7.3 DNA Contains the "Recipes" for a Cell's Proteins

The amount of DNA in any cell is enormous. In humans, for example, each pinpoint-sized nucleus contains some 6.4 billion base pairs of genetic information.

An organism's **genome** is all of the genetic material in its cells. Genomes vary greatly in size and packaging. The genome of a bacterial cell typically consists of one circular DNA molecule. In a eukaryotic cell, however, the majority of the genome is divided among multiple chromosomes housed inside the cell's nucleus; each **chromosome** is a discrete package of DNA coiled around histones and other proteins (figure 7.7). The mitochondria and chloroplasts of eukaryotic cells also contain DNA and therefore have their own genomes.

The chromosome in figure 7.7 is tightly coiled; to use its genetic information, the cell must "unpack" the chromosome and expose the double helix. Although much of the DNA has no known function, some of it encodes RNA and proteins. This section introduces the **gene,** which is a sequence of DNA nucleotides that encodes a specific protein or RNA molecule. Because many proteins are essential to life, each organism has many genes. The human genome, for example, includes 20,000 to 25,000 genes scattered on its 23 pairs of chromosomes. Likewise, a bacterial chromosome is also divided into multiple genes.

A. Protein Synthesis Requires Transcription and Translation

In the 1940s, biologists working with the fungus *Neurospora crassa* deduced that each gene somehow controls the production of one protein. In the following decade, Watson and Crick described this relationship between nucleic acids and proteins as a flow of information they called the "central dogma." ⓘ *Neurospora,* section 20.5

Figure 7.8 summarizes the process of protein production. First, in **transcription,** a cell "rewrites" a gene's DNA sequence to a complementary RNA molecule. Then, in **translation,** the information in RNA is used to assemble a different class of molecule: a protein (just as an interpreter translates one language into another).

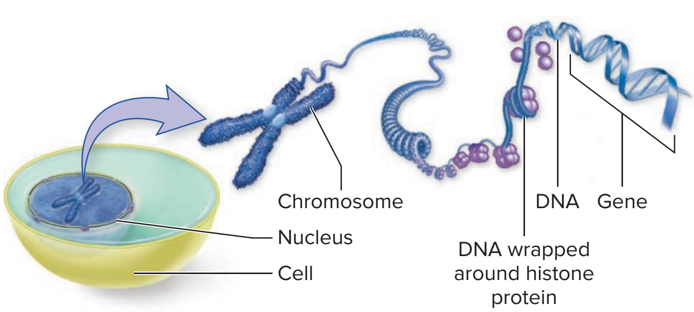

Figure 7.7 From Cell to Chromosome to Gene. A eukaryotic cell's nucleus contains chromosomes, which consist of DNA wrapped around specialized proteins. A gene is a segment of DNA that encodes a protein or an RNA molecule.

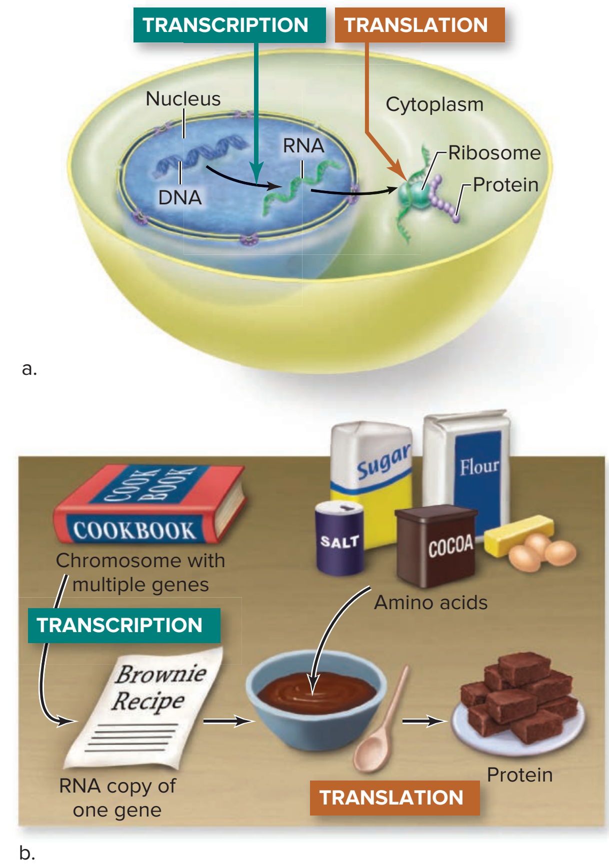

Figure 7.8 DNA to RNA to Protein. (a) The central dogma of biology states that information stored in DNA is copied to RNA (transcription), which is used to assemble proteins (translation). (b) DNA stores the information used to make proteins, just as a recipe stores the information needed to make brownies.

According to this model, a gene is therefore somewhat like a recipe in a cookbook. A recipe specifies the ingredients and instructions for assembling one dish, such as spaghetti sauce or brownies. Likewise, a protein-encoding gene contains the instructions for assembling a polypeptide, amino acid by amino acid (the polypeptide subsequently folds to become the finished protein). A cookbook that contains many recipes is analogous to a chromosome, which is an array of genes. A person's entire collection of cookbooks, then, is analogous to a genome.

To illustrate DNA's function with a concrete example, suppose a cell in a female mammal's breast is producing milk to feed an infant (see figure 3.13). One of the proteins in milk is albumin. The following steps summarize the production of albumin, starting with its genetic "recipe":

1. Inside the nucleus, an enzyme first transcribes the albumin gene's DNA sequence to a complementary sequence of RNA.
2. After some modification, the RNA emerges from the nucleus and binds to a ribosome.
3. At the ribosome, amino acids are assembled in a specific order to produce the albumin protein.