Contents

CHAPTER 1

Biology

1.1 Cell Theory

Definition 1.1 (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 nucleuotides.
- First cell is presumed to be self-replication RNA enclosed by phospholipids.

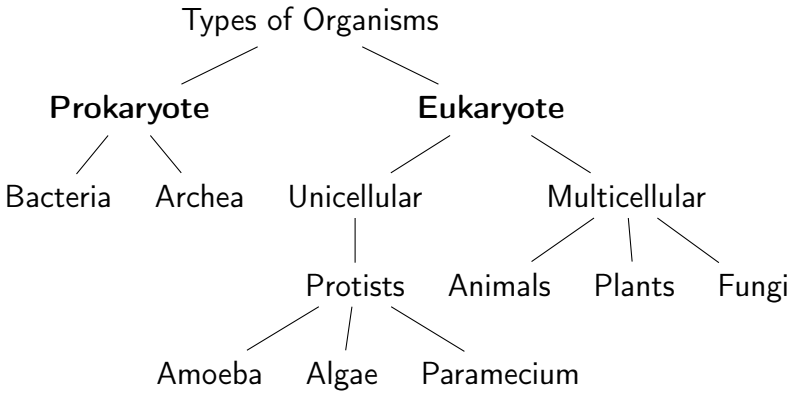
Figure 1.1: Robert Hooke invented the simple microscope to look at thin pieces of cork tree. Classical cell theory was proposed by Schwann, Schleiden, and Virchow.

1.2 Prokaryote and Eukaryote

Organisms are divided into two types: prokaryote and eukaryote.

Definition 1.2 (Prokaryote)**.** Organisms that have cells which contain **no nucleus**.

Definition 1.3 (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.



1.3 Organelles

Definition 1.4 (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.

1.3.1 Cell Membrane

Definition 1.5 (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 1.2.

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

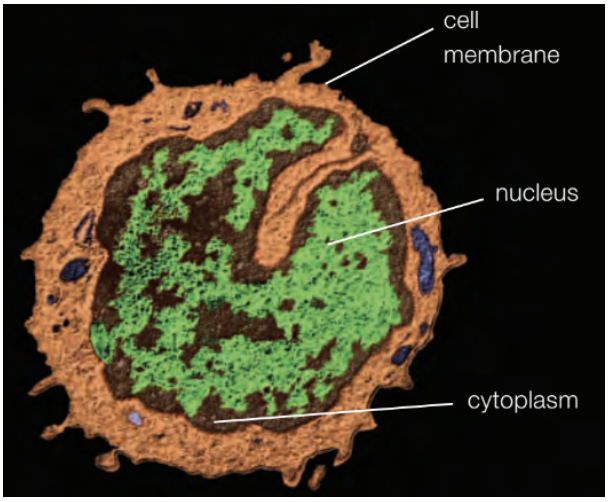


Figure 1.2: A cell showing the cell membrane, cytoplasm, and large nucleus.

1.3.2 Cytoplasm

Definition 1.6 (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 1.2.

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

1.3.3 Nucleus

Definition 1.7 (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 1.3.

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

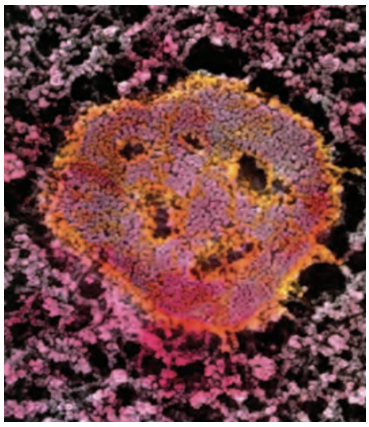


Figure 1.3: The nucleus and chromatin in a human cell, as seen through an electron microscope.

1.3.4 Vesicles

Definition 1.8 (Vesicles). Vesicles are membrane-bound organelles that store nutrients, waste, and other substances used by the cell. Vesicles can fuse with the cell membrane.

1.3.5 Vacuoles

Definition 1.9 (Vacuoles). Vacuoles are basically vesicles but bigger and do not fuse with the cell membrae. You can think of them as the storage system. See Figure 1.4./

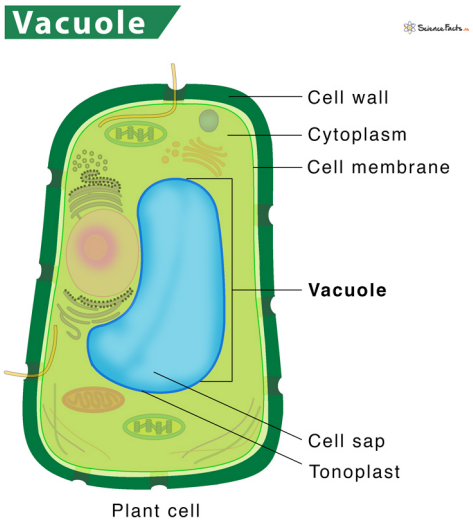


Figure 1.4: A vacuole inside of a plant. You can tell it is inside of a plant because a plant only has ONE large vacuole.

1.3.6 Mitochondria

Definition 1.10 (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 1.5.

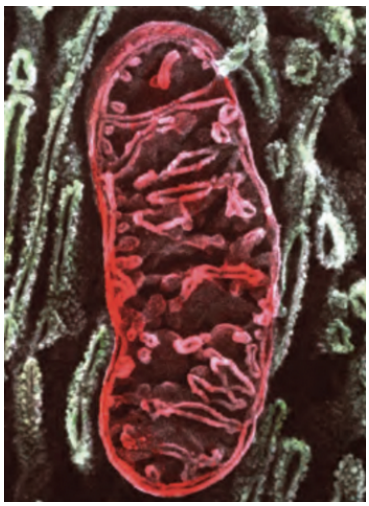


Figure 1.5: A mitochondrion, as seen through an electron micoroscope.

