Characteristics of Life

2

2.0 CHAPTER PREVIEW

In this chapter we will discuss:

- The meaning of "organism."
- The properties that all living things share.
- The common things that almost all organisms on earth require to live.

2.1 OVERVIEW

It may seem silly, but when studying life science, one must know which things are alive and which things are not. You can often tell what is alive and what is not by looking at the object. We use the term "**organism**" to refer to anything that is living. You know that a rock is not alive, so it's not an organism, but a tree, a tiger, or a robin is alive, so they are organisms. But what about yeast that makes bread rise (it is an organism) and viruses (they are not organisms)? What about the structure in Figure 2.1.1? To study "life," one must know what is and is not alive. All organisms share common properties whether they are single cell organisms, such as bacteria and yeasts, or multicellular organisms, such as trees and human beings. Let's dive in and learn what they are!

Figure 2.1.1

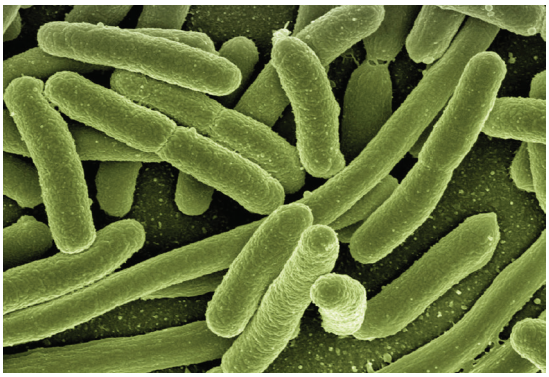
Is it Alive?
It is usually easy to tell if something is alive—if it's an organism—just by looking at it, and we can also often tell by looking at a dead organism that it was once alive. But with some organisms, it is almost impossible to know if they are living things just by looking at them. Coral is one of those organisms. It looks (and feels) like a rock, but it's not; it's a living thing! Coral is an animal that lives in the ocean. Because of organisms like coral, life scientists outline the common properties that all living things—all organisms—have.

2.2 PROPERTIES OF LIFE: CELLS

All life forms are made up of one or more cells; therefore, the cell is the basic functional unit of all of life. Some organisms are made up of only one cell and are called **unicellular** (or single cell) organisms. Almost all unicellular organisms are too small to be seen unless they are viewed with a microscope. Bacteria are the most numerous organisms on earth and are unicellular. Other organisms are made up of many cells and are called **multicellular** organisms. Almost all multicellular organisms are large enough to be seen with the naked eye. A human being is made up of about 37 trillion cells (that is thirty-seven thousand billion!). Larger organisms, such as the sperm whale, are made of quadrillions of cells (that's thousands of trillions!). We will discuss the structure and function of a cell in a couple of chapters.

Figure 2.2.1

Basic Cell Graphic and a Bacterial Cell
The cells on the left are bacteria. They are enlarged about 10,000x with a SEM. All bacteria are unicellular organisms. This means that each cell is an individual, functioning organism. There are more bacteria living in your mouth than the number of people who have ever inhabited the earth! The picture on the right is a sample of blood from a multicellular organism (human), as seen through a light microscope, enlarged about 1,000x. Blood is made up of a watery substance in which cells are suspended. The smaller cells are red blood cells that carry oxygen to our tissues and organs. The larger cell is a white blood cell called a neutrophil. It fights infections caused by bacteria. All multicellular organisms are made up of many individual cells, which function together for the good of the organism.



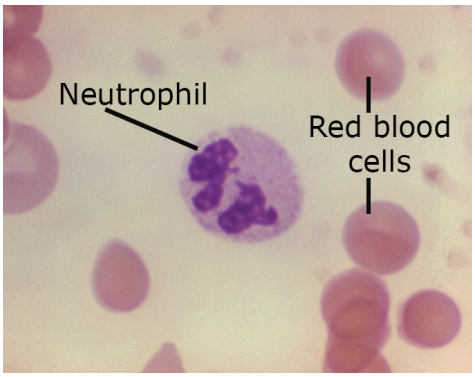


Figure 2.2.2

Giardia lamblia
SEM view of a unicellular organism called *Giardia lamblia*. It infects hundreds of millions of people's intestines around the world and causes severe diarrhea.

FIGURE 2.2.3

Multicellularity
All the organisms that you can see here—grass, deer, trees and bushes—are multicellular, each composed of millions to trillions of cells, all functioning together for the good of the organism.

