# 24.1 Levels of Organization

**KEY CONCEPT** **The human body has five levels of organization.**

**MAIN IDEAS**

- Specialized cells develop from a single zygote.
- Specialized cells function together in tissues, organs, organ systems, and the whole organism.

**VOCABULARY**

determination
cell differentiation
tissue
organ
organ system

## *Connect to Your World*

Climbing a wall of ice requires careful interaction among all parts of the body. You probably know that the brain and muscles work together to coordinate the climber's movements. The heart and lungs also have to work together to help provide energy for the climb. Yet every human body starts out as a single cell, a fertilized zygote. How does a single cell give rise to all the different types of cells, tissues, and organs in the human body? Further, how do such different parts coordinate their activities to keep the body functioning?

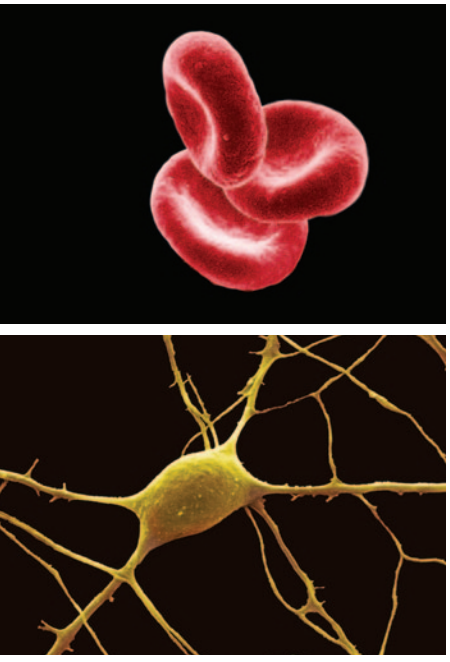


**FIGURE 1.1** The disk-shaped red blood cells (top) carry oxygen to all parts of the body. The neuron (bottom), through its extensions, receives and transmits messages from and to other neurons. (colored SEMs; magnifications: blood cells 2800×; neuron about 1600×)



**MAIN IDEA**

## Specialized cells develop from a single zygote.

If you were to watch an emergency medical team in action, you would quickly notice that each person has a special job. One keeps in radio contact with the main hospital. Another monitors the patient's vital signs. Still others perform life-saving procedures. All emergency teams are made up of people, but each person within the group has a different job.

Likewise, multicellular organisms are made up of cells, but different cells in the organism have different functions. Take a moment to study the images of the blood cells and nerve cells, or neurons, in **FIGURE 1.1.** You will notice that the red blood cells are round with a concave center. This structure gives them more surface area to help deliver oxygen to all parts of the body. In contrast, neurons develop extensions that transmit and receive messages from other neurons.

Humans, like almost all multicellular organisms, are collections of specialized cells that work together. These cells arise from a single cell, the zygote, which is formed by the union of an egg and sperm. The zygote divides and differentiates into more than 200 different types of human cells. These cells allow you to do everything from lifting a glass, to learning people's names, to maintaining your body temperature on a cold day. Cell specialization involves two main steps: determination and differentiation.

### Determination

The cells produced during the first few divisions of the zygote are known as embryonic stem cells. These cells have the potential to become any type of specialized cell in the body. Within a few weeks, however, a process called **determination** occurs, in which most stem cells become committed to develop

into only one type of cell. For instance, a stem cell might become a cardiac muscle cell or a spinal neuron. These committed cells still retain all of the genetic information needed to build an entire organism. However, during determination, they lose their ability to express some of this information.

Once a cell is committed to becoming a specialized cell, it will develop into only that type of cell. For instance, a cell that will become a neuron can only be a neuron, even if it is transplanted into another part of the body. During normal development, determination cannot be reversed.

## Differentiation

**Cell differentiation** is the process by which committed cells acquire the structures and functions of highly specialized cells. Cell differentiation occurs because specific genes in each cell are turned on and off in a complex, regulated pattern. The different structures of these specialized cells, such as those shown in **FIGURE 1.2**, allow them to perform specific functions within the body.