1.3.7 Lysosomes

Definition 1.11 (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 1.6.

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

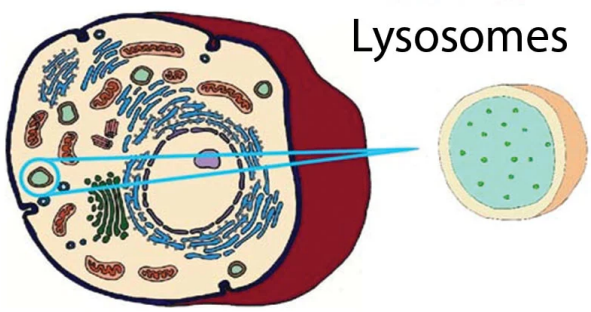


Figure 1.6: Lysosomes

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

1.3.8 Rough Endoplasmic Reticulum

Definition 1.12 (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 1.7.

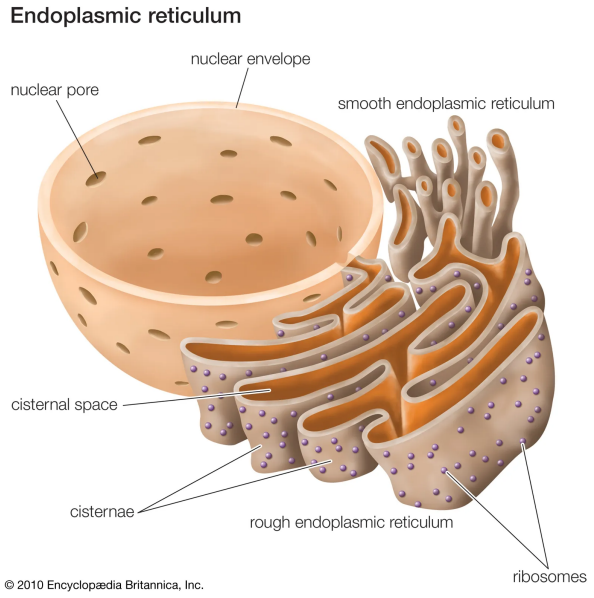


Figure 1.7: The rough and smooth endoplasmic reticulums.

1.3.9 Smooth Endoplasmic Reticulum

Definition 1.13 (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 1.7.

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 prescence of ribosomes in both cases.

1.3.10 Ribosomes

Definition 1.14 (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.

1.3.11 Golgi Body/Apparatus

Definition 1.15 (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 1.8).

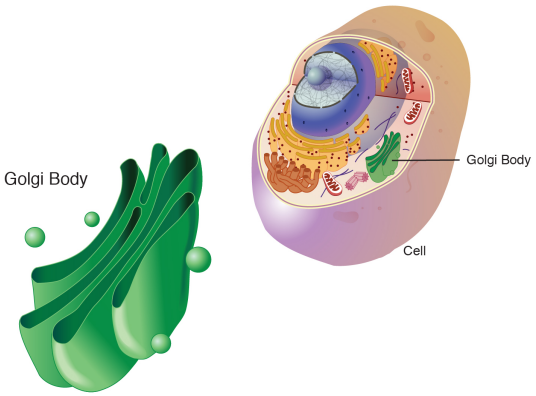


Figure 1.8: Golgi body.

1.3.12 Cytoskeleton

Definition 1.16 (Cytoskeleton). The cytoskeleton gives structure to the cell and is made of protein filaments.

1.3.13 Chloroplast

Definition 1.17 (Chloroplast). Chloroplasts are only found in plants cells and some algae. Contains a pigment called chlorophyll that absorbs light and energy to undergo photosynthesis

$$6\,\mathrm{CO_2} + 6\,\mathrm{H_2O} + \text{light} \longrightarrow \mathrm{C_6H_{12}O_6} + 6\,\mathrm{O_2}$$

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

1.4 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**
• Nucleus • Nuclear membrane • Cytoplasm • Endoplasmic Reticulum (ER); smooth and rough • Ribosomes • Golgi apparatus/body • Vesicles • Vacuoles • Mitochondria • Cell membrane • Lyosomes	• All of the previously mentioned... • Chloroplast • Cell wall • Large central vacuole

Table 1.4.1: Plant cells have an extra **chloroplast, cell wall, and large central vacuole**.

See Figure 1.17 for animal cell and Figure 1.10 for plant cell.