2.3 PROPERTIES OF LIFE: DEOXYRIBONUCLEIC ACID (DNA)

Whether uni- or multicellular, all life forms contain **DNA**, or **deoxyribonucleic acid**. DNA is a complex molecule that carries the information for the development of every characteristic of an organism. It is in every cell of every living organism and is passed from parent to offspring, so the offspring has the information needed to function properly. DNA contains genetic information, and **genetics** is the study of the passage of traits from parents to offspring. A short segment of DNA that has the information for the development of one characteristic is called a **gene**; therefore, when DNA is passed from parent to offspring, genes are passed from parent to offspring. The parental passage of genes and traits is called **inheritance** or heredity.

Practically, this means DNA contains all the information that causes an organism to be that organism. DNA holds the information for a Guernsey cow to grow into and function like a Guernsey cow and a fire maple tree to grow into and function like a fire maple tree. Any organism's characteristic that you can think of is controlled by its DNA. A Guernsey cow looks the way it does in terms of head shape, coloring, hoof size, tail length, etc., because these traits developed based on the information contained in its DNA.

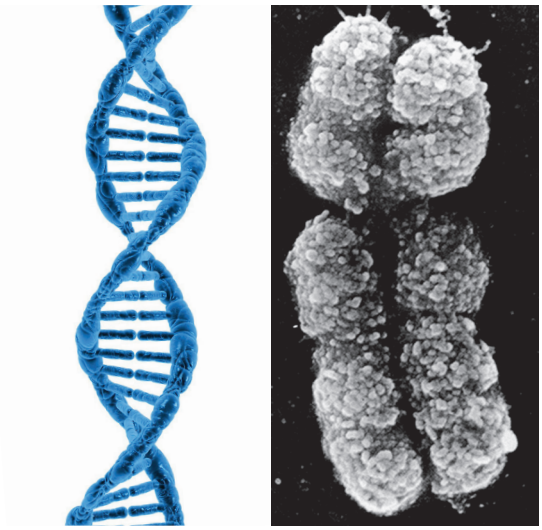


Figure 2.3.1

DNA
DNA is called "the blueprint of life" because it holds the information that determines everything about an organism. Hair color, height, how fast you digest your food, how long you sleep, and millions of other characteristics of every organism on earth are all controlled by DNA. The graphic on the left reveals the structure of a molecule of DNA (which we'll learn more about later). It took researchers many years to determine this structure. The picture on the right is what an actual DNA molecule looks like when it is inside a cell that's about to divide into two cells. DNA in this form is called a chromosome. DNA is like a slinky. Sometimes the DNA is spread out like a slinky when you stretch it out as far as it can go, and other times it's wound tightly, like a slinky when it is just sitting there.

Figure 2.3.2

DNA Controls Traits
Every trait, or characteristic, of an organism is controlled by the information contained in DNA. The striped coloration of the zebra is controlled by DNA, as is the lighter-looking zebra's coloration. The reason the two zebras look different is that their DNA contains slightly different genetic information. The lighter zebra's genes hold information that instructed light brown stripes instead of the normal black and white stripes the other zebra's genes produced. The pansy flower (middle) develops on the pansy plant because the information contained in its DNA directs the flower to grow and look the way it does. DNA also causes the flower to grow to a certain size and to have a certain coloration pattern. Why does a pansy flower look different than a rose? Because the DNA of a pansy plant is different from the DNA of a rose plant (right). The information contained in the pansy's genes causes the flower to grow to look like a pansy flower, and the information contained in the rose DNA causes the flower to grow to look like a rose.

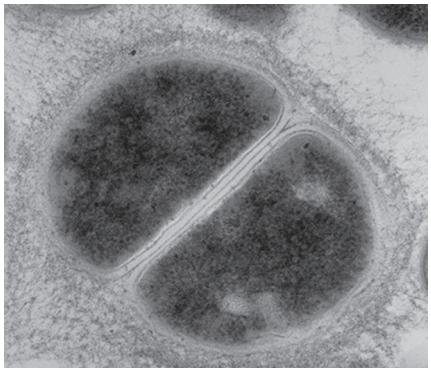
2.4 PROPERTIES OF LIFE: REPRODUCTION

All life forms make more of themselves, or **reproduce**, for the purpose of generating more organisms that look and function just like the original. This assures the survival of that life form. No non-living things reproduce. There are two kinds of reproduction, sexual and asexual.

Asexual reproduction is the formation of a new cell or organism without the exchange of genetic material between two parents. It happens when a single cell splits into one or more cells exactly like it. Organisms and cells that are produced from asexual reproduction all contain the same DNA information as the organism they came from. Asexual reproduction is like making photocopies because all the copies (offspring) are identical to the original (parent).

