

0.1 Cell Theory

Definition 0.1 (Cell Theory). The cell theory states

1. All living things are made of one or more cell.
2. The cell is the simplest unit that can carry out all life processes.
3. All cells come from pre-existing cells.

Additionally:

- Cells have not been synthesized in labs yet.
- Appeared 3.8 billion years ago.
- Hydrothermal vents created electrical gradient to form first organic molecules such as amino acids and nucleotides.
- First cell is presumed to be self-replication RNA enclosed by phospholipids.



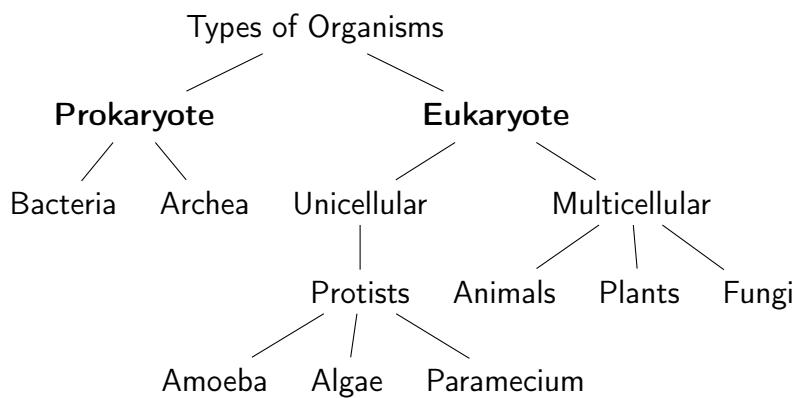
Figure 0.1: Robert Hooke invented the simple microscope to look at thin pieces of cork tree. Classical cell theory was proposed by Schwann, Schleiden, and Virchow.

0.2 Prokaryote and Eukaryote

Organisms are divided into two types: prokaryote and eukaryote.

Definition 0.2 (Prokaryote). Organisms that have cells which contain **no nucleus**.

Definition 0.3 (Eukaryote). Organisms that have cells which contain **a nucleus**. These fit under either **unicellular** or **multicellular**, meaning one nucleus and more than one nucleus, respectively.



0.3 Organelles

Definition 0.4 (Organelles). An organelle is a small structure in a cell that is surrounded by a membrane and has a specific function.

Basically, that organelles act like the organs in your body but instead it is for the cell. There are many different organelles, varying for plants and animals.

0.3.1 Cell Membrane

Definition 0.5 (Cell Membrane). The cell membrane is like the outer wall of the cell. It is semi-permeable, meaning it allows only certain substances/materials through. See Figure 0.2.

The cell membrane is made of a double layer of lipids. A lipid is a fat-like molecule that does not dissolve in water.

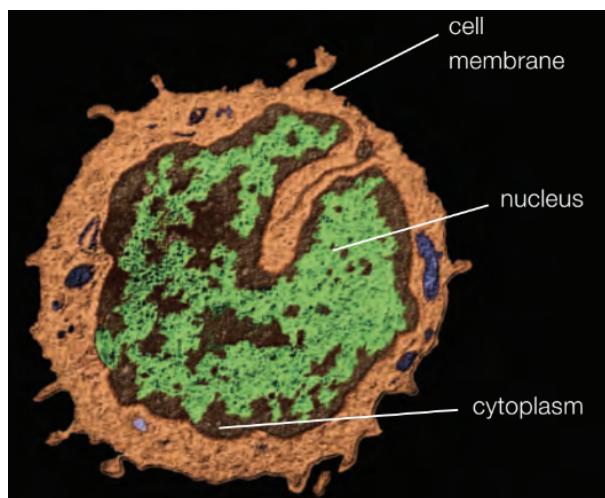


Figure 0.2: A cell showing the cell membrane, cytoplasm, and large nucleus.

0.3.2 Cytoplasm

Definition 0.6 (Cytoplasm). The cytoplasm is a gel-like substance that fills the cell and surrounds organelles. Cytoplasm contains the nutrients required by the cell to carry on its life purposes. See Figure 0.2.

All organelles are suspended in cytoplasm. The physical nature of the cytoplasm allows the nutrients and organelles to move within the cell.

0.3.3 Nucleus

Definition 0.7 (Nucleus). The nucleus is the control center of the cell. It controls all activities in the cell, including growth and reproduction. One important thing is that it contains nearly all of the cell's DNA. See Figure 0.3.

Note: DNA stands for deoxyribonucleic acid. DNA is very important to the cell because it contains the coded information for making proteins and other molecules. Proteins serve many purposes and are found in various locations of the cell.

