can people be outside when the temperature is below freezing, but still have a stable body temperature around 37°C (98.6°F)? Why do you shiver when you are cold, sweat when you are hot, and feel thirsty when you need water?

Homeostasis (HOH-mee-oh-STAY-sihs) is the maintenance of constant internal conditions in an organism. Homeostasis is important because cells function best within a limited range of conditions. Temperature, blood sugar, acidity, and other conditions must be controlled. Breakdowns in homeostasis are often life-threatening.

Homeostasis is usually maintained through a process called negative feedback. In negative feedback, a change in a system causes a response that tends to return that system to its original state. For example, think about how a car’s cruise control keeps a car moving at a constant set speed. A cruise control system has sensors that monitor the car’s speed and then send that information to a computer. If the car begins to go faster than the set speed, the computer tells the car to slow down. If the car slows below the set speed, the computer tells the car to speed up. Similarly, if your body temperature drops below normal, systems in your body act to return your temperature to normal. Your muscles cause you to shiver, and blood vessels near your skin’s surface constrict. If your body temperature rises above normal, different responses cool your body.

Behavior is also involved in homeostasis. For example, animals regulate their temperature through behavior. If you feel cold, you may put on a jacket. Reptiles sit on a warm rock in sunlight if they get too cold, and they move into shade if they get too warm.



FIGURE 1.6 The polar bear can maintain homeostasis in very cold climates. Its hollow hair is one adaptation that helps the bear retain its body heat. (SEM; magnification 450×)

Summarize What is homeostasis, and why is it important?

▶ MAIN IDEA

Evolution explains the unity and diversity of life.

Connecting CONCEPTS

Evolution The processes of evolution, natural selection, and adaptation are described in more detail in Unit 4.

Evolution is the change in living things over time. More specifically, evolution is a change in the genetic makeup of a subgroup, or population, of a species. The concept of evolution links observations from all levels of biology, from cells to the biosphere. A wide range of scientific evidence, including the fossil record and genetic comparisons of species, show that evolution is continuing today.

Adaptation

One way evolution occurs is through natural selection of adaptations. In natural selection, a genetic, or inherited, trait helps some individuals of a species survive and reproduce more successfully than other individuals in a particular environment. An inherited trait that gives an advantage to individual organisms and is passed on to future generations is an **adaptation**. Over time, the makeup of a population changes because more individuals have the adaptation. Two different populations of the same species might have different adaptations in different environments. The two populations may continue to evolve to the point at which they are different species.

Consider the orchid and the thorn bug in **FIGURE 1.7**. Both organisms have adapted in ways that make them resemble other organisms. The orchid that looks like an insect lures other insects to it. The insects that are attracted to the orchid can pollinate the flower, helping the orchid to reproduce. The thorn bug's appearance is an adaptation that makes predators less likely to see and eat it.

FIGURE 1.7 Through evolution, some orchids (left) have flowers that look like insects and some insects, such as the thorn bug (right), look like parts of plants.



This adaptation allows the thorn bug to survive and reproduce. In different environments, however, you would find other orchid and insect species that have different adaptations.

Adaptation in evolution is different from the common meaning of adaptation. For example, if you say that you are adapting to a new classroom or to a new town, you are not talking about evolution. Instead, you are talking about consciously getting used to something new. Evolutionary adaptations are changes in a species that occur over many generations due to environmental pressures, not through choices made by organisms. Evolution is simply a long-term response to the environment. The process does not necessarily lead to more complex organisms, and it does not have any special end point. Evolution continues today, and it will continue as long as life exists on Earth.

Unity and Diversity

Evolution is a unifying theme of biology because it accounts for both the diversity and the similarities, or the unity, of life. As you study biology, you will see time after time that organisms are related to one another. When you read about cells in Unit 2 and genetics in Unit 3, you will see that all organisms have similar cell structures and chemical processes. These shared characteristics result from a common evolutionary descent.

Humans and bacteria have much more in common than you may think. Both human and bacterial genetics are based on the same molecules—DNA and RNA. Both human and bacterial cells rely upon the same sources of energy, and they have similar cell structures. Both human and bacterial cells have membranes made mostly of fats that protect the inside of the cell from the environment outside the cell.

Now think about the vast number of different types of organisms. All of the species now alive are the result of billions of years of evolution and adaptation to the environment. How? Natural selection of genetic traits can lead to the evolution of a new species. In the end, this genetic diversity is responsible for the diversity of life on Earth.

Analyze How does evolution lead to both the diversity and the unity of life?

1.2 ASSESSMENT



REVIEWING MAIN IDEAS

1. Describe a biological **system**.
2. Give an example of how structure is related to function in living things.
3. Why is **homeostasis** essential for living things?
4. What is the relationship between **adaptation** and natural selection?

CRITICAL THINKING

5. **Analyze** How are structure and function related to adaptation?
6. **Apply** How is the process of natural selection involved in **evolution**?

Connecting CONCEPTS

7. **Cells** Do you think homeostasis is necessary at the level of a single cell? Explain.