Chapter 1

Biochemistry: What You Need to Know and Why

In This Chapter

- Considering biochemistry
- Finding out about the types of cells
- Seeing the differences between plant and animal cells

If you are enrolled in a biochemistry course, you may want to skip this chapter and go right to the chapter(s) where we discuss the material you are having trouble with. But if you are *thinking* about taking a course in biochemistry or just want to explore an area that you know little about, keep reading. This chapter gives you basic information about cell types and the parts of the cell — which are extremely important in biochemistry.

Sometimes it's easy to get lost in the technical stuff and forget about the big picture. This chapter sets the stage for the details.

Why Biochemistry?

We suppose the flippant answer would be "Why not?" or "Because it is required."

That first response is not too bad an answer, actually. Look around. See all the living or once living things around you? The processes that allow them to grow, multiply, age, and die are all biochemical in nature. Sometimes we sit back and marvel at the complexity of life, the myriad of chemical reactions that are taking place right now within our own bodies, how all these biochemical reactions are working together so that we can sit and contemplate them. When John learned about the minor structural difference between starch and cellulose he remembers thinking: "Just that little difference in the one linkage between those units is basically the difference between a potato and a tree?" It made him want to learn more, to delve into the complexity of the chemistry of living things, to try to understand. We encourage you to step back from the details occasionally and marvel at the complexity and beauty of life.

What Is Biochemistry and Where Does It Take Place?

Biochemistry is the chemistry of living organisms. Biochemists study the chemical reactions that occur at the molecular level of organisms. Normally it is listed as a separate field of chemistry. However, in some schools it is part of biology, and in others it is separate from both chemistry and biology.

Biochemistry really reaches out and combines aspects of all the fields of chemistry. Because carbon is the element of life, *organic chemistry* plays a large part in biochemistry. Many times biochemists study how fast reactions occur — that's *physical chemistry.* Often metals are incorporated into biochemical structures (such as iron in hemoglobin) — that's *inorganic chemistry.* Biochemists use sophisticated instrumentation to determine amounts and structures — that's *analytical chemistry.* Biochemistry is similar to *molecular biology;* both study living systems at the molecular level, but biochemists concentrate on the chemical reactions that are occurring.

Biochemists may study individual electron transport within the cell, or they may study the processes involved in digestion. If it's alive, biochemists will study it.

Types of Living Cells

All living organisms contain cells. A *cell* is a prison of sorts. The working apparatus of the cell is imprisoned within the "bars" — known as the *cell membrane*. Just as a prison inmate can still communicate with the outside world, so can the cell contents. The prisoner must be fed, so nutrients must be able to enter every living cell. There is a sanitary system for the elimination of waste. And, just as inmates may work to provide materials for society outside the prison, a cell may produce materials for life outside the cell.

There are two types of cells: prokaryotes and eukaryotes. (Viruses also bear some similarities to cells, but these are limited.) Prokaryotic cells are the simplest type of cells. Many one-celled organisms are prokaryotes.

TIP

The simplest way to distinguish these two types is that a *prokaryotic cell* contains no well-defined nucleus, whereas the opposite is true for a *eukaryotic cell.*

Prokaryotes

Prokaryotes are mostly bacteria. Besides the lack of a nucleus, there are few well-defined structures inside a prokaryotic cell. The prison wall has three components: a cell wall, an outer membrane, and a plasma membrane. This wall allows a controlled passage of material into or out of the cell. The materials necessary for proper functioning of the cell float about inside it, in a soup known as the *cytoplasm.* Figure 1-1 depicts a simplified version of a prokaryotic cell.

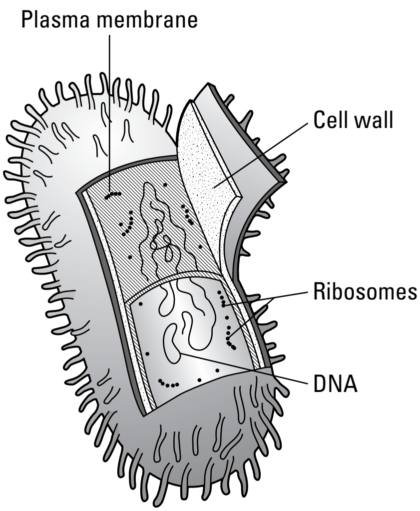

Figure 1-1: Simplified prokaryotic cell.

