

Figure 1.1 Schematic representation of a human cell

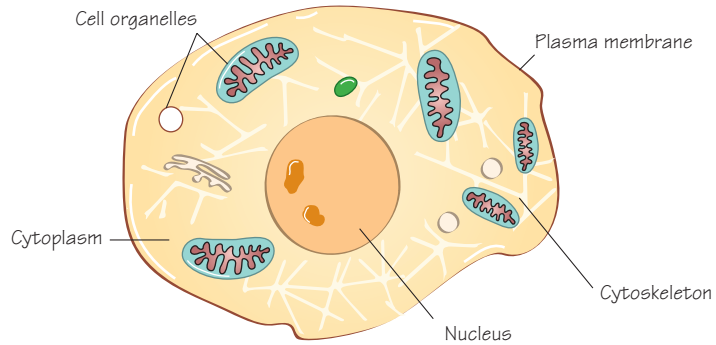


Figure 1.2 Cell division and the cell cycle

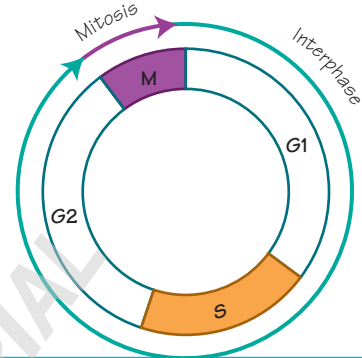
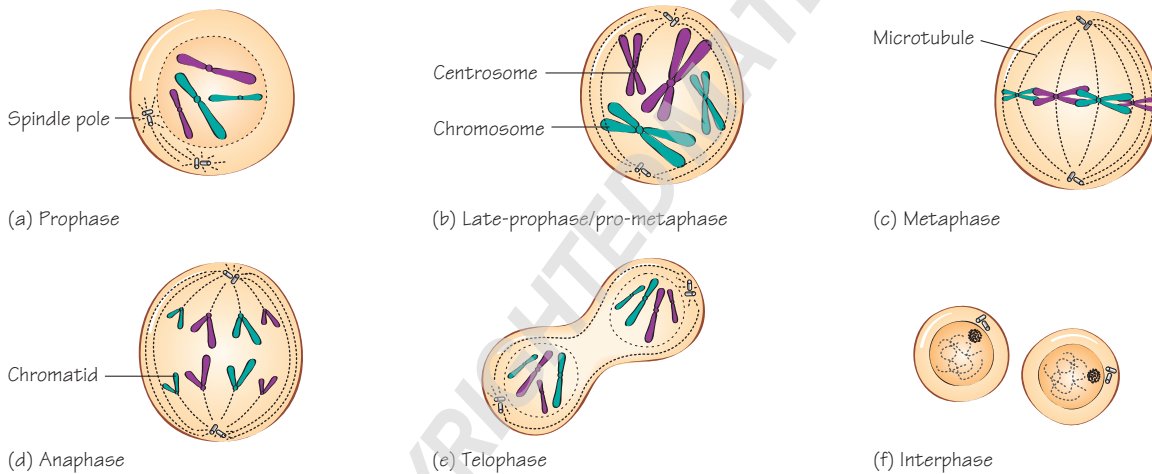


Figure 1.3 A schematic view of mitosis. (a) prophase; (b) late-prophase/pro-metaphase; (c) metaphase; (d) anaphase; (e) telophase; (f) interphase



A cell is the smallest functional and structural unit capable of replicating itself. As such, a cell is considered the basic unit of life. The boundary of a cell is the **plasma membrane** (see Chapter 2), while the **cytoskeleton** provides structural support (Figure 1.1). Cells of the human body have a characteristic nuclear compartment, which contains the genetic material, and are thus classified as **eukaryotic** cells as opposed to **prokaryotic** bacterial cells, which do not contain a nucleus. Cellular structures with specific functions, **organelles**, are discussed in Chapter 3.

Tissues

There are more than 200 different types of cells in the human body. These types are highly specialised (**differentiated**) to carry out specific functions. Groups of cells carrying out a similar function and forming a structure are called **tissue**. Different tissues combine to form organs. There are four main types of tissue.