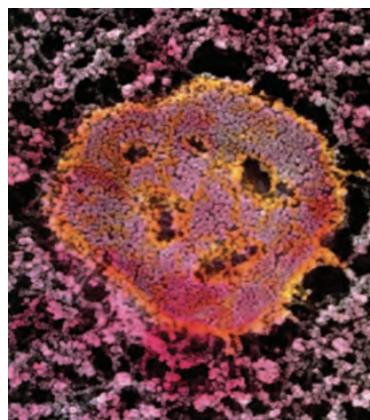


Figure 0.3: The nucleus and chromatin in a human cell, as seen through an electron microscope.

0.3.4 Vesicles

Definition 0.8 (Vesicles). Vesicles are membrane-bound organelles that store nutrients, waste, and other substances used by the cell. Vesicles can fuse with the cell membrane.

0.3.5 Vacuoles

Definition 0.9 (Vacuoles). Vacuoles are basically vesicles but bigger and do not fuse with the cell membrane. You can think of them as the storage system. See Figure 0.4./

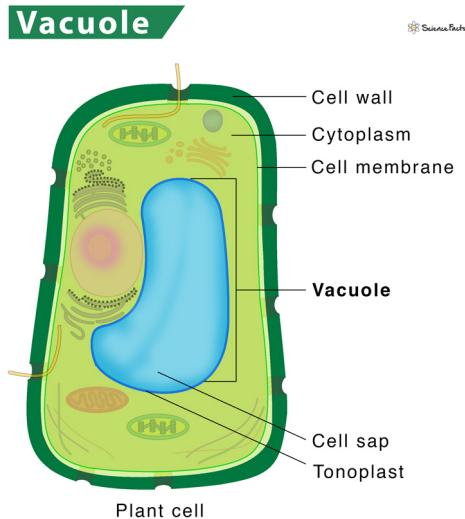


Figure 0.4: A vacuole inside of a plant. You can tell it is inside of a plant because a plant only has ONE large vacuole.

0.3.6 Mitochondria

Definition 0.10 (Mitochondria). The powerhouse of the cell. The mitochondria supplies the cell with energy by converting the chemical energy within sugar into energy that the cell can use. See Figure 0.5.

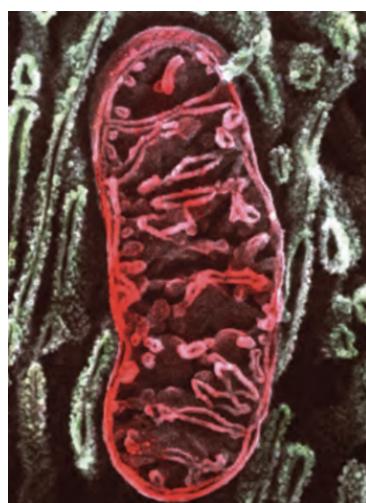


Figure 0.5: A mitochondrion, as seen through an electron microscope.

0.3.7 Lysosomes

Definition 0.11 (Lysosomes). Lysosomes are organelles where digestion takes place. They are small organelles that are filled with enzymes. Lysosomes also break down

| invading bacteria and damaged cell organelles. See Figure 0.6.

Essentially, they work as the clean-up system in the cell.

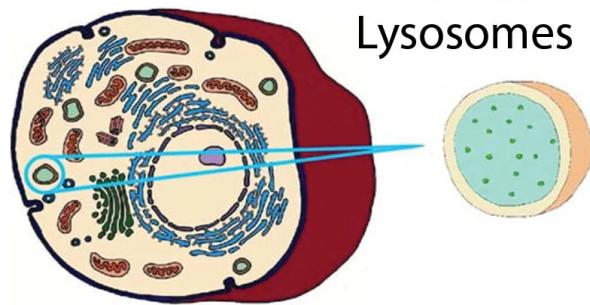


Figure 0.6: Lysosomes

Note (Enzyme): An enzyme is a protein that can speed up chemical reactions in the cell.

0.3.8 Rough Endoplasmic Reticulum

| **Definition 0.12** (Rough Endoplasmic Reticulum). The rough endoplasmic reticulum is like a conveyor belt for proteins and nutrients that are destined for the nucleus. The rough endoplasmic reticulum is studded with ribosomes which allows it to easily transport proteins once they are made. You can think of the rough endoplasmic reticulum as an organelle that synthesizes proteins. See Figure 0.7.

