The Cell Cycle

The life cycle of an individual cell is called the *cell cycle.* The moment of *cell cleavage,* when a cell membrane grows across the "equator" of a dividing cell, is considered to be the end of the cycle for the mother cell and the beginning of the cycle for each of the daughter cells.

Typically, but by no means universally, *interphase* is the longest period of the cell cycle. Interphase comes to an end when the cell divides in the process of *meiosis.* We discuss both these periods of the cell cycle in the following sections.

Cells that divide, cells that don't

All cells arise from the division of another cell, but not all cells go on to divide again:

- **Zygote:** This is the diploid cell that comes into existence when the sex cells (ovum and sperm, both haploid) fuse at conception. Almost immediately, the zygote divides into two somatic cells.
- **Somatic cells:** These include all the cells of the body except the sex cells — in other words, all the diploid cells of the body. Somatic cells may be *relatively differentiated* (somewhat specialized), *terminally differentiated* (they never divide again), or stem cells.
- **Stem cells:** These are special kinds of rather "generic" somatic cells that divide to produce one new stem cell and one new somatic cell that goes on to differentiate into a particular type of cell in a particular type of tissue. The *embryo* (organism in the very early stages of development) has very special stem cells, called *pluripotent* ("many powers") stem cells, which have the ability to give rise to just about any kind of cell an organism needs, given the right chemical environment. When an organism has developed beyond the embryo stage, embryonic stem cells disappear, and other types of stem cells, called *adult* stem cells, arise in particular tissue types and specialize in producing new cells for that tissue. (Turn to Chapter 9 for a description of how stem cells in the bone marrow give rise to many types of blood cells.)
- **Sex cells (gametes):** These form when specialized somatic cells in the reproductive system divide by a process called *meiosis.* Meiosis is the only cellular process in the human life cycle that produces *haploid* cells. See Chapter 14 for more details on sex cells and the processes of meiosis.

Table 3-2 summarizes how different types of cells behave when it comes time to divide.

Table 3-2 Dividing Behavior of Different Cell Types

Cell Type	*Arise From*	*Divide?*	*Give Rise To*
Zygote	Fusion of two sex cells	Y	Two somatic cells
Somatic cell	Somatic cell or stem cell	Y or N*	Somatic cells; sex cells**
Stem cell	Stem cell	Y	One specialized somatic cell and one stem cell
Sex cell	Somatic cell	N	NA

**Some somatic cells go on to terminal differentiation and never divide again.*

***Sex cells arise from meiosis of certain somatic cells. They are haploid cells and never divide again.*

Interphase

Interphase begins when the cell membrane fully encloses the new cell and lasts until the beginning of mitosis or meiosis. The duration of interphase may be anywhere from minutes to decades. Generally speaking (there are always exceptions in cell biology), cells do most of their differentiating and most of their routine metabolizing during interphase. Stem cells grow in size and reduplicate organelles during interphase, in preparation for mitosis (more on mitosis in a minute). Some other cells enter mitosis after an extended period of steady-state metabolism. Sometimes, a cell remains in interphase, carrying out its physiological function for years and years until it dies.

DNA replication

DNA replication is an early event in cell division, occurring during interphase, just prior to the beginning of mitosis or meiosis but within the protected space in the nuclear envelope. Maintaining the integrity of the DNA code is absolutely vital.

During DNA replication, the double helix must untwist and "unzip" so that the two strands of DNA are split apart. As shown in Figure 3-6, each strand becomes a template for building the new complementary strand. This process occurs a little at a time along a strand of DNA. The entire DNA strand doesn't unravel and split apart all at once. When the top part of the helix is open, the original DNA strand looks like a *Y*. This partly open/partly closed area where replication is happening is the *replication fork*.

