2.1 Genetics follows a set of rules that govern inheritance.

2.1.1 From Gene to Protein

The Role of Genes

Genetics is the study of how inheritable characteristics, such as eye colour in humans and flower colour in plants, are passed on from generation to generation. Before examining patterns of inheritance associated with these characteristics, it's useful to study the role of **genes** and how they relate to the production of protein. Why? Because the protein made by our cells determines a vast number of characteristics—from how tall we are likely to grow, to the complexion of our skin, to the colour of our hair, and to whether we grow up as males or as females. Genes contain the information needed to make protein. And genes are what parents pass on to their offspring during reproduction.

Molecular biologists in the last century explored how genes work. In doing so, they discovered the **genetic code**—the chemical language through which the information needed to produce a complete human is transmitted. They found that:

- Genetic information (genes) is located in our chromosomes. In Unit 1, you learned that chromosomes are composed of long strands of a molecule called deoxyribonucleic acid (DNA).
- Genetic information is used by our cells to make protein. Genes determine which of 20 kinds of amino acids are to be linked together into a chain that, when finished, makes a long protein molecule. Human DNA contains enough information to assemble about 100 000 different kinds of protein.
- Nearly every cell in the human body contains all the genetic information necessary to produce a new human.

Molecular biologists also discovered that:

- All known life forms use the same genetic code and the same, or closely related, cellular apparatus to produce protein. This is why a human gene can be placed into a bacterium to produce the life-saving protein called insulin, used to treat many people with diabetes.
- The genes in humans and chimpanzees are 98% identical. We even share many genes with organisms that appear vastly different from us. For example, almost all of the genes present in a tiny worm called a nematode are also present in humans (although we have many additional ones that they do not have).
- Viruses attack our cells by substituting their own genes into the cellular apparatus of human cells. Instead of making human protein, our infected cells make viral protein. Because of similarities in biochemistry, a virus can spread from a goose to a pig to a human. In fact, most forms of the common flu are believed to have originated in birds from Asia, where they are raised in close proximity to pigs and humans.

For more information about the relationship between genes and protein, check out bcscience.com.

The Genetic Code

All cells contain an intricate biochemical apparatus that reads the information in genes and then uses it to construct protein. This apparatus is passed on from the parent cell to the daughter cell during cytokinesis, when the daughter cell receives a portion of the cytoplasm.

By analogy, genes act like a DVD that has been placed into a DVD player. Specific markings on the DVD correspond to specific pixels that are lit up on the TV screen. The genetic code relates the ordering of four special chemicals in DNA to the ordering of specific amino acids in protein.

The four special chemicals that make up the long DNA molecule are called bases. These four bases are represented by the letters C, G, T, and A, and can join together to form a very long chain. In humans, these chains, or strands, are several million bases long. Each strand contains many genes. The strands come together in pairs to form the DNA molecule: They wind around each other in a special way to form a double spiral, called a double helix. Opposite every C on one DNA strand is a G on the other strand; opposite every T on one strand is an A on the other (Figure 2.1).

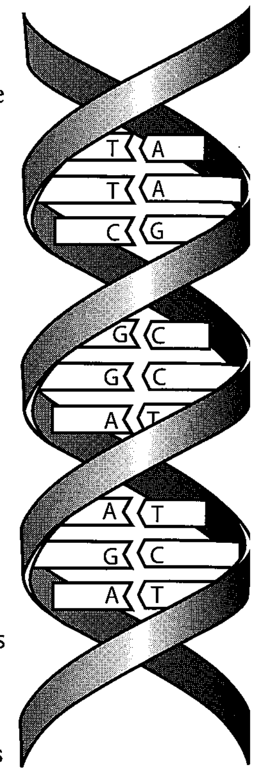


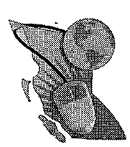
FIGURE 2.1 The double helix. DNA is a double strand that contains two long chains of bases. Each chain contains the information needed to assemble a protein.

The Role of Protein

Protein plays a critical role in our biochemistry. Table 2.1 shows some examples of different proteins hard at work in our bodies.

TABLE 2.1 Examples of How Protein Works in the Body

Location in Body	Role
Chromatin	Proteins wind up and unwind the DNA in our chromosomes. Some can split open a DNA molecule like a zipper, and others can zip it up again. Proteins can move up and down the DNA molecule and repair certain kinds of genetic mistakes. Some proteins can activate genes to produce a new protein; while others can turn the genes off.
Cytoplasm	Proteins assist in chemical reactions in all cells, helping the reactions to go faster. The chemicals in such reactions are called enzymes.
Cell membrane	Proteins sit in the cell membrane and control the passage of chemicals through it in both directions. Proteins also protrude from the outside of the membrane and act as markers. These markers help white blood cells determine whether or not the cell is a foreign invader.
Bloodstream	Proteins float in the bloodstream. Some attack invading bacteria and work by ripping the cell membranes of bacteria open. Some proteins activate white blood cells to detect and destroy invading cells. Others signal distant parts of the body to prepare for changes, such as sudden increases or decreases in physical activity.



For more information on protein building, check out bcscience.com.

The examples in Table 2.1 show the importance of protein—and the importance of genes, which control the production of protein.