Chapter 8: Introduction to Reproduction at the Cellular Level

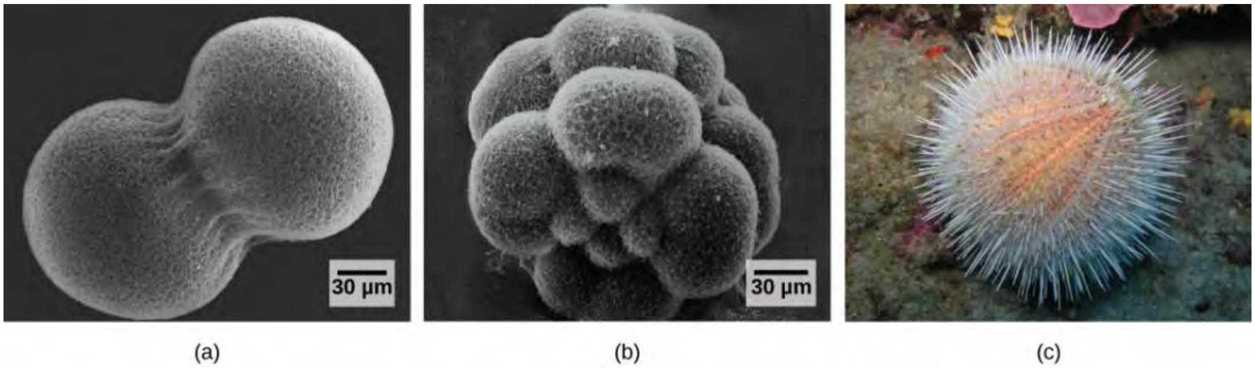

Figure 8.1 A sea urchin begins life as a single cell that (a) divides to form two cells, visible by scanning electron microscopy. After four rounds of cell division, (b) there are 16 cells, as seen in this SEM image. After many rounds of cell division, a (c) mature sea urchin is formed. (credit a: modification of work by Evelyn Spiegel, Louisa Howard; credit b: modification of work by Evelyn Spiegel, Louisa Howard; credit c: modification of work by Marco Busdraghi; scale-bar data from Matt Russell / Biology 2E OpenStax)

One of the seven properties of life is that all organisms must reproduce. Reproduction can be done both on a cellular and an organismal level. Many multicellular organisms, including humans, reproduce sexually by first making specialized reproductive cells. Life begins when these reproductive cells come together to form a fertilized egg. The single fertilized cell then begins to divide through a process that generates trillions of genetically identical cells. All multicellular organisms use cell division for growth, maintenance, and cell repair.

Single-celled organisms, such as bacteria or yeast, must also reproduce; however, they do so on their own, asexually. At the end of asexual reproduction, the new daughter cells should be identical to the parent cell.

In this chapter, students will learn about different forms of cell division. Students will become familiar with the steps that must occur for cell division to take place and the consequences of what happens if cell division does not occur in a precise, controlled manner.

8.1 The Genome

Learning objectives

By the end of this section, you will be able to:

- *Describe the DNA of prokaryotic and eukaryotic genomes*
- *Explain why DNA must be condensed in the cell*
- *Describe how DNA is condensed to fit in the cell*
- *Be able to define and explain all bolded terms*

Collectively, all the DNA found within the cell is called its **genome**. An organism's genome determines its overall characteristics. Prokaryotic and eukaryotic cells differ in both the quantity and organization of their genomes; therefore, they differ in their characteristics. Before learning how cells replicate, students will first take a closer look at both prokaryotic and eukaryotic genomes.

Genomic DNA

In prokaryotes, the genome is typically composed of a single chromosome. The chromosome is made of a double-stranded DNA molecule organized in a loop or a circle. The circular chromosome is found in a region called the nucleoid (Figure 8.2). Some prokaryotes also have smaller loops of DNA called plasmids. Plasmids are not essential for normal growth, but often contain unique genes that confer beneficial properties, such as antibiotic resistance. These plasmids can be exchanged between different bacteria, and therefore, the beneficial properties can propagate.

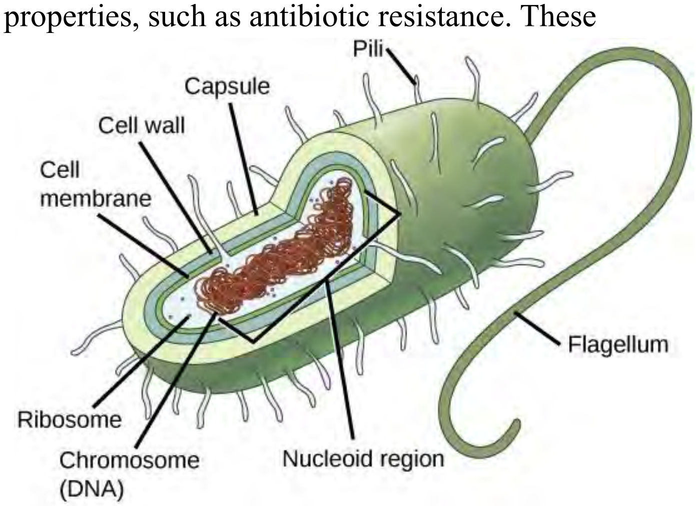

Figure 8.2 Prokaryotes, including both Bacteria and Archaea, have a single, circular chromosome located in a central region called the nucleoid. (credit: Clark et al. / Biology 2E OpenStax)