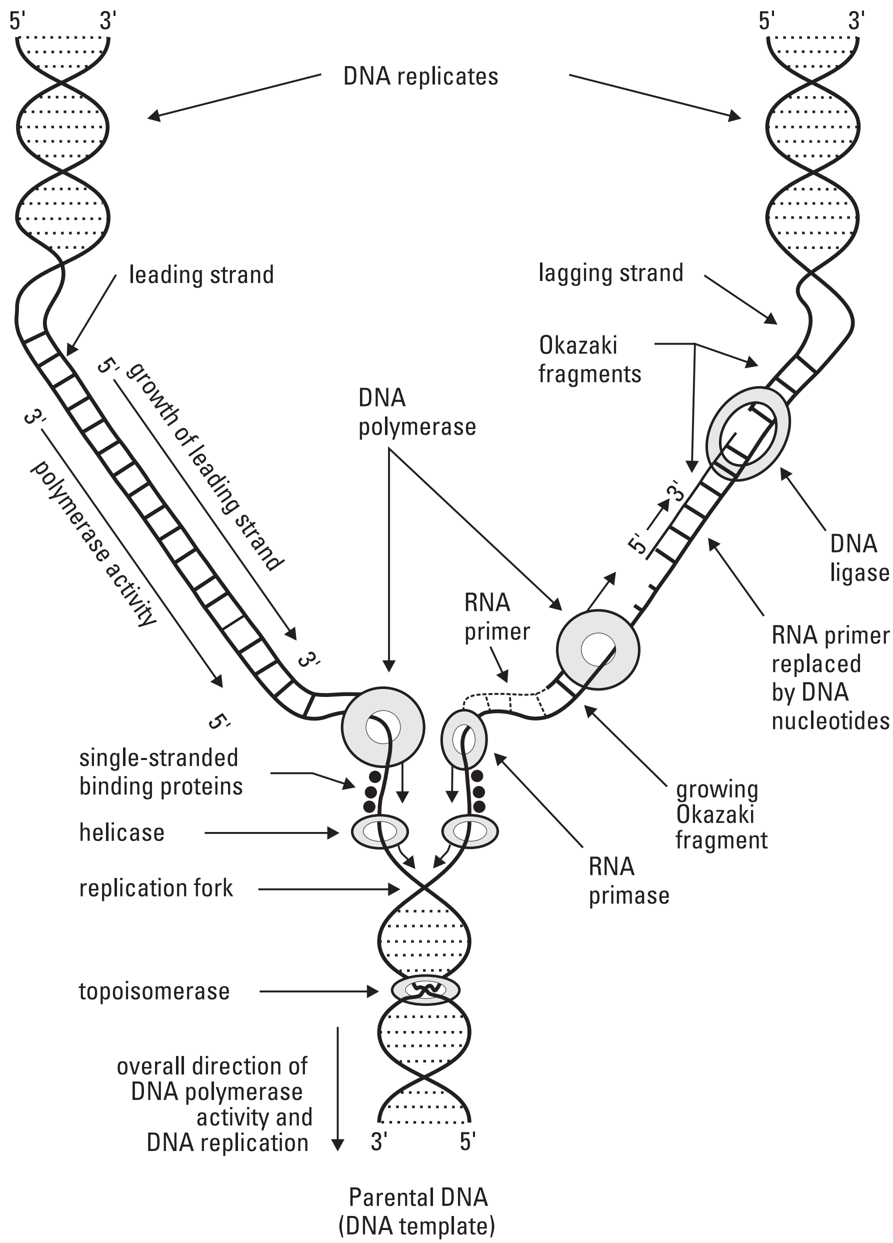

Figure 3-6: The DNA replication process.

In Figure 3-6, the symbols *5'* and *3'* (read *five prime* and *three prime*) indicate the direction in which DNA replication is occurring. The template strand is read in the 3'-to-5' direction. The bases that are complementary to the template strand are added in the 5'-to-3' direction.

Mitosis

A cell enters a process of *mitosis* (division) in response to signals from the nucleus. As shown in Figure 3-7, mitosis is a multistage process, proceeding in the following stages:

1. **Prophase: The nuclear envelope is dismantled, and the duplicated DNA, in the form of *chromatin,* thickens and coils into *chromosomes.*** Each duplicated chromosome is composed of two identical strands of DNA referred to as *chromatids.* The chromatids are held together by a protein mass called the *centromere.* (**Note:** When the chromatids separate, each is considered a new chromosome.) Cellular structures called *centrioles* and *spindle fibers* move apart to the poles of the cells and move chromosomes to the middle of the dividing cell.
2. **Metaphase: The chromosomes are moved by the spindle fibers to form a perfect row at the center of the spindles, midway between the centrioles.** At this point, 92 chromatids are in a double set of 46 chromosomes.
3. **Anaphase: The centromere is split by enzymatic activity, and the chromatids are pulled by the spindle fibers toward one of the centrioles: 46 to one, 46 to the other.** Following this movement, the chromosomes are referred to as *daughter chromosomes,* and the set at one pole is identical to the set at the opposite pole. But the cell isn't quite ready to divide yet.
4. **Telophase: A fresh nuclear membrane is reassembled around each set of chromosomes.** The spindles dissolve, which frees the daughter chromosomes.

At this point, when each of the two identical nuclei is at one pole of the cell, mitosis is technically over. However, the cell's cytoplasm still has to actually split apart into two masses, a process called *cytokinesis.* The center of the mother cell indents and squeezes the cell membrane across the cytoplasm until two separate cells are formed. The two daughter cells are then in interphase and go on to differentiation or not, depending on the instructions to the cell from the genome.

