Chapter 1

Exploring the World of the Cell

In This Chapter

- Discovering the microscopic world
- Getting matter and energy
- Reading the genetic code

Molecular and cellular biology is about studying cell structure and function down to the level of the individual molecules that make up the cell. The most famous molecule in cells is DNA, and much of molecular biology focuses on this molecule — reading DNA, working with DNA, and understanding how cells use DNA.

In this chapter, I present an overview of molecular and cellular biology and how it relates to your life. My goal is to illustrate the importance of molecular and cellular biology and to give you a preview of the topics I explore in more depth in the later chapters of this book.

Cells and Viruses: Discovering the Inhabitants of the Microscopic World

If you were alive just 400 years ago, you would've had no idea that germs can spread diseases, that your blood contains cells that carry oxygen around your body, or that new people are made when sperm cells join with egg cells. Four hundred years ago, no one had any idea that there was an entire world just beyond the power of the human eye. A Dutch cloth merchant named Antony van Leeuwenhoek changed all that when he used small, hand-held microscopes to peer beyond the known world into the world of the cell.

In 1676, van Leeuwenhoek used his microscopes to look into a drop of lake water — water that appeared clear to his eyes — and was astounded to see tiny creatures swimming around in it. van Leeuwenhoek was the first to see bacteria, blood cells, and sperm cells fertilizing an egg. Along with Robert Hooke, who observed the first plant cells, van Leeuwenhoek laid the foundation for the development of cell biology and microbiology and began new chapters in the sciences of anatomy, physiology, botany, and zoology.

You: On the cellular level

Imagine your eyes have super powers, and you're staring at your own skin, revealing a patchwork of thin, flaky cells. These skin cells are just one type of more than 200 types of cells found in your body — cells that make up your tissues, organs, and organ systems (see Figure 1-1). Increase the power of your eyes, and you can zoom in on your chromosomes, which are made of DNA (see Chapter 7) and contain the instructions for your traits (see Chapter 15).

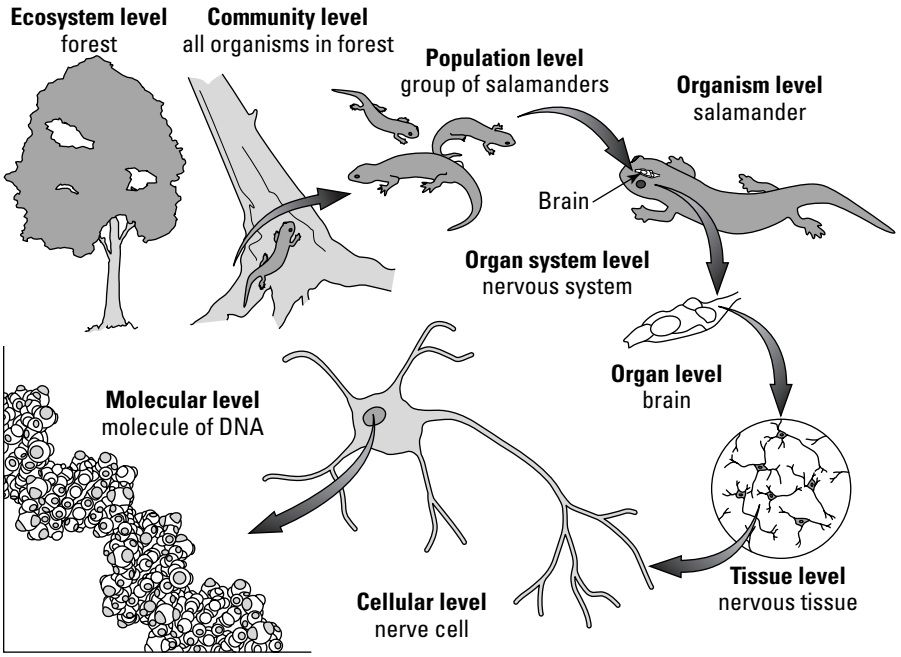

Figure 1-1: The organization of living things.

Them: Bacteria and viruses

If you looked at your body with super-powered eyes, your cells aren't the only cells you'd see. All over your body and, in fact, everywhere on Earth you look, you can see another type of cell — the prokaryotic cell (see Chapter 2). Prokaryotic cells come in two types:

- **Bacteria** are probably most familiar to you because they can make you sick, but bacteria do many good things, too. The bacteria that live all over your body actually help keep you from getting sick, and many of the foods you eat, such as yogurt, owe their flavors to bacteria.
- **Archaea** are just as common as bacteria but are usually less familiar to people because they aren't known for causing human disease, and they're still being studied by scientists. On a microscope (or with super-powered eyes), archaea look just like bacteria, so scientists didn't realize archaea existed until around 40 years ago when improvements in molecular biology made their discovery possible.