Eukaryotes

Eukaryotes are animals, plants, fungi, and protists. *You* are a eukaryote. In addition to having a nucleus, eukaryotic cells have a number of membrane-enclosed components known as *organelles*. Eukaryotic organisms may be either unicellular or multicellular. In general, eukaryotic cells contain much more genetic material than prokaryotic cells.

Animal Cells and How They Work

All animal cells (which are, as you now know, eukaryotic cells) have a number of components, most of which are considered to be organelles. The primary components of animal cells are listed in Table 1-1. (These components, and a few others, are also present in plant cells.) Figure 1-2 illustrates a simplified animal cell.

Table 1-1 Parts of an Animal Cell

Cell membrane	Centrioles
Endoplasmic reticulum	Golgi apparatus
Lysosomes	Mitochondria
Nucleus and nucleolus	Ribosomes
Small vacuoles	

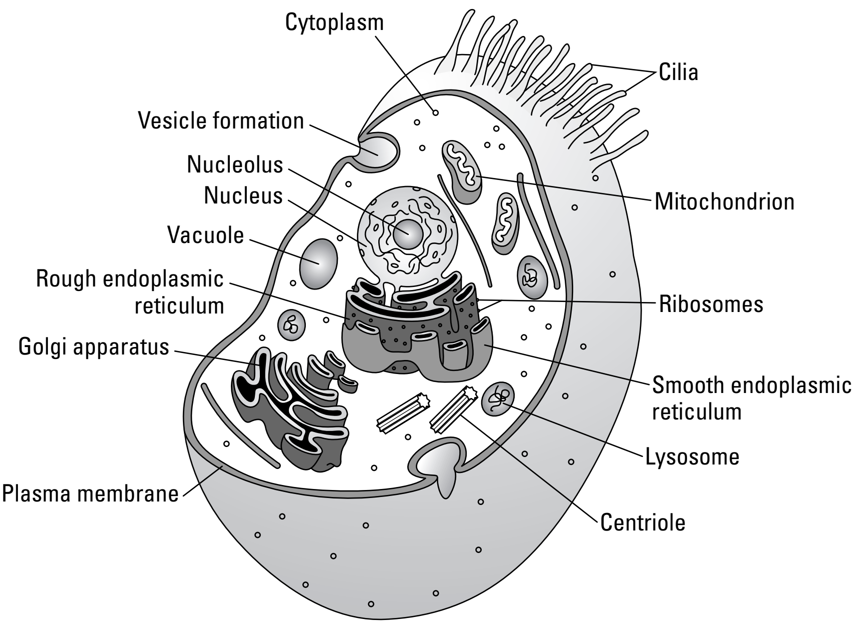

Figure 1-2: Simplified illustration of an animal cell.

The plasma membrane separates the material inside the cell from everything outside the cell. The *plasma* or cytoplasm is the fluid inside the cell. It is important for the health of the cell to prevent this fluid from leaking out. However, necessary materials must be able to enter through the membrane, and other materials, including waste, must be able to exit through the membrane.

Transport through the membrane may be active or passive. *Active transport* requires that a price be paid for a ticket to enter (or leave) the cell. The cost of the ticket is energy. *Passive transport* does not require a ticket. Passive transport methods include diffusion, osmosis, and filtration.

Centrioles behave as the "train conductors" of the cell. They organize microtubles, which help move the parts of the cell during cell division.

The cell can be thought of as a smoothly running factory. The *endoplasmic reticulum* is the main part of the cell factory. There are two basic regions to this structure, known as the *rough* endoplasmic reticulum and the *smooth* endoplasmic reticulum. The rough endoplasmic reticulum contains ribosomes, and the smooth endoplasmic reticulum contains no ribosomes (more about ribosomes and their function is coming up in this chapter). The rough endoplasmic reticulum, through the ribosomes, is the assembly line of the factory. The smooth endoplasmic reticulum is more like the shipping department, which ships the products of the reactions that occur within the cell, to the Golgi apparatus.

The *Golgi apparatus* serves as the postal system of the cell. It looks a bit like a maze, and within it, materials produced by the cell are packaged in vesicles, small membrane-enclosed sacs. The vesicles are then mailed to other organelles or to the cell membrane for export. The cell membrane contains "customs officers" (called *channels*), who allow secretion of the contents from the cell. Secreted substances are then available for other cells or organs.

