The Mitotic Phase

The mitotic phase is a multistep process where chromosomes in the duplicated state are aligned, separated, and moved to opposite poles of the cell. The cell is then divided into two new *identical* daughter cells. The first portion of the mitotic phase, **mitosis**, is composed of five stages. Each stage has key events which allow for the chromosomes to be equally divided amongst the two daughter cells. The second portion of the mitotic phase, called **cytokinesis**, is the physical separation of the cytoplasmic components into two new daughter cells.

Mitosis

Mitosis is divided into five phases: prophase, prometaphase, metaphase, anaphase, and telophase. Each of these phases includes important events that allow for equal division of the chromosomes into two new daughter cells (Figure 8.11).

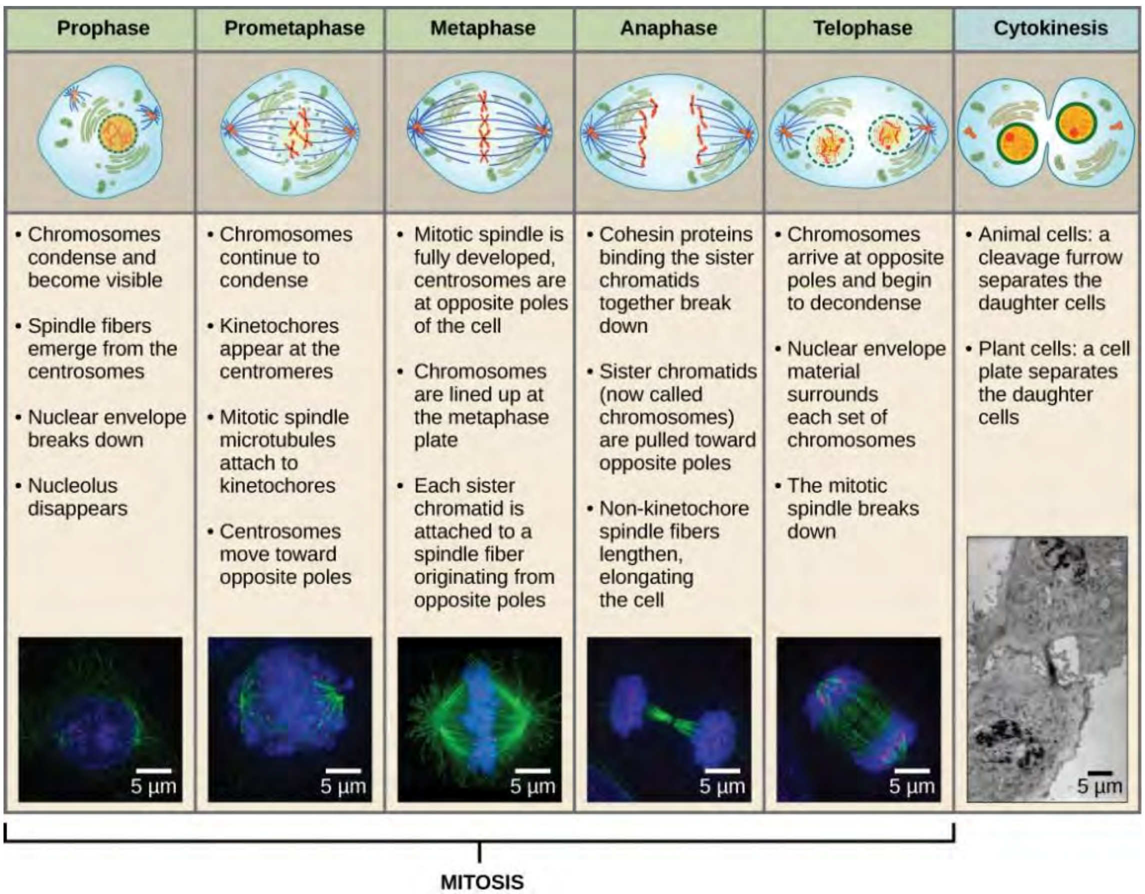

Figure 8.11 Animal cell mitosis is divided into five stages—prophase, prometaphase, metaphase, anaphase, and telophase—visualized here by light microscopy with fluorescence. (credit "diagrams": modification of work by Mariana Ruiz Villareal; credit "mitosis micrographs": modification of work by Roy van Heesbeen; credit "cytokinesis micrograph": modification of work by the Wadsworth Center, NY State Department of Health; donated to the Wikimedia Foundation; scale-bar data from Matt Russell/ Concepts of Biology OpenStax)

Prophase

During **prophase**, the first phase of mitosis, several events occur which will allow chromosomes in the duplicated state to be divide. During this phase, the nuclear envelope starts to breakdown into small vesicles. The Golgi apparatus and endoplasmic reticulum fragment and disperse to the outer edges of the cell, and the nucleolus disappears. The centrosomes begin to move to opposite poles of the cell with the help of microtubules. As the microtubules begin to form the mitotic spindle, they extend between the centrosomes, pushing the centrosomes farther and farther apart. The sister chromatids begin to coil tightly and become visible when using a light microscope.

Prometaphase

During **prometaphase**, many of the processes that began in prophase continue. The remaining nuclear envelope completely disappears. The mitotic spindle continues to develop as more microtubules are formed and then stretched across the entire length of the cell. Chromosomes become more condensed, and individual chromosomes become more visible. A protein complex called the **kinetochore** attaches each sister chromatid to microtubules at the centromere region.