The specialization enabled by differentiation is what allows different types of cells to have different functions. The function of muscle cells, for example, is to produce movement by contracting and relaxing. However, skeletal muscle and smooth muscle cells have different structures. Skeletal muscle cells align in bands of orderly rows and contain many nuclei. They are responsible for nearly all voluntary muscle movements, such as lifting your foot to kick a ball. In contrast, smooth muscle cells are shorter and have only one nucleus. They perform involuntary movements, such as raising the hairs on your arm.

Other cells have even more specialized structures and functions. Sperm cells, for instance, develop whiplike tails that enable them to swim. Cells lining the gut are elongated and tightly packed to provide more surface area for the absorption of nutrients.

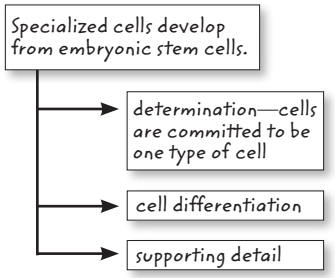
Not all cells continue to develop into specialized cells. The process of programmed cell death, called apoptosis (AP-uhp-TOH-sihs), is also a normal part of development. For example, when your hands first formed, your fingers resembled a mitten. The death of cells between the fingers allowed individual fingers to develop.

**Analyze** **Why do multicellular organisms need specialized cells?**

### READING TOOLBOX

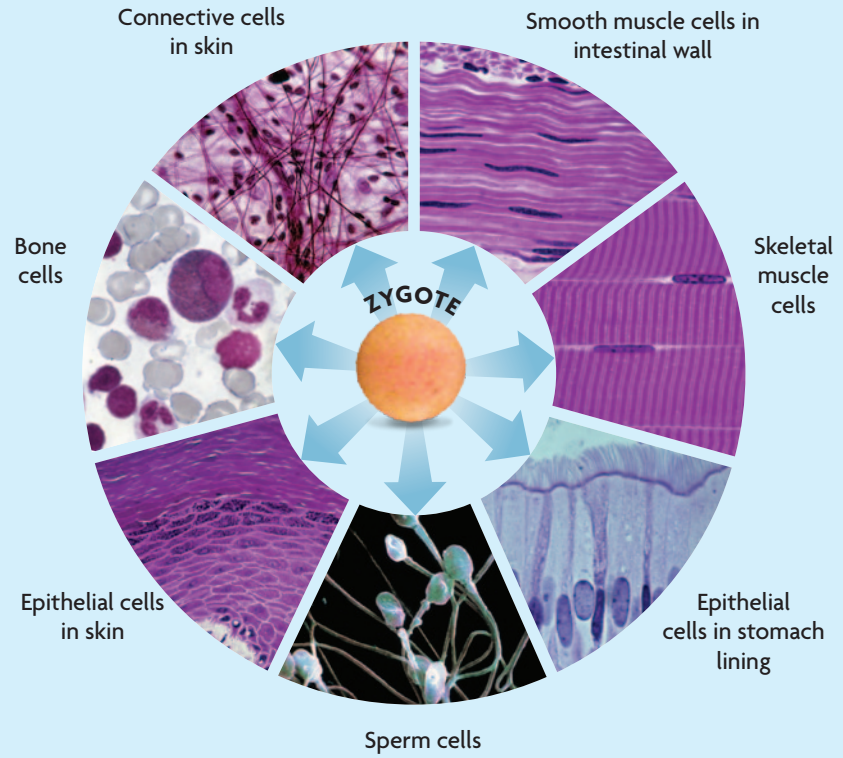
**TAKING NOTES**

Use a supporting main ideas strategy to take notes about processes such as cell specialization.




### FIGURE 1.2 Cell Differentiation

**Cells develop specialized structures and functions during differentiation.**




**Contrast** **How do the structures of sperm cells and epithelial cells in the stomach differ?**