Your super-powered eyes could also show you another type of alien creature, even smaller than the cells of bacteria and archaea — viruses (see Chapter 3). Viruses really are like little alien ships that land on your cells and take them over, enslaving the molecules within your cells and making them work to build more viruses. Your cells don't work for you anymore, and you feel the effects — your throat gets sore, your nose runs, or you ache all over. Fortunately, your immune system comes to the rescue, sending in white blood cells to fight off the invading viruses.

Because bacteria and viruses both make people sick, they often get confused — even in the news media! However, bacteria and viruses have very different structures — bacteria are cells, and viruses are not — which makes a big difference when it comes to medicine. Antibiotics target bacterial cells, and they *don't* work on viruses!

Speaking the language of cells

If you want to learn about cells, you need to speak their chemical chemistry. Cells are made of molecules, they communicate through molecules, and they respond to signals by changing existing molecules or making new ones. The DNA code (see Chapter 7), written in the chemical letters A, T, C, and G, is used by your body to create cellular workers like proteins (see Chapter 6) that control how your cells function. DNA and proteins, along with carbohydrates (see Chapter 5) and lipids (see Chapter 8), are the fundamental building blocks that make up your cells and thus your entire body.

The Life of a Cell: How Cells Get What They Need to Survive and Reproduce

Your cells are the smallest piece of you that is alive. All the things that you can think of that you need to do to keep your body alive — get energy from food, take in oxygen, and release wastes — are also true for your cells:

- When you eat food, you take in a source of energy and matter for your cells that you process with your cellular metabolism (see Chapter 10).
- Your cells do cellular respiration (see Chapter 11), using oxygen to transfer energy out of food into a form that they can use to do work.
- Cells can also use the energy and molecules from food to grow and make new cells (see Chapter 13).

Ultimately, you can trace all the food that you eat back to cells, like those of plants, that make food through photosynthesis (see Chapter 12). In fact, life on Earth couldn't even exist without the organisms that make food, because they capture the energy and matter that all cells need to survive.

Sexual Reproduction: Shuffling the Genetic Deck for the Next Generation

You began life as a single cell, when a sperm cell from your dad combined with an egg cell from your mom. Your parents made these special reproductive cells through a special type of cell division called meiosis (see Chapter 14). Each cell from your parents donated half of your genetic information — 23 chromosomes from Mom and 23 from Dad — for a total of 46 chromosomes in each of your cells. What you look like and much of how you behave is a result of the interaction between the genes you got from Mom and the genes you got from Dad.

Tracking the inheritance of genes and how they interact to determine traits is part of the science of genetics (see Chapters 15 and 16). Through genetics, you can understand things like why your eyes are a certain color or why some traits seem to run in families.

DNA to Protein: Following the Instructions in the Genetic Code

The instructions for your traits, from the level of the cell to the level of the whole you, are encoded in your DNA. Whenever your cells divide to make new cells, they must copy your DNA through DNA replication (see Chapter 17) so that each new cell gets a set of instructions. The working cells of your body are constantly reading the DNA code and using the instructions to build molecules, such as proteins, that they need to do their jobs for the body. Proteins are constructed by the combined efforts of two processes, called transcription and translation (see Chapter 18).

Signals, such as hormones, can tell your working cells that they need to change their behavior. To change their behavior, your cells may need to change their tools. Gene regulation (see Chapter 19) allows your cells to turn off some genes for proteins and turn others on. In fact, how your cells use your DNA is just as important as what your code actually says!

DNA Technology: Tackling the World's Problems

You've probably heard a lot about the impacts of biotechnology — genetically modified organisms (GMOs), DNA fingerprinting, the Human Genome Project, and gene therapy are just some of the topics that regularly appear in the news.

A revolution in biology has occurred over the past 50 years or so, a revolution based on scientists' ability to read and manipulate the genetic code of life. Scientists can extract, snip, copy, read, modify, and place DNA from cells into different cells using recombinant DNA technology (see Chapter 20). New technologies developed in the last 20 years allow scientists to read the entire genetic code, or *genome,* of organisms (see Chapter 21), essentially opening up the book of life for everyone to read.

New branches of biology are growing to study all this new information and present many opportunities for future careers:

- **Bioinformatics** is a science that blends computing, biology, and information technology to organize and analyze the large amounts of information that are being generated by biologists all around the world.
- **Genomics** is the study of entire genomes of organisms. By studying all of the DNA sequence of a cell, scientists are discovering new proteins and new understandings of how DNA is regulated in cells.
- **Proteomics** is the study of the entire body of proteins in a cell and how they interact with each other. The types of proteins found in different cells are compared in order to look for patterns common to certain cell types.

Molecular biology has spread throughout the older branches of biology as well. Botany, zoology, ecology, physiology — every "ology" you can think of, really — now has a molecular component. Living things are studied down to the level of the cell and the molecules, such as DNA and proteins, that make up the cell.

Even medicine is becoming increasingly molecular — Departments of Molecular Medicine are popping up all over — as doctors and scientists seek to understand and treat disease at the level of the cell and molecule. Designer drugs that specifically target the molecular defect of a particular disease are already in the works.

Molecular and cellular biology already impacts your life in many ways and will almost certainly become more important in your future.