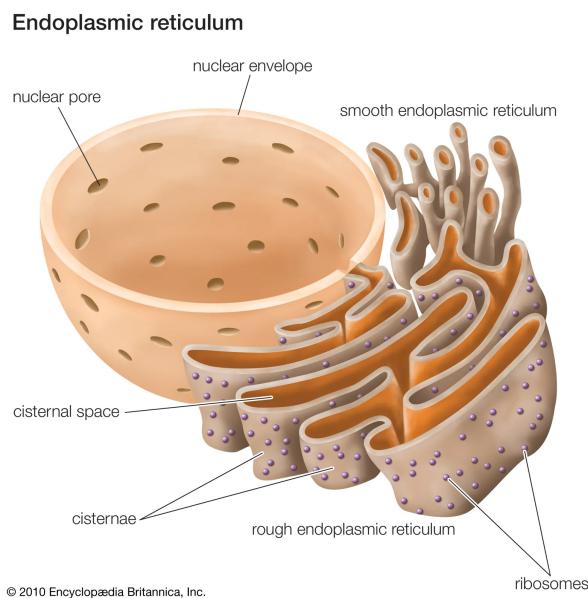


Figure 0.7: The rough and smooth endoplasmic reticulums.

0.3.9 Smooth Endoplasmic Reticulum

Definition 0.13 (Smooth Endoplasmic Reticulum). Similar to the smooth endoplasmic reticulum, except that it lacks ribosomes and is involved in lipid metabolism, including the synthesis of phospholipids, steroids, and other lipids. See Figure 0.7.

Note (Lipid): Lipid is another word for "fat".

Basically, the rough endoplasmic reticulum is involved in protein synthesis and processing, whereas the smooth endoplasmic reticulum is involved in lipid metabolism and detoxification. The main difference is the presence of ribosomes in both cases.

0.3.10 Ribosomes

Definition 0.14 (Ribosomes). Ribosomes are small, dense-looking organelles that may be attached to the rough endoplasmic reticulum or free in the cytoplasm. Ribosomes are the sites where the proteins are assembled.

0.3.11 Golgi Body/Apparatus

Definition 0.15 (Golgi Body/Apparatus). The golgi body receives proteins from the endoplasmic reticulum and processes them for removal from the cell. They modify, sort, and package these proteins for delivery throughout the cell or outside of the cell. The golgi body looks like a stack of flattened membranes (see Figure 0.8).

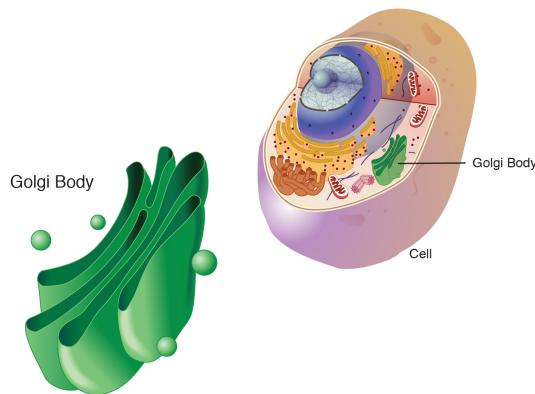


Figure 0.8: Golgi body.

0.3.12 Cytoskeleton

Definition 0.16 (Cytoskeleton). The cytoskeleton gives structure to the cell and is made of protein filaments.

0.3.13 Chloroplast

Definition 0.17 (Chloroplast). Chloroplasts are only found in plants cells and some algae. Contains a pigment called chlorophyll that absorbs light and energy to undergo photosynthesis



Note (Thylakoids): Chloroplasts are made of little sacs called **thylakoids**. A stack of thylakoids is called a **grana**. You can think of the thylakoids as solar panels.

0.4 Animal vs Plant Cells

Plant cells contain all of the organelles contained within animal cells, except for a few extra.
To contrast

Animal Cell	Plant Cell
<ul style="list-style-type: none">• Nucleus• Nuclear membrane• Cytoplasm• Endoplasmic Reticulum (ER); smooth and rough• Ribosomes• Golgi apparatus/body• Vesicles• Vacuoles• Mitochondria• Cell membrane• Lysosomes	<ul style="list-style-type: none">• All of the previously mentioned...• Chloroplast• Cell wall• Large central vacuole

Table 0.4.1: Plant cells have an extra **chloroplast, cell wall, and large central vacuole.**

See Figure 0.9 for animal cell and Figure 0.10 for plant cell.