Figure 2.4.1

Asexual Reproduction
All living organisms reproduce. Some organisms reproduce sexually, some reproduce asexually, and some organisms can reproduce both ways. Asexual reproduction results in the generation of a new organism or cell without exchanging genetic material (DNA) between parents. There are many forms of asexual reproduction. For example, when someone takes a plant stem from a living plant and plants it in a pot of dirt, and a new plant grows from it, that's a form of asexual reproduction. On the right is a TEM view of another type of asexual reproduction, a bacterial cell that's splitting into two cells. After the cells split, each one is a complete, functioning new organism, genetically identical to the other.



Sexual reproduction requires a male and a female organism to mate, which means "combine genetic material." DNA from the male parent combines with DNA from the female parent, which forms a new cell. This new cell then grows into a new organism and contains half its genetic information from the female parent and half from the male parent. Offspring reproduced sexually almost never look exactly like the female or male parent, but organisms produced asexually always look exactly the same as the parent organism.

2.5 PROPERTIES OF LIFE: COMPLEX AND ORGANIZED

All life forms are highly organized and complex structures. Even unicellular organisms, what some biologists often call "simple life forms," are actually quite complex things. This is proven by the utter inability of any scientist to create life using only the basic molecules that make up a living organism. Of course, the complexity and organization are coded for in the DNA. This complexity exists on many levels. For example, all life forms perform many complicated chemical reactions every second (millions and more), and the product of one reaction is needed for the next reaction to occur. These chemical reactions are highly controlled, so they do not occur when they should not occur. Even the internal structure of a single cell is complex and organized.

Multicellular organisms have a higher level of complexity than unicellular organisms. The cells of multicellular organisms are organized into tissues, tissues are organized into organs, and organs are organized into systems.

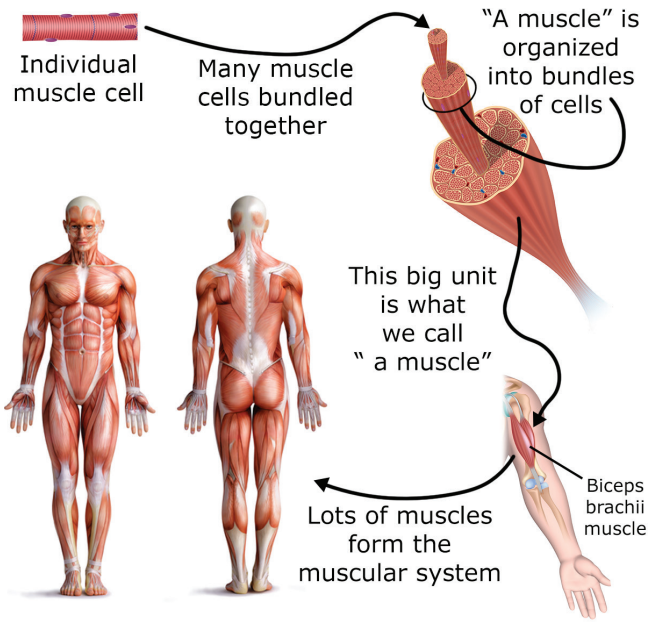


Figure 2.5.1

Organs and Tissues Organization
Multicellular organisms are highly organized. Individual cells that group together and have the same function are called a **tissue**. For example, a muscle cell is an individual cell that can contract and relax. Groups of muscle cells gather together into bundles, and a collection of multiple bundles is called "a muscle," like the biceps brachii muscle that flexes (bends) the elbow. Since an **organ** is a collection of different tissues that work together to perform a common function, an entire muscle like the biceps is actually an organ because it's composed not only of muscle cells, but also connective tissue and other types of cells. Multicellular organisms are further grouped into **systems**, which are collections of organs whose functions contribute to the survival and reproduction of the organism. The muscular system is the collection of all muscles that function to move an organism.

2.6 PROPERTIES OF LIFE: RESPONSIVE

All living things are responsive to their surroundings or **environment**. This means that they have various ways to sense and react to changes in the environment. The ability to sense changes is controlled by different types of **receptors**, which are specialized structures (eyes, ears, etc.) that allow an organism to sense its environment. The input of the sensors is received and coordinated by a central unit (like a brain), which causes the appropriate response to whatever change the sensors pick up. These sensing and responsive abilities of an organism help it to locate food, find shelter, stay safe and find a mate. The responses almost always result in movement of the organism. Sometimes the movement is on the outside of the organism and can be seen. Other times the movement occurs on the inside of the organism and cannot be seen.

Figure 2.6.1

Life is Responsive
All life forms have receptors that allow them to sense and respond to changes in their environment. Lions have keen eyesight and a heightened sense of smell which they use to locate a possible meal. The Springbok antelope uses its excellent eyesight and sense of smell to become aware of an animal that's trying to sneak up and eat it. The antelopes are also always on a high state of alert, so they can startle and respond quickly.