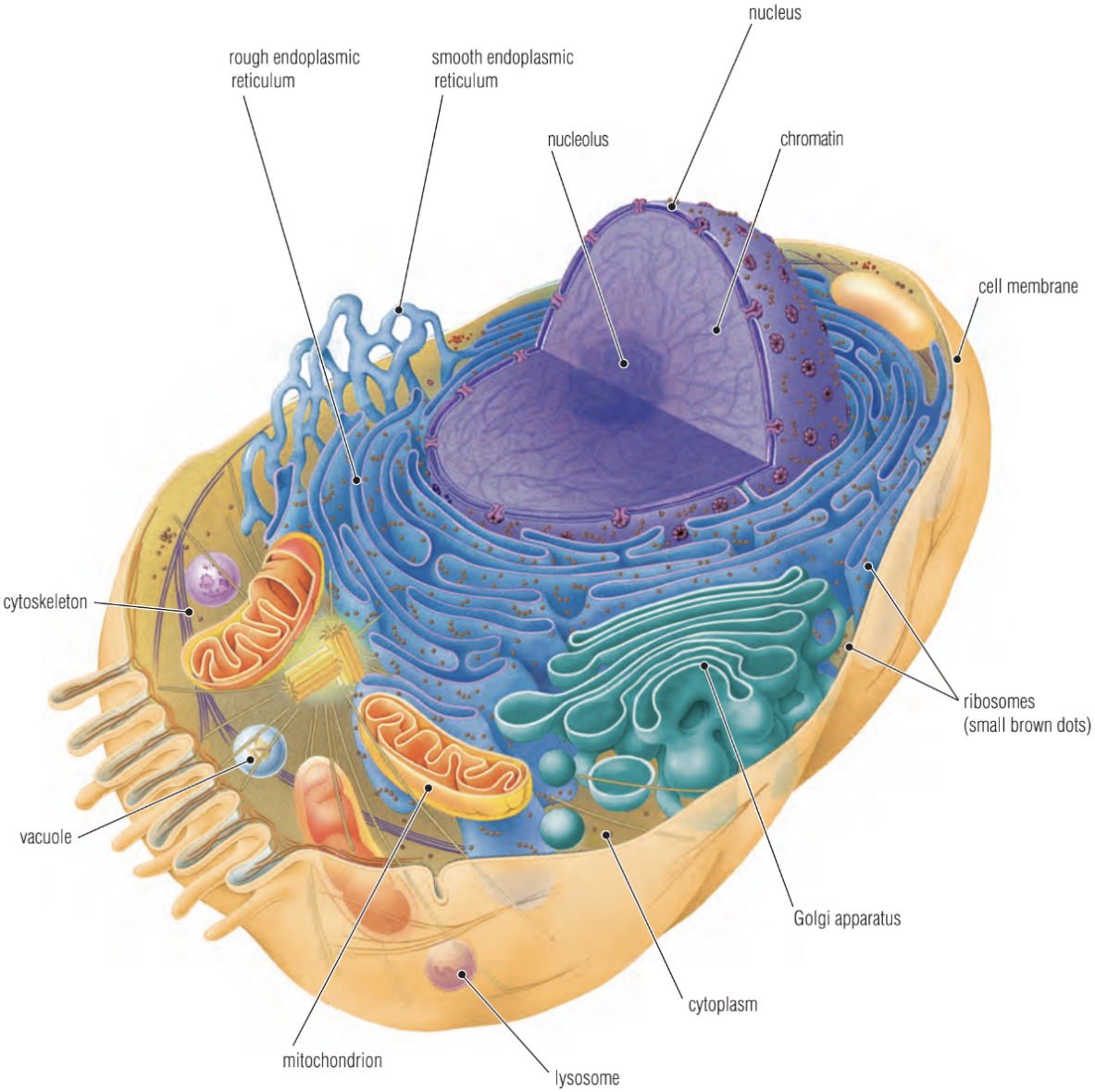


Figure 1.9: Animal cell.