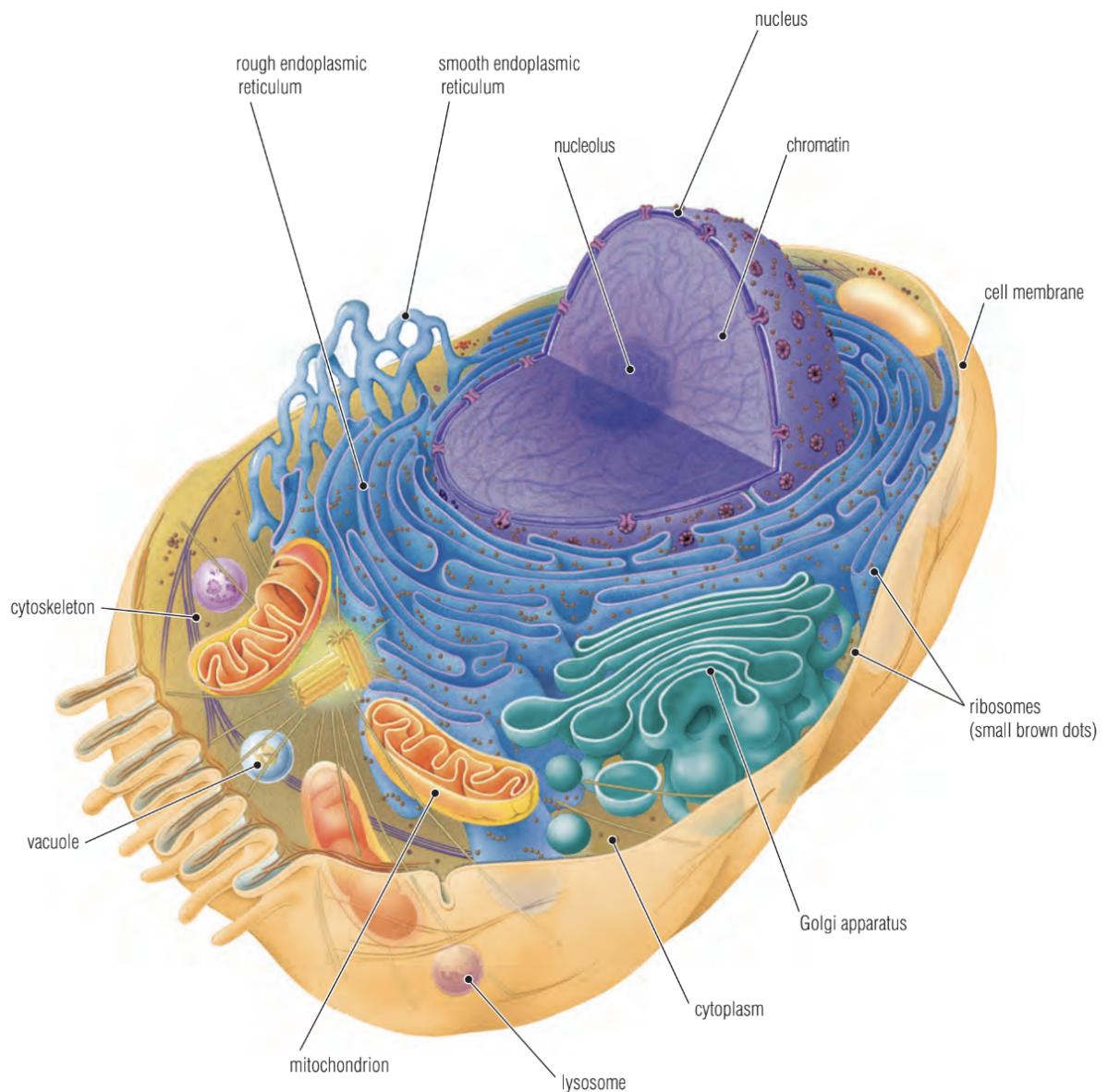


Figure 0.9: Animal cell.