- **Epithelial** tissue is found at the boundaries of structures in the body. The basal (**basolateral**) side faces the underlying tissue, which provides nutrients and support, while the **apical** side is exposed to a different environment. For instance, the apical side of intestinal epithelium faces the inside of the intestine and is exposed to constituents from (digested) food; the apical side of stomach epithelium is exposed to the acidic environment inside the stomach; lung and skin are exposed to air. Secreting glands are also formed by epithelial tissue. There are distinct types of epithelial structures:

- **stratified** epithelium: formed by layers of epithelial cells;
- **simple** epithelium: formed by a single layer of cells;
- **squamous** epithelium: formed by cells which are wider than tall;
- **columnar** epithelium: formed by cells which are taller than wide.

- Stratified squamous epithelium can be **keratinised**, forming a hard and dry layer as found in the skin, nails and hair, or **non-keratinised**, which is found in soft tissue such as the inside of the mouth. An example of simple columnar epithelium is the lining of the stomach.

- **Connective** tissue provides structure and rigidity. It is characterised by a large space between cells, which is filled with fibrous material that is part of the **extracellular matrix**. **Fibroblasts** are the most common cell type in connective tissue. **Adipose** tissue stores energy in the form of fat, but is also important for the protection and insulation of organs and is now recognised as having an endocrine role. Other types of connective tissue include blood, cartilage and bone.

- **Muscle** cells (**myocytes**) are characterised by their ability to contract when they receive appropriate signals. There are three different types of muscle tissue: skeletal muscle is directly attached to bones; cardiac muscle is the muscle of the heart; smooth muscle lines blood vessels and organs of the body.

- **Nerve cells** can sense stimuli and transfer electrical signals to chemical signals, which are sensed by surrounding cells. Nerve cells can have long extensions that are involved in the sensing and transmission of signals (Chapters 18 and 19).

Cell division

The mass and volume of tissues can increase by **cell growth**, the increase of cell mass and volume by taking up nutrients and synthesis-

ing new cell structures, and **cell proliferation**, the increase of cell numbers by cell division. There are two types of cell division.

- **Mitosis**, in which each daughter cell acquires the same amount of genetic material as the parental cell.

- **Meiosis**, in which each daughter cell acquires half the amount of genetic material of the parental cell, only occurs in specialised germ tissue.

When cells receive signals to divide they progress through the cell cycle (Figure 1.2). In adult tissue, most cells reside in the **interphase**. The interphase can be further divided into three phases. In the **G1 phase** (first gap phase), cells prepare for the duplication of the genetic material. When cells start duplicating their DNA, they progress through the **S phase** (synthesis phase). Following the **G2 phase** (second gap), cells undergo mitosis (**M phase**). Compared with the interphase, the mitotic phase is very short. Mitosis (Figure 1.3) can be separated into the following distinct stages.

- **Prophase**: the DNA/chromatin condenses and the characteristic chromosomes become visible. The **mitotic spindle** starts to form outside the nucleus.

- In the **late prophase/pro-metaphase**, the nuclear membrane starts to degrade and the mitotic spindle body moves into the nuclear region. Regions in the chromosomes, **centrosomes**, are attached to the mitotic spindle.

- **Metaphase**: the chromosomes are aligned in the centre plane between the spindle poles.

- **Anaphase**: the chromatids of the sister chromosomes start to separate while the spindle poles move further apart.

- **Telophase**: the chromatids reach the spindle poles, which starts to disappear. The chromatids decondense and a nuclear membrane is formed around the chromatids.

During mitosis, the division of the cytoplasm between the two daughter cells is called **cytokinesis**. Cytokinesis starts during prophase, but is not completed until after the end of telophase when the two daughter cells have formed.

Stem cells

Stem cells are undifferentiated cells with two characteristics.

- **Self-renewal**: the ability to repeatedly divide while maintaining an undifferentiated state. Stem cells undergo **asymmetric cell division**: one of the daughter cells retains stem cell characteristics while the other daughter cell undergoes differentiation.

- The ability to differentiate into specialised cell types.

Stem cells are **pluripotent** if they retain the ability to differentiate into all cell types and tissues. For example, **embryonic stem cells** are pluripotent stem cells derived from early-stage embryos. **Adult stem cells** are not pluripotent, but are more specialised and can only form one or several tissues. For example, adult haematological stem cells isolated from the bone marrow can differentiate into the various cell types found in blood. Other adult stem cells are more specialised, e.g. skin stem cells found in the epidermis, which can only differentiate into skin cells. **Induced pluripotent** stem cells are derived from differentiated tissue that is genetically reprogrammed to return to their undifferentiated state.