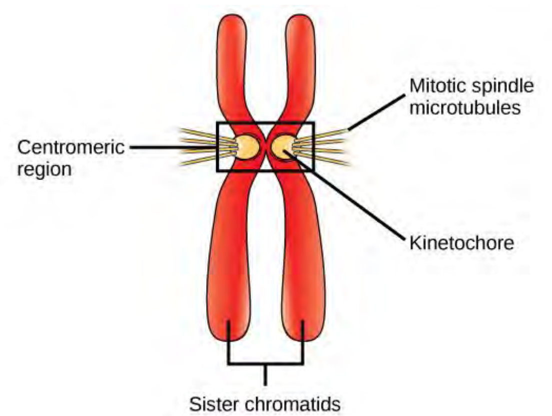

Figure 8.12 During prometaphase, mitotic spindle microtubules from opposite poles attach to each sister chromatid at the kinetochore. (credit: Clark et al. / Biology 2E OpenStax)

Metaphase

During **metaphase**, all the chromosomes align in a region called the metaphase plate with the help of the mitotic spindle. The **metaphase plate** is a region midway between the two poles of the cell. The sister chromatids are tightly attached to one another. At this time, the chromosomes are in their most condensed form.

Anaphase

During **anaphase**, the sister chromatids are split apart with the help of both the kinetochore proteins and the spindle fibers. Each chromatid is now referred to as a chromosome in the unduplicated state. Each chromosome is rapidly pulled toward the centrosome to which its microtubule is attached. The cell becomes visibly elongated as the microtubules slide against each other at the metaphase plate.

Telophase

During **telophase**, as the chromosomes reach the opposite poles, they begin to decondense or unravel. The mitotic spindles are broken down into amino acid monomers that will be used to assemble the cytoskeleton for each daughter cell. Two nuclear envelopes begin to form around each separated group of chromosomes.

Cytokinesis

Cytokinesis is the second part of the mitotic phase. During **cytokinesis**, cell division is completed when the cytoplasmic components are physically separated into two identical daughter cells. Although the stages of mitosis are similar for most eukaryotes, the process of cytokinesis is very different for eukaryotes that have cell walls, such as plant cells.

In cells that lack cell walls, such as animal cells, cytokinesis begins during anaphase. A contractile ring composed of actin protein filaments forms just inside the plasma membrane at the center of the cell. The microfilaments pull the equator of the cell inward, forming a fissure called the **cleavage furrow**. The cleavage furrow deepens as the actin ring contracts, and eventually, the membrane and cell are cleaved into two separate identical daughter cells (Figure 8.12).

In plant cells, a cleavage furrow is not possible because of the rigid cell walls surrounding the plasma membrane. A new cell wall must form between the two daughter cells. During interphase, the Golgi apparatus accumulates enzymes, structural proteins, and glucose molecules, which will later be used to build the new cell wall. Once these materials are collected, the Golgi apparatus breaks into vesicles that disperse throughout the dividing cell. During telophase, microtubules move these Golgi vesicles to the metaphase plate. Once there, the vesicles begin to fuse, forming a structure called the **cell plate**. As more vesicles fuse, the cell plate enlarges until it merges with the cell wall at the periphery of the cell. Enzymes use the glucose that has accumulated between the membrane layers to help build a new cell wall of cellulose. (Figure 8.13).

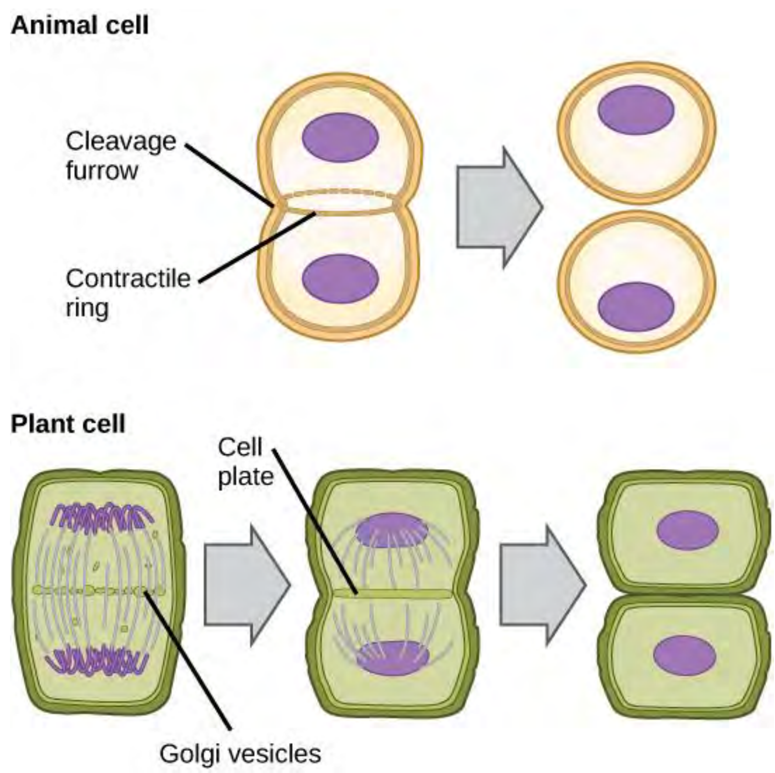

Figure 8.13 In part (a) a cleavage furrow forms at the former metaphase plate in the animal cell. In part (b) The cell plate grows from the center toward the cell walls. (credit: Clark et al. / Biology 2E OpenStax)