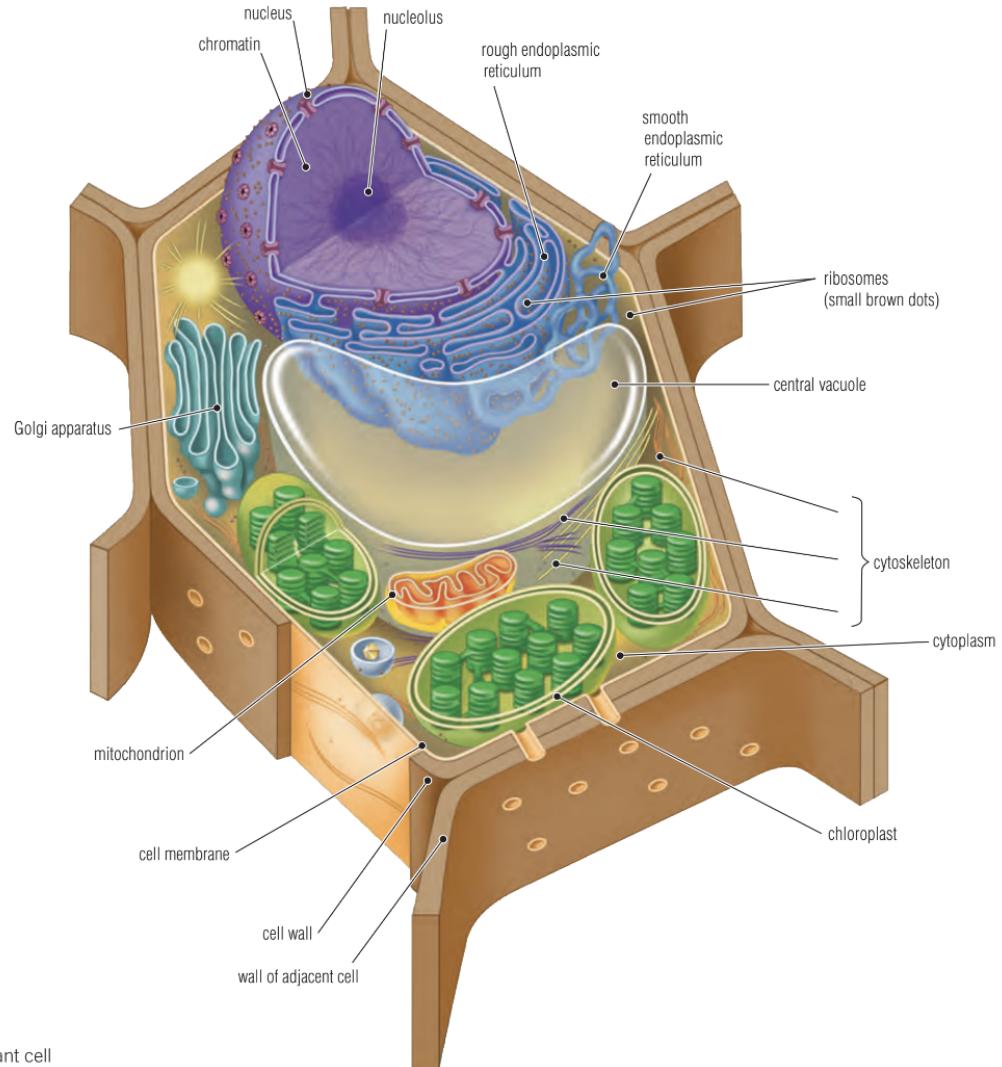


Figure 1.5 A plant cell

Figure 0.10: The plant cell contains an extra chloroplast, cell wall, and large central vacuole.

0.5 Histology

Definition 0.18 (Histology). A branch of study that concerns the study of biological tissues using a microscope.

Thin slices are placed on microscope slides to be visualized underneath a microscope. Specimens stained with various dyes and chemicals to visualize organelles.

0.6 Asexual vs Sexual

0.6.1 Asexual

Definition 0.19 (Asexual). Producing from only one parent. Exact same genes/DNA of the parent cell.

Advantages:

- Only need one parent.
- Very efficient; not many resources are required to initiate asexual reproduction.
- Happens very quickly.

Disadvantages:

- Decreases overall genetic resilience of the population.
- In turn there will be issues with diseases wiping out the entire population. This is because if there is say ebola, then it will wipe out everyone, since everyone is the same. If it kills one person, it will kill everyone too.

0.6.2 Sexual

Definition 0.20 (Sexual). Producing offspring by fusion of two gametes (egg and sperm). Offspring will have genetic material from both parents and newer cells will be created through mitosis.

Advantages:

- Genetic variability of the population will be high.
- As a result, the population will be more resilient in the face of pathogens.
- For example, some people weren't affected at all by the bubonic plague because they had a slight variance in their genetics that made them immune to the disease.

Disadvantages:

- Two parents are required; slower than asexual reproduction.
- Time and energy are required to find a suitable mate for reproduction.
- Not every individual in the population gets to reproduce. Example: fat and obese people have a lower chance to reproduce than muscular people.
- Genetically heritable conditions can be passed down. Example: diabetes.

0.7 The Cell Cycle

Definition 0.21 (Cell Cycle). In your body, cells are constantly dying and being replenished. During much of the cell cycle, the cell prepares for **cell division**. The three stages are:

1. Interphase
2. Mitosis
3. Cytokinesis

See Figure 0.11.

Cell division occurs for the purpose of reproduction. There are two types, namely **asexual** and **sexual**.