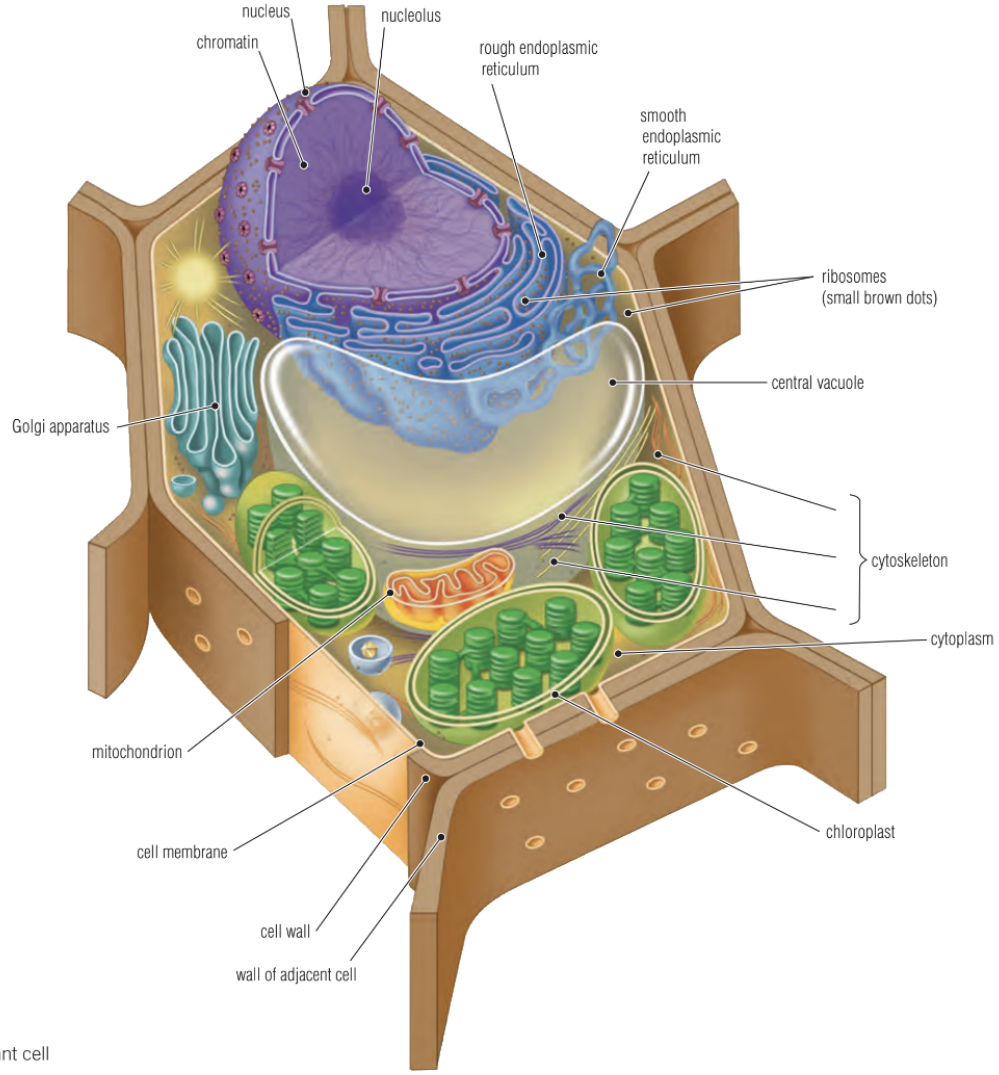


Figure 1.5 A plant cell

Figure 1.10: The plant cell contains an extra chloroplast, cell wall, and large central vacuole.

1.5 Histology

Definition 1.18 (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 data types and chemicals to visualize organelles.

1.6 Asexual vs Sexual

1.6.1 Asexual

Definition 1.19 (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 quicktly.

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 whipe out everyone, since everyone is the same. If it kills one person, it will kill everyone too.

1.6.2 Sexual

Definition 1.20 (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 threw 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.

1.7 The Cell Cycle

Definition 1.21 (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 1.11.

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

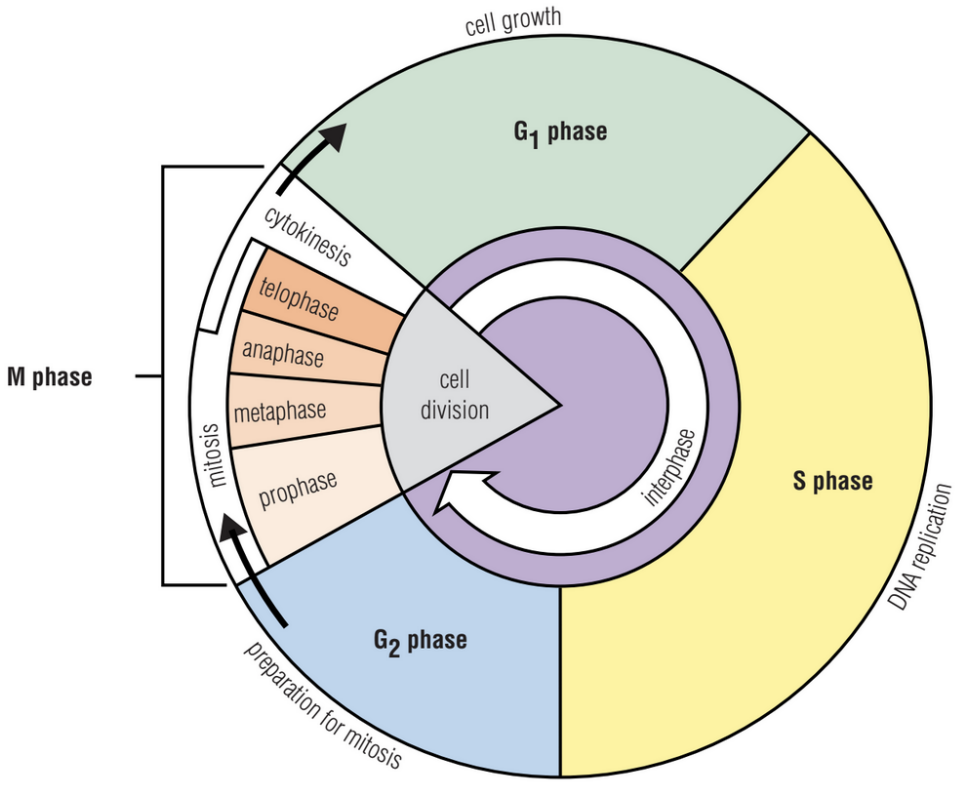


Figure 1.11: The cell cycle has four phases. During most of the cell cycle, the cell is growing, replicating its DNA, and preparing for cell division.

1.7.1 Cell Division

Definition 1.22 (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 1.7.4).

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.

1.7.2 Chromosomes

Definition 1.23 (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 1.12.

