As seen in figure 2.5, every chromosome is composed of sister chromatids. The chromosome has a waistline that represents the position of the centromere. The structure from the centromere to the tip (telomere) of the chromosome is the chromosome arm. The length of the chromosome arms depends on the type of chromosome based on the position of the centromere.

MITOSIS

The M phase or division phase is the stage when actual cell division takes place (fig. 2.6). In *mitosis*, the cell division happens in somatic cells (body cells) as well as in sex cells (cells involved in sexual reproduction). The chromosomes in somatic cells (2n) are derived from the fusion of unpaired haploid cells (n) from the paternal and maternal parents. In diploid individuals, the haploid chromosome number that represents the complete set of chromosomes from the male or female parent is called the *genome* (X). In mitosis, a cell divides to produce two new cells that are genetically identical to each other and are identical to the original or parental cell. Mitosis has two parts; *karyokinesis* (division of nuclear content) and *cytokinesis* (division of cytoplasmic content).

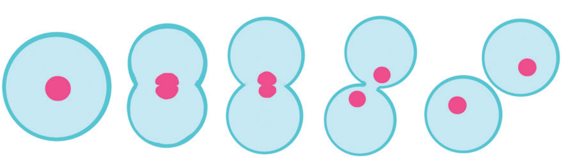


Fig. 2.6 In mitosis, after the genetic content is doubled, it is distributed equally to the two daughter cells, making them identical to each other.

Karyokinesis

During mitosis, the chromosomes are already visible. The chromosome is composed of *chromosome arms* and the centromere or the primary constriction (fig. 2.7). The tip of the chromosomes has telomeres. Since before mitosis, the cell enters S phase where the DNA is replicated, each of the chromosome is composed of sister chromatids.

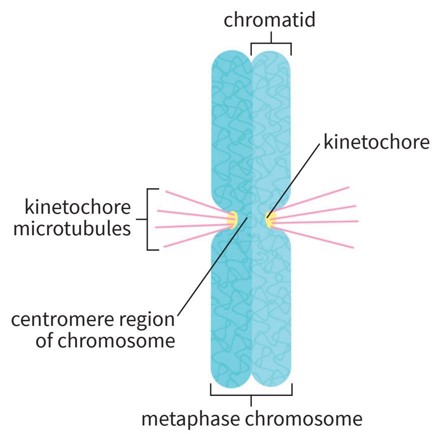


Fig. 2.7 The kinetochore proteins attach to the centromere, while the microtubules or spindle fibers attach to the kinetochore proteins.

Depending on the position of the centromere, chromosomes may be classified as metacentric, submetacentric, acrocentric, and telocentric (fig. 2.8). In a metacentric chromosome, the centromere is in the middle of the chromosome arm, that is, the length of the chromosome arms is equal. In *submetacentric* chromosome, the centromere is located submedian, with one arm longer than the other. When the centromere is located subterminal, with a shorter arm in one end and longer one in the other end, the

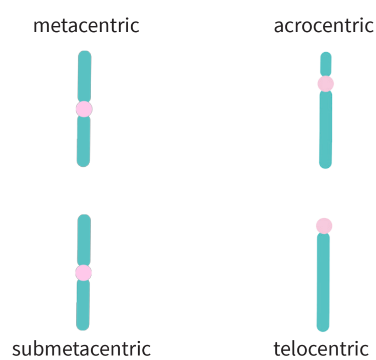
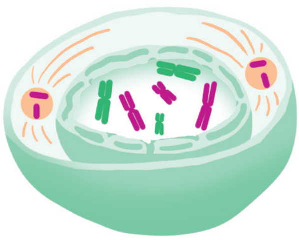
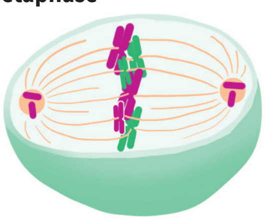
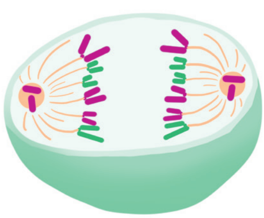
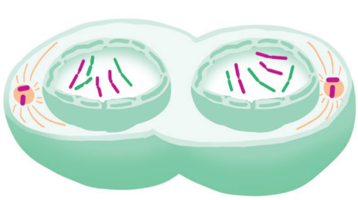


Fig. 2.8 Types of chromosomes based on the position of the centromere: (*a*) metacentric, (*b*) submetacentric, (*c*) acrocentric, and (*d*) telocentric

chromosome is *acrocentric*. In *telocentric* chromosome, the centromere is located at the terminal end of the chromosome arm.