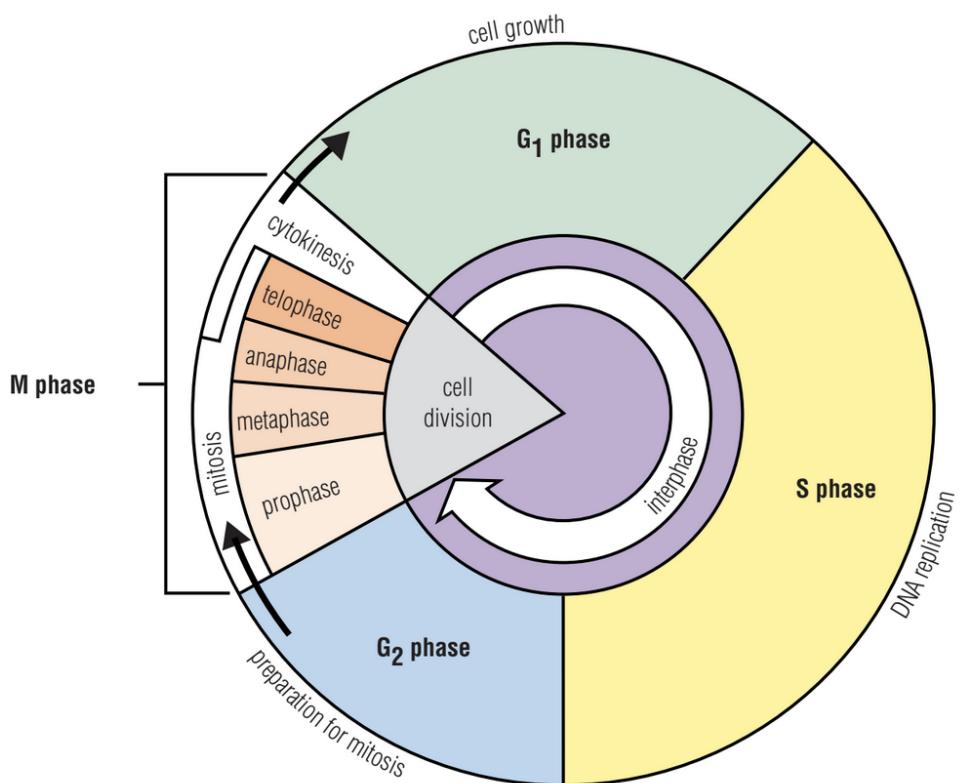


Figure 0.11: The cell cycle has four phases. During most of the cell cycle, the cell is growing, replicating its DNA, and preparing for cell division.

0.7.1 Cell Division

Definition 0.22 (Cell Division). Cell division is the process by which a single cell divides into two or more daughter cells. This process is essential for the growth and maintenance of all living organisms.

One method of cell division is known as **mitosis** (see Section 0.7.4).

Cell division allows organisms to **grow**.

- Nutrients move through diffusion (high concentration to low concentration).
- Water enters and leaves the cell through osmosis (high concentration to low concentration).
- Cells need to divide to ensure a high surface area to maximize diffusion of nutrients/waste and osmosis of water.
- We need lots of cells that will cover a greater surface area because it speeds up the process of diffusion.

Cell division allows organisms to **repair**.

- Organisms need to repair cells from damage or old age.

Repair Rate for Cells

Cell Type	Turnover Time
Stomache	2-4 days
Skin	10-30 days
Red blood cells	4 months
Liver cells	6-12 months
Brain cells	Life time

- Stages of skin regeneration:
 - New skin cells.
 - Coming to surface.
 - Degeneration process.
 - Dead skin cells.

0.7.2 Chromosomes

Definition 0.23 (Chromosomes). Each chromosome is a long piece of DNA and protein. They carry genetic information in the form of genes. The number of chromosomes between each organism varies. Chromosomes are only visible when the cell is dividing. See Figure 0.12.