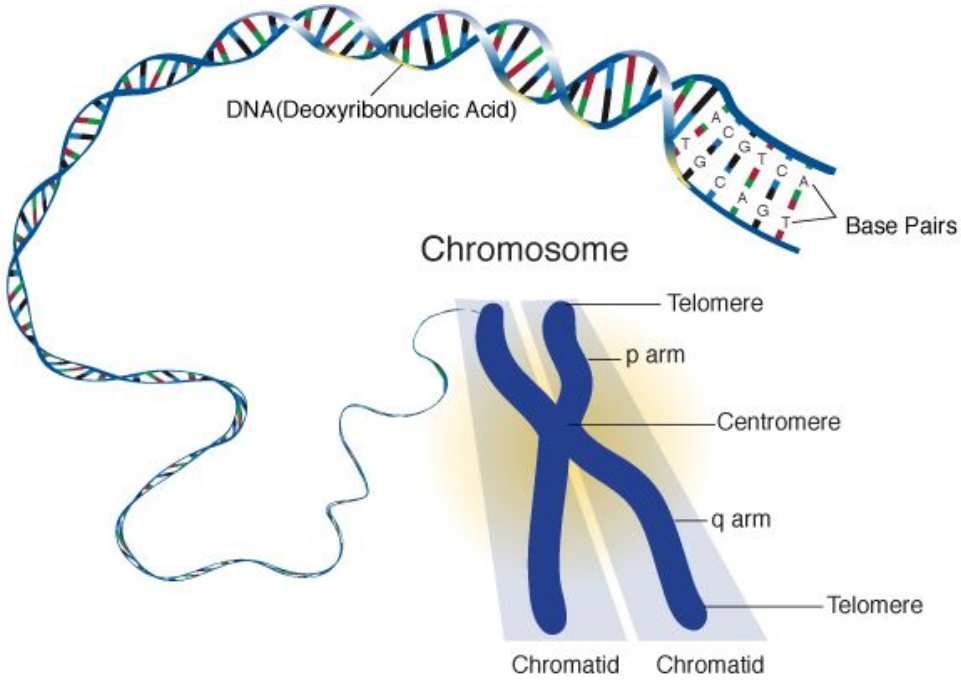


Figure 1.12: Chromosomes.

Before cell division can occur, each chromosome is copied, as shown in Figure 1.13. The chromosome consists of two identical copies, can **sister chromatids**. When the cell divides, one chromatid goes to each of the new cells.

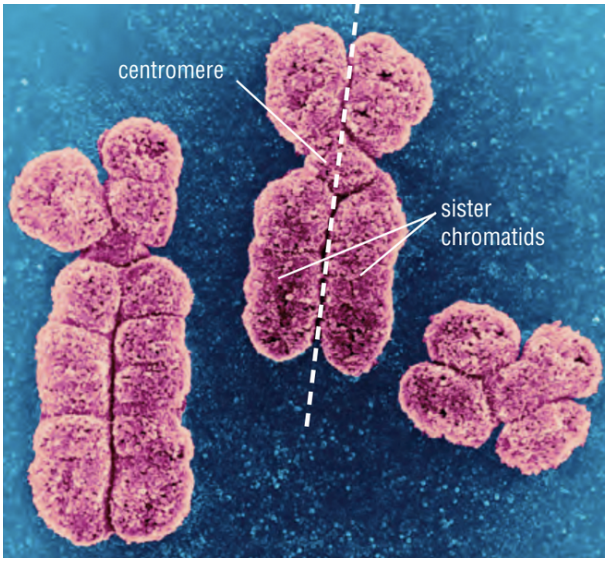


Figure 1.13: Each chromosome consists of two identical sister chromatids. The **centromere** is where the sister chromatids attach.

1.7.3 Interphase

Definition 1.24 (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 1.14.

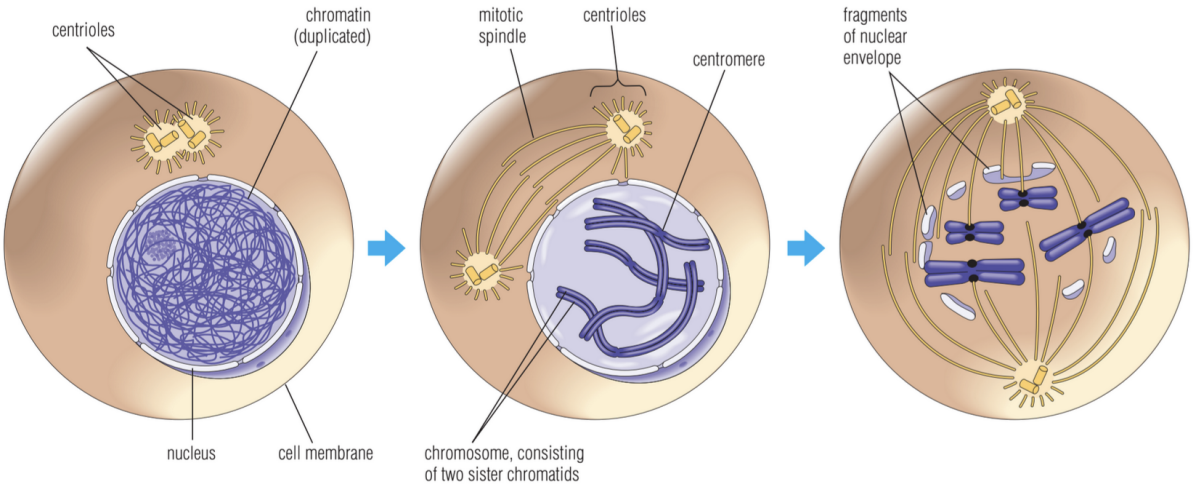


Figure 1.14: S phase and G2 phase.

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

1.7.4 Mitosis

Definition 1.25 (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 1.15.

1.7.5 Cytokinesis

Definition 1.26 (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.