Mitosis is divided into four stages: prophase, metaphase, anaphase, and telophase. Table 2.1 shows the stages of mitosis and their outstanding features, considering the division of a somatic cell with 2n = 6.

Table 2.1 Stages of mitosis and their outstanding features

STAGES OF MITOSIS	OUTSTANDING FEATURES	CHROMOSOME/ CHROMATID PER CELL OR PER POLE
Prophase 	[redacted]	[redacted]
Metaphase 	[redacted]	[redacted]
Anaphase 	[redacted]	[redacted]
Telophase 	[redacted]	[redacted]

Cytokinesis

Cytokinesis is the second phase of the cell cycle when the cytoplasm divides, creating two daughter cells. The first part (mitosis) is the division of nuclear content, while the second part (cytokinesis) is the division of the cytoplasmic content.

Cytokinesis completes the cell division by dividing the cytoplasm into two daughter cells. In animals, many fungi, and protist, cytokinesis happens through furrowing. The furrow girdles the cell, which deepens to finally divide the cytoplasm into two. In plants, cytokinesis happens through cell plate formation, wherein a new cell wall is formed and grows laterally until it divides the cytoplasm into two and forms two cells.

Cells undergoing mitosis can be observed under a microscope. Onion (*Allium cepa* L.) is a popular example for observing mitosis. The root tip of an onion has a meristematic region, the region of active cell division. This meristematic region is a good source of dividing cells. The cells are processed and stained with a dye, which has a high binding affinity to the chromosomes. The stained chromosomes become visible under the microscope, and the different stages can easily be differentiated. Figure 2.9 shows images of onion cells undergoing each of the four stages of mitosis.

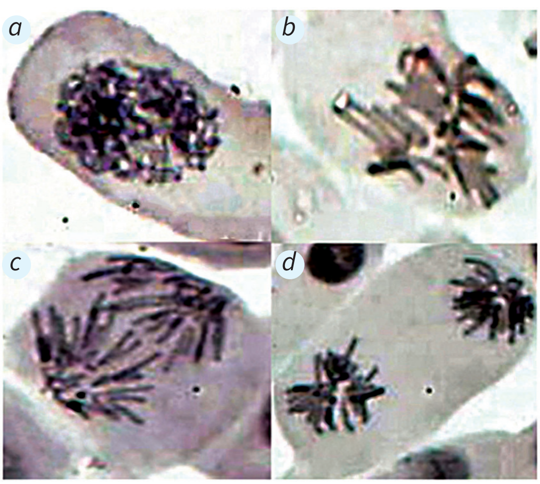


Fig. 2.9 Onion cells undergoing (*a*) prophase, where the chromosomes are clumped at the center of the cell; (*b*) metaphase, where the chromosomes are found at the equatorial plate; (*c*) anaphase, where the chromosomes move to the opposite poles; and (*d*) telophase, where the chromosomes regroup in each opposite poles.

The Role of Mitosis

Mitosis plays significant functions in living organisms. It is important for asexual reproduction. Unicellular organisms such as baker's yeast (*Saccharomyces cerevisiae*) multiply or increase in number through mitosis. In humans, the fusion of a sperm cell and an egg cell forms a single fertilized egg, which then undergoes repeated mitosis to develop into a fetus. An average adult individual is composed of trillions of cells. In plants, after the male and female gametes fused, mitosis occurs to give rise to a multicellular organism. Every cell that undergoes mitosis must precisely transmit the correct amount of genetic material to its daughter cells.

If, for example, you are accidentally hurt and wounded after playing a game, the cells in the periphery of the wound would undergo mitosis. Cells would continue dividing until they come in contact with each other. This is called *contact inhibition*. The cells would cease to divide further if the wound had already been covered with new cells.

Mitosis is also very important in the regeneration of epidermal cells of burn patients. Epidermal cells of patients are induced to undergo mitosis in culture that can be used for epidermal grafts.

The use of tissue culture for clonal propagation of agricultural plants like bananas would produce plants that are genetically identical to each other because they were derived from the shoot meristem of the parental plant. Shoot tips are placed aseptically on culture medium and induced to form little plants inside the culture bottles. These plants are identical to each other because in the initial stage of tissue culture, the cells divide through mitosis.