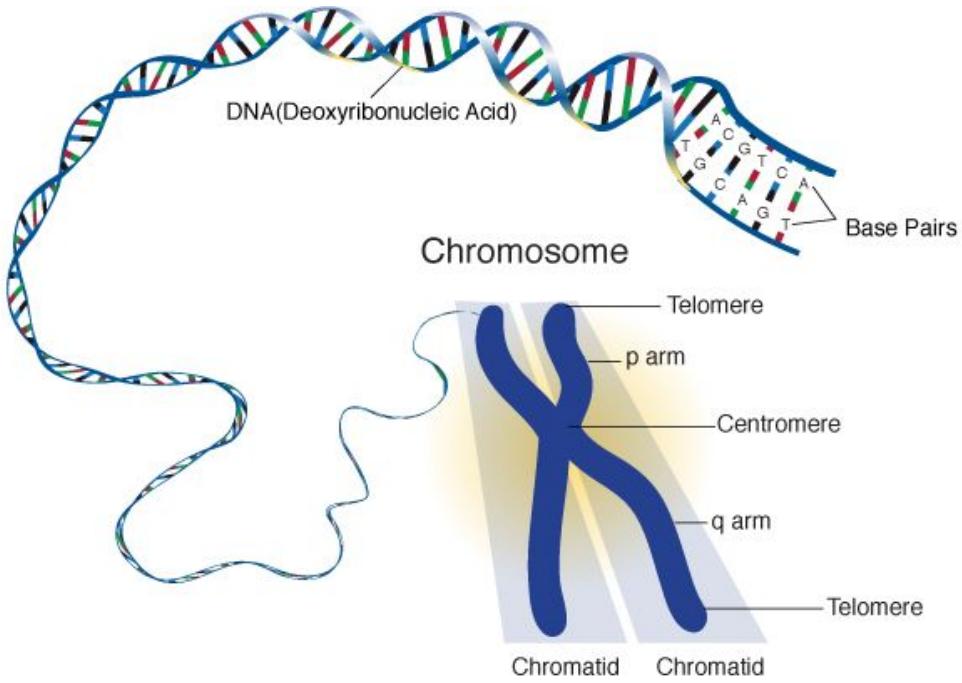


Figure 0.12: Chromosomes.

Before cell division can occur, each chromosome is copied, as shown in Figure 0.13. The chromosome consists of two identical copies, can **sister chromatids**. When the cell divides, one chromatid goes to each of the new cells.

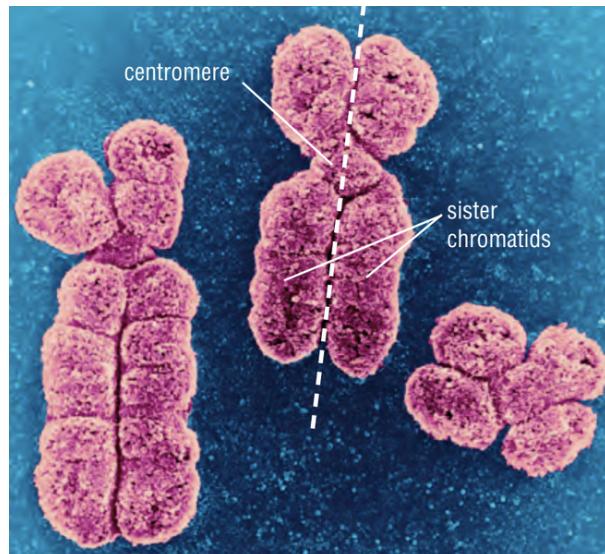


Figure 0.13: Each chromosome consists of two identical sister chromatids. The **centromere** is where the sister chromatids attach.

0.7.3 Interphase

Definition 0.24 (Interphase). The cell spends the most time in interphase. This phase refers to a period where the cell carries out its regular cell functions. This stage prepares

the cell for **mitosis**. There are three phases (in the particular order):

1. **G1 Phase:** the cell grows in size and carries out normal metabolic processes.
2. **S Phase:** DNA replication, resulting in the formation of two identical copies of the cell's genetic material.
3. **G2 Phase:** organelles are duplicated. The cell undergoes further growth and prepares for division by synthesizing proteins necessary for mitosis. See Figure 0.14.

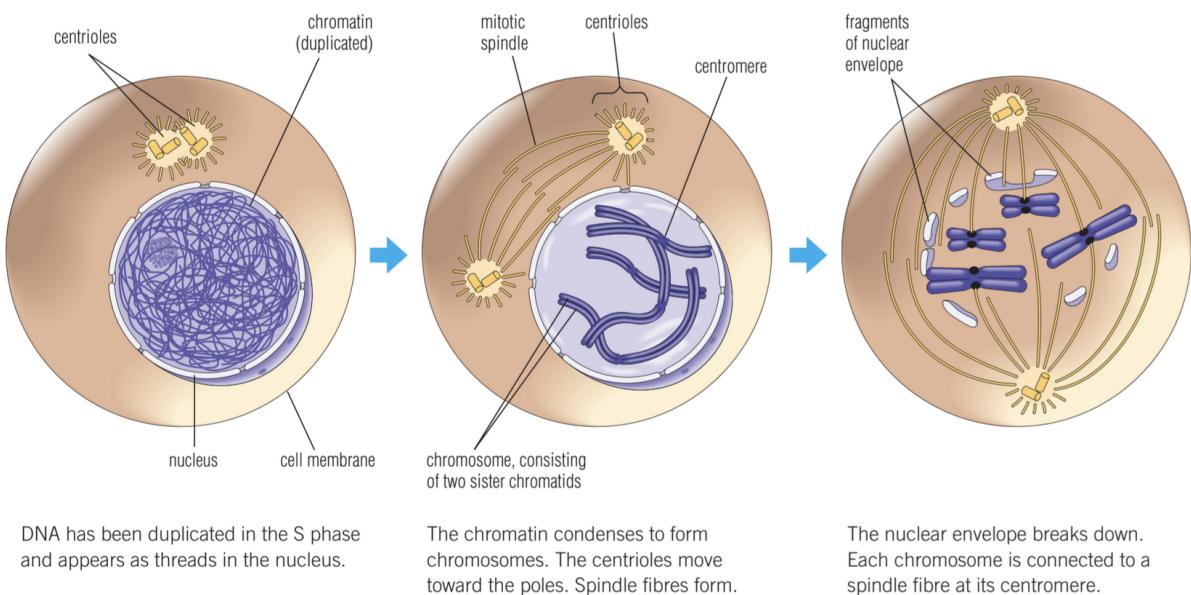


Figure 0.14: S phase and G2 phase.

Note: The cell grows until it reaches a certain size, at which it is healthier for the cell to undergo cell division.

0.7.4 Mitosis

Definition 0.25 (Mitosis). Mitosis is the stage in which DNA in the nucleus is divided. There are 4 stages of mitosis:

1. **Prophase:** the chromosomes shorten and thicken.
2. **Metaphase:** chromosomes line up in the middle of the cell.
3. **Anaphase:** chromatids break apart at the centromere and move to opposite poles.
4. **Telophase:** two nuclei formed after nuclear envelopes reform around each group of chromosomes.

| See Figure 0.15.

0.7.5 Cytokinesis

Definition 0.26 (Cytokinesis). Cytokinesis is the final stage of the cell cycle, where the cytoplasm is split and two daughter cells are formed. In an animal cell, this is done through the pinching of the membrane (cleavage furrow). In a plant cell, this is done through the formation of a cell plate.

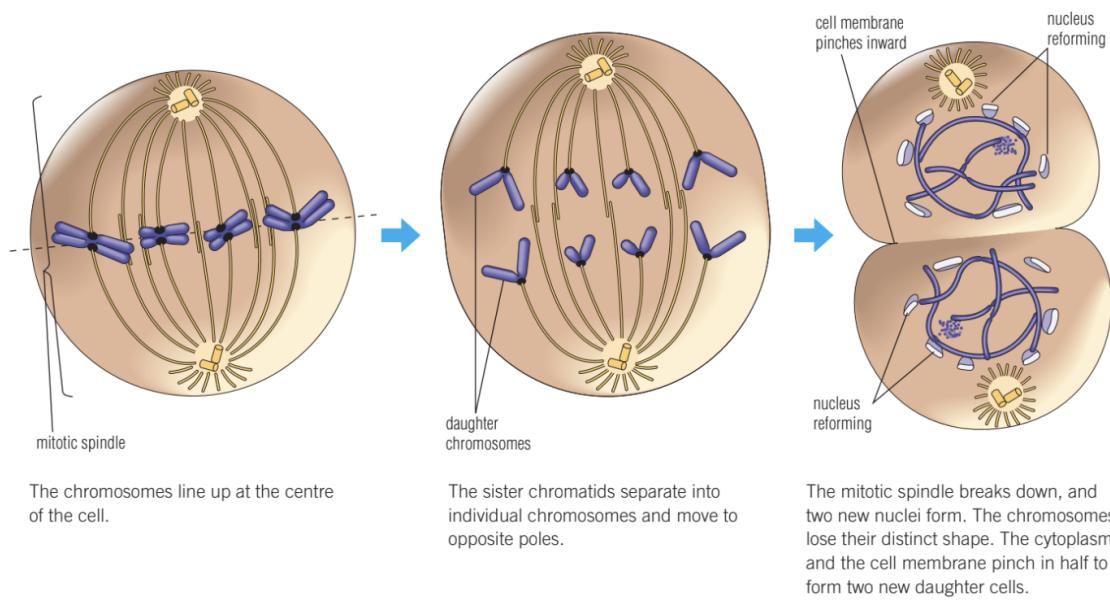


Figure 0.15: Prophase then metaphase, anaphase, and telophase then cytokinesis.