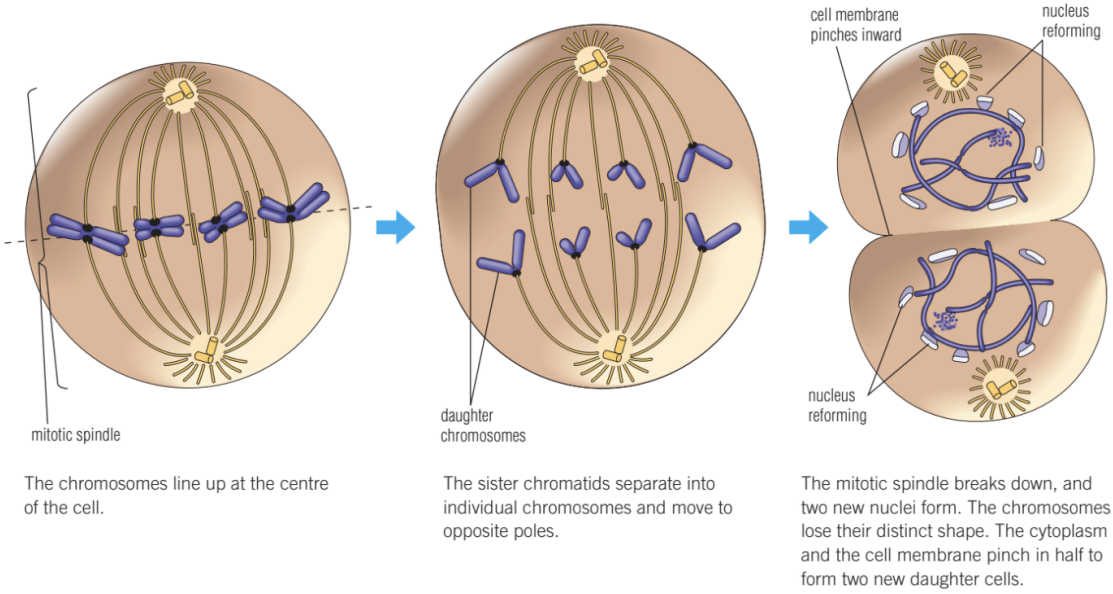


Figure 1.15: Prophase then metaphase, anaphase, and telophase then cytokinesis.

1.8 Cell Cycle Questions

1. What is the purpose of the cell cycle?

   Solution.

   - Sustain the processes for cell division to occur.
   - Cell growth; duplication of DNA and duplication of organelles.
   - Maintain regular cell function.

2. Define the term "interphase" and describe its purpose.

   Solution. It refers to the period of time in which the cell carries out its regular cell functions. The purpose of interphase is to get the cell ready to divide (growth of the cell, duplication of the cell, duplication of DNA, duplication of organelles).

3. (a) What is mitosis?

   Solution. This is when a single parent cell divides into two new daughter cells. The parent cells and daughter cells have the same DNA.

   (b) Why is mitosis important to the cell?

   Solution. **Cell reproduction**; making new cells. **Growth**; optimization of cell surface area to cell volume ratio. High surface area to volume ratio is important. A high surface area to volume ratio maintains that nutrients can enter the cell efficiently and that waste can leave the cell efficiently.

4. Define and distinguish between the following terms: chromosomes, centromere, and sister chromatids.

   Solution.

   - **Chromosome**:
     - Genetic material.
     - Coiled version of cellular DNA called chromatin)
     - Comprised of sister chromatids.
   - **Sister chromatids**:
     - Identical copies of DNA which are part of the chromosomes.
     - Attached at the center with a centromere during prophase and metaphase.
     - The sister chromatids are separated in mitosis during anaphase.
   - **Centromere:**
     - Holds the sister chromatids together during prophase and metaphase.
     - 2 sister chromatids attached by a centromere rom the chromosome.

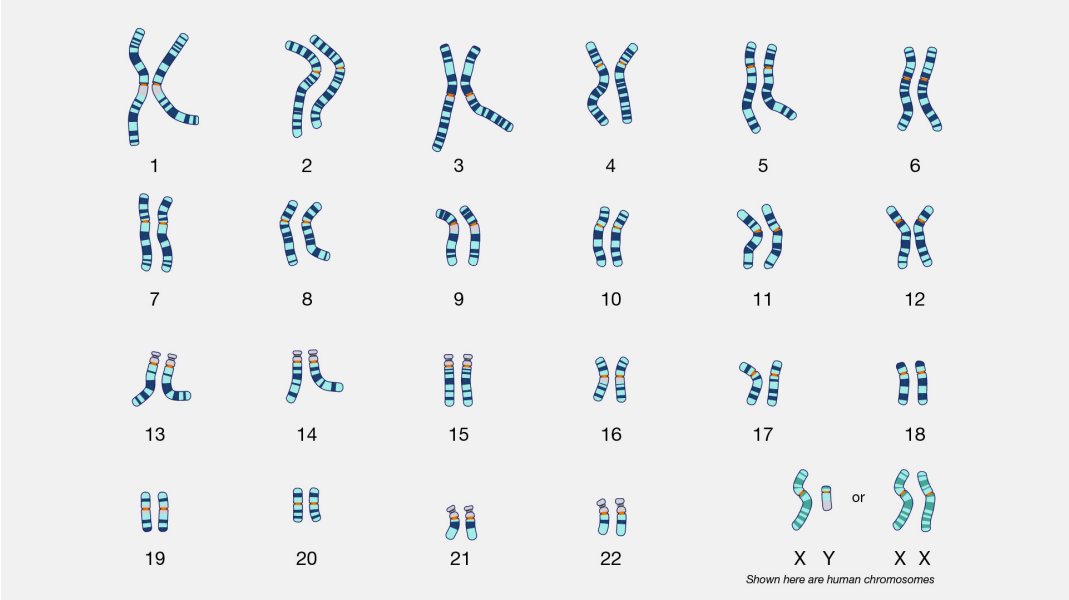


Figure 1.16: Karyotypes. In the bottom right, we see that there is XY or XX. The reason for this is because the one on the right (XY chromosome) is the male chromosome, and the one on the left (XX chromosome) is the female chromosome.

5. Explain the meaning of cytokinesis.

Solution. Happens after telephase. Is defined as the splitting/division of the cytoplasm. In an animal cell, this is done through the pinching of the membrane (we call this a cleavage furrow). In a plant cell, this is done through the formation of the cell plate.