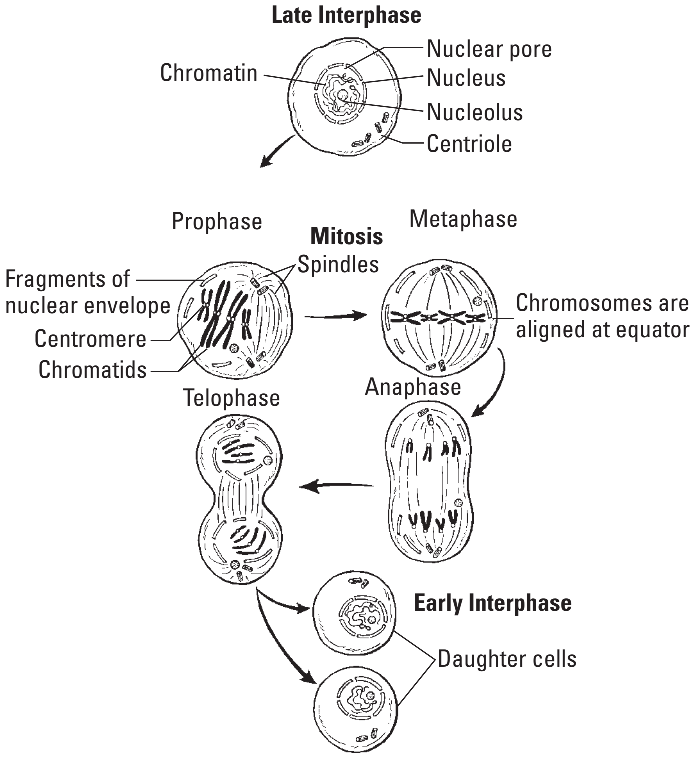

Figure 3-7: The stages of mitosis: prophase, metaphase, anaphase, and telophase.

Almost 100 percent of the time, the DNA replication process results in two identical copies of the genome. Mutations that get passed on to the next generation through the sex cells are usually fatal to the organism, often as early as the zygote or embryo stage. But if the mutation permits the organism to survive and reproduce, it provides the raw material for "natural selection" in the process of evolution.

Organizing Cells into Tissues

A *tissue* is an assemblage of cells, not necessarily identical but from the same origin, that together carry out a specific function. As we discuss in Chapter 1, tissue is the second level of organization in organisms, above (larger than) the cell level and below (smaller than) the organ level.

Like just about everything else in anatomy, tissues are many and various, and they're grouped into a reasonable number of "types" to make talking about them and understanding them a little simpler. The tissues of the animal body are grouped into four types: *connective tissue, epithelial tissue, muscle tissue,* and *nervous tissue.* All body tissues are classified into one of these groups.

Connecting with connective tissue

Connective tissues connect, support, and bind body structures together. Generally, connective tissue is made up of cells that are spaced far apart within a gel-like, semisolid, solid, or fluid matrix. (A *matrix* is a material that surrounds and supports cells. In a chocolate chip cookie, the dough is the matrix for the chocolate chips.)

Connective tissue has many functions, and thus many forms. In some parts of the body, such as the bones, connective tissue supports the weight of other structures, which may or may not be directly connected to it. Other connective tissue, like adipose tissue (fat pads), cushions other structures from impact. You encounter lots of connective tissue in the chapters to come because every organ system has some kind of connective tissue.

We discuss the important connective tissues *bone* and *cartilage* in some detail in Chapter 4, and we discuss the important connective tissue *blood* in detail in Chapter 9. (What? Blood is a tissue? A connective tissue? Yes, and you'll see why.)

The following other types of connective tissue are found in the human body:

- **Areolar (a type of loose connective tissue):** This tissue surrounds and separates structures in every part of the body. Various types of cells are scattered through a gel-like matrix, called *amorphous ground substance,* along with wavy ribbons and cylindrical threads of protein fibers.
- **Dense regular connective tissue:** The secretory cells of this type of connective tissue produce dense bands and sheets of parallel protein fibers, like those in ligaments and tendons.
- **Dense irregular connective tissue:** The protein fibers in this tissue type are arranged in thick, tough, irregularly-oriented bundles. The dermis is a typical tissue of this type (see Chapter 6).
- **Adipose tissue (a type of loose connective tissue):** Composed of fat cells, adipose tissue provides fuel storage as well as support and protection to its underlying structures.
- **Reticular tissue (a type of loose connective tissue):** This type of tissue forms a web or net and functions as a filter in such organs as the spleen, the lymph nodes, and the bone marrow.

Continuing with epithelial tissue

Epithelial tissue forms the epidermis of the *integument* (the skin and the accessory structures such as sweat glands, oil glands, nails, and hair follicles; see Chapter 6), a continuous covering of the outside of the body, and the *endothelium,* a continuous lining of the internal surfaces of the blood vessels.