Lysosomes are the landfills of the cell. They contain digestive enzymes that break down substances that may harm the cell (Chapter 6 has a lot more about enzymes). The products of this digestion may then safely reenter the cell. Lysosomes also digest "dead" organelles. This slightly disturbing process, called *autodigestion,* is really part of the cell digesting itself.

The *mitochondria* (singular mitochondrion) are the cell's power plants, where the cell produces energy. Mitochondria use food, primarily the carbohydrate *glucose,* to produce energy, which comes mainly in the form of *adenosine triphosphate* (ATP — to which Chapter 13 is dedicated).

Each cell has a *nucleus* and, inside it, a *nucleolus.* These serve as the control center of the cell and are the root from which all future generations originate. A double layer known as the *nuclear membrane* surrounds the nucleus. Usually the nucleus contains a mass of material called *chromatin.* If the cell is entering a stage leading to reproducing itself through cell division, the chromatin separates into *chromosomes.*

In addition to conveying genetic information to future generations, the nucleus produces two important molecules for the interpretation of this information. These molecules are *messenger ribonucleic acid* (mRNA) and *transfer ribonucleic acid* (tRNA). The nucleolus produces a third type of ribonucleic acid known as *ribosomal ribonucleic acid* (rRNA). (Chapter 9 is all about nucleic acids.)

Ribosomes contain protein and ribonucleic acid subunits. It is in the ribosomes where the amino acids are assembled into *proteins.* Many of these proteins are enzymes, which are part of nearly every process occurring in the organism. (Part II of this book is devoted to amino acids, proteins, and enzymes.)

The *small vacuoles,* or simply *vacuoles,* serve a variety of functions, including storage and transport of materials. The stored materials may be for later use or may be waste material no longer needed by the cell.

A Brief Look at Plant Cells

Plant cells contain the same components as animal cells — plus a cell wall, a large vacuole, and, in the case of green plants, chloroplasts. Figure 1-3 illustrates a typical plant cell.

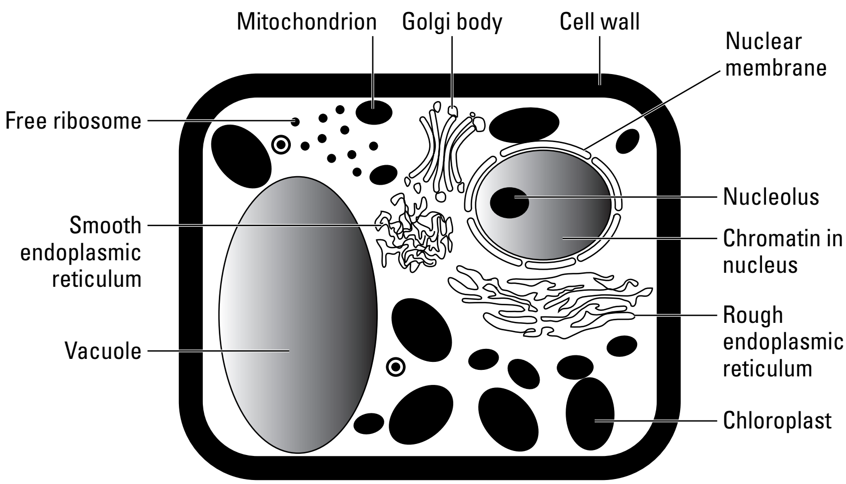

Figure 1-3: Simplified illustration of a plant cell.

The *cell wall* is composed of cellulose. Cellulose, like starch, is a polymer of glucose. The cell wall provides structure and rigidity.

The *large vacuole* serves as a warehouse for large starch molecules. Glucose, which is produced by photosynthesis, is converted to *starch,* a polymer of glucose. At some later time, this starch is available as an energy source. (Chapter 7 talks a lot more about glucose and other carbohydrates.)

Chloroplasts, present in green plants, are specialized chemical factories. These are the sites of photosynthesis, in which *chlorophyll* absorbs sunlight and uses this energy to combine carbon dioxide and water to produce glucose and release oxygen gas.

TIP

The green color of many plant leaves is due to the magnesium-containing compound chlorophyll.

Now that you know a little about cells, press on and let's do some biochemistry!