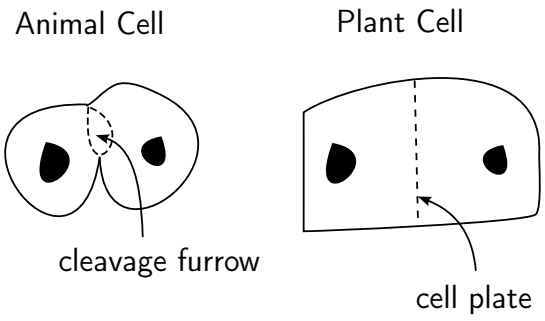


Figure 1.17: Animal Cell vs Plant Cell

1.9 Healthy Cell Checkpoints

Definition 1.27 (Healthy Cell Checkpoints). A cell will not divide if

- Signals from surrounding cells tell the cell not to divide.
- Not enough nutrients for cell growth.
- DNA has not been replicated.
- DNA is damaged.

Cell can undergo programmed cell death (apoptosis). See Figure 1.18.

For more information, visit `https://www.khanacademy.org/science/ap-biology/cell-communication-and-cell-cycle/regulation-of-cell-cycle/a/cell-cycle-checkpoints`

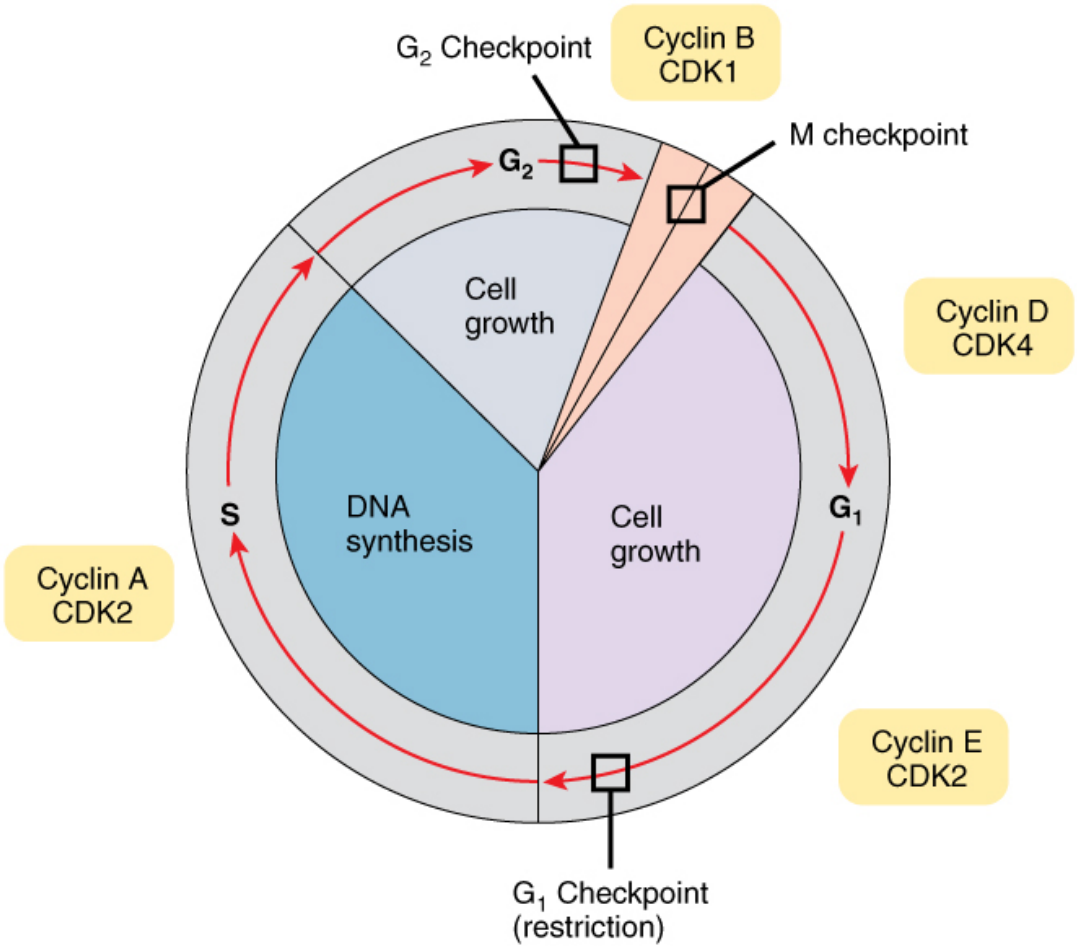


Figure 1.18: If a cell doesn't get the go-ahead cues it needs at the G_1 checkpoint, it may leave the cell cycle and enter a resting state called the G_0 **phase**. Some cells stay permanently in G_0, while others resume dividing if conditions improve.