In eukaryotes, the genome is made up of several linear chromosomes (Figure 8.3). **Chromosomes** consist of double-stranded DNA molecules wrapped around proteins. Each eukaryotic species has a characteristic number of chromosomes in its nuclei. In humans, all cells (with the exception of our eggs and sperm) contain 46 chromosomes, or 23 pairs of chromosomes (Figure 8.3).

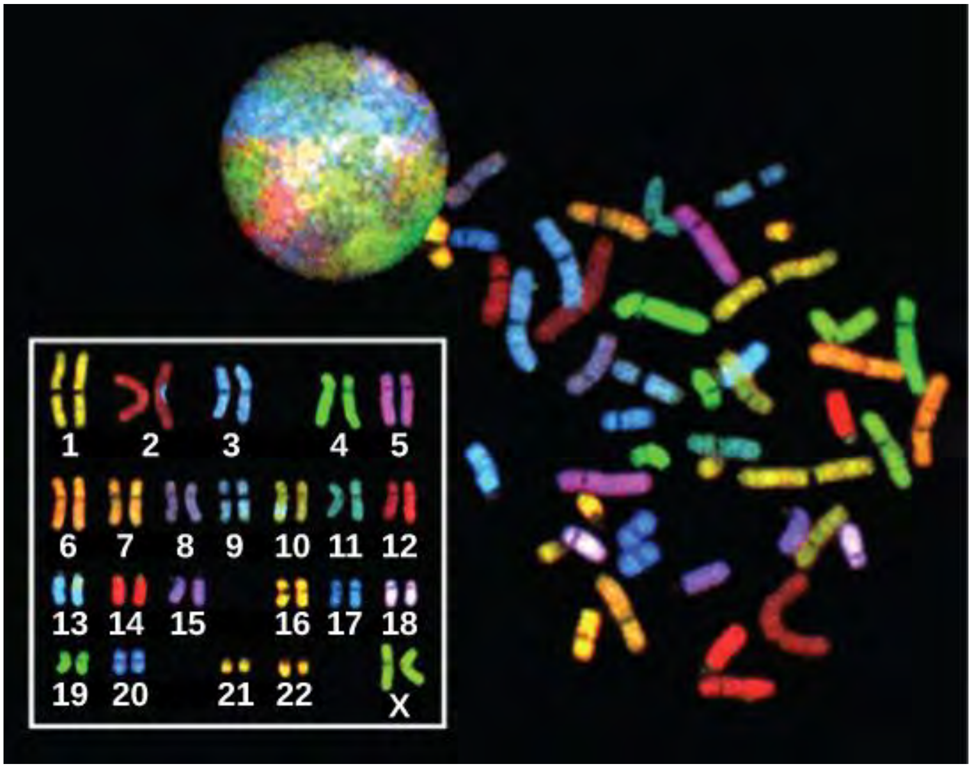

Figure 8.3 There are 23 pairs of chromosomes in a female human cell. In this image, the chromosomes were exposed to fluorescent stains to distinguish them. (credit: "718 Bot"/Wikimedia Commons, National Human Genome Research / Biology 2E OpenStax)

Eukaryotic Chromosomal Structure and Packaging

If the DNA from all 46 chromosomes in a human cell were laid out end-to-end, it would measure approximately two meters! The average size of a human cell is about 10 µm; this means that the DNA must be *packaged* or *condensed* to fit into the cell's nucleus. At the same time, it must also be readily accessible so that it can be used to make proteins. For this reason, the long strands of DNA are either loosely or tightly condensed with the help of different proteins.

To begin, DNA is loosely condensed by winding it around special proteins called histone proteins. As the DNA is wound around the protein, it forms a long fiber-like strand called **chromatin**. Within the chromatin fibers, stretches of DNA wind around several histone proteins simultaneously forming beadlike complexes called nucleosomes. The nucleosomes can coil, which *condenses* the DNA even more (Figure 8.4).

When a cell divides, the DNA will be condensed even more and individual chromosomes will become visible. Chromosomes are always present in the form of chromatin; however, they cannot be easily seen until the cell is preparing to divide.