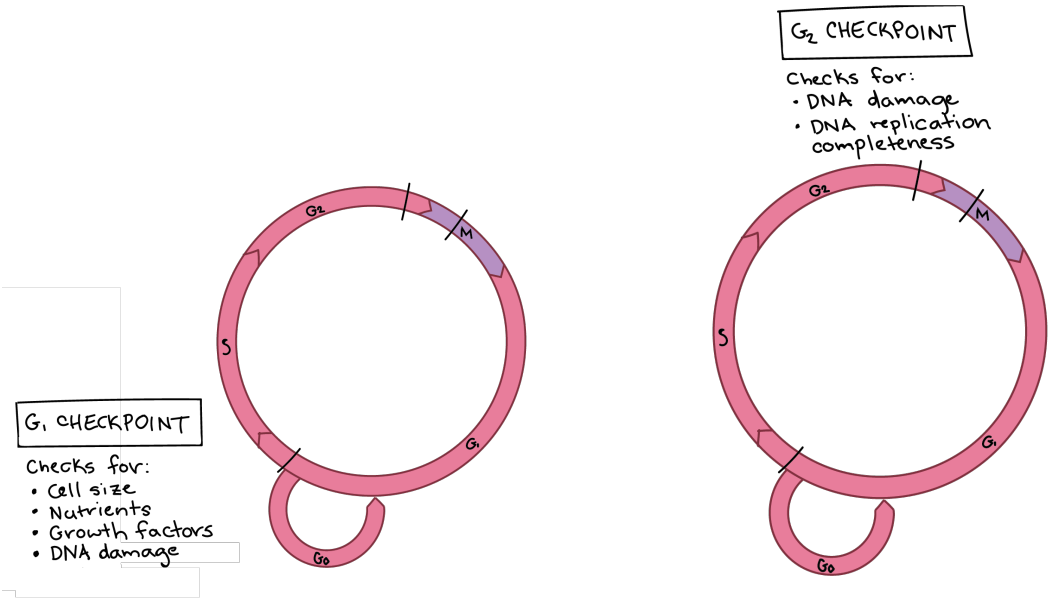
1.9.1 G_1 Checkpoint

Definition 1.28 (G_1 Checkpoint)**.** The main decision point for a cell; that is, the primary point at which it must choose whether or not to divide. Once the cell passes the G_1 checkpoint and enters S phase, it becomes ireversibly committed to division. See Figure ??.

1.9.2 G_2 Checkpoint

Definition 1.29 (G_2 Checkpoint)**.** At this stage, the cell will check:

- **DNA integrity**: is any of the DNA damaged?
- **DNA replication**: was the DNA completely copied during S phase? If there is damage, the cell will stall at the G_2 phase to repair. If the damage is unrepairable, the cell will undergo apoptosis (self destruction). See Figure ??.



(a) G_1 checkpoint. **(b)** G_2 checkpoint.

Figure 1.19: The G_1 and G_2 checkpoints.

1.9.3 The Spindle Checkpoint

Definition 1.30 (The Spindle Checkpoint)**.** The M checkpoint is known as the "spindle checkpoint". Here, the cell examines whether all the sister chromatids are correctly attached to the spindle microtubles. See Figure 1.20.

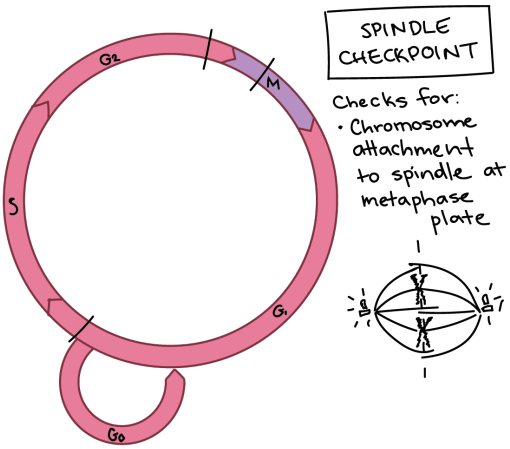


Figure 1.20: The spindle checkpoint (M checkpoint).

1.10 Cancer

Definition 1.31 (Cancer)**.** This is a group of diseases in which cells grow and divides uncontrollably. See Figure 1.21 and Table 1.10.1.

This is caused by mutations to the DNA within cells which can allow rapidgrowth, fail to stop uncontrolled cell growth, or make errors when correcting DNA. Mutations are inherited or caused by environmental factors (i.e. radiation, viruses, carcinogens, etc.).

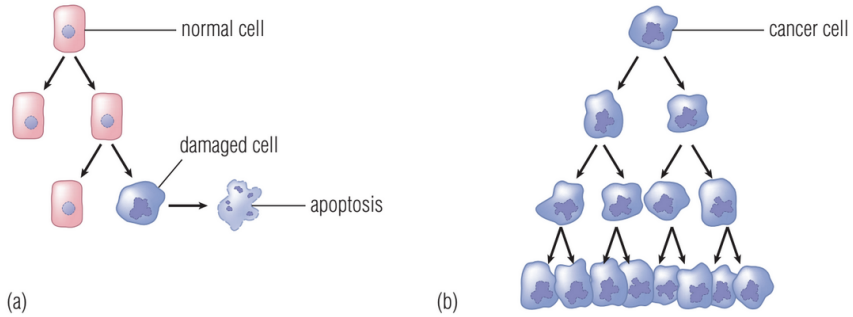


Figure 1.21: (a) Cell division and cell death in normal cells. (b) Cell division in cancer cells.

1.10.1 Stages of Cancer

Stage 0: cancer cells remain in place to form a mass cells called a tumour.
Stage 1: small tumour has not grown deeply into nearby tissues and has not spread to lymph nodes.
Stage 2 & **3:** larger tumours have grown deeply into nearby tissue and may have spread to lymph nodes.
Stage 4: cancer has spread to other organs or parts of the body (metastasis).

Colorectal Cancer 5 year survival rates

Stage	Survival Rate
I	94%
II	82%
III	67%
IV	11%

Normal Cells	Cancer Cells
Make exact copies of themselves through mitosis.	Make exact copies of themselves through mitosis.
Reproduces for about 50-60 cell divisions.	Does not stop reproducing.
Stick together to form masses of cells as appropriate.	Does not stick to other cells. Behaves independently.
Self-destruct (apoptosis) when too old or damaged.	May move to another location of the body.

Table 1.10.1: Comparing normal cells with cancer cells.

1.10.2 Cancer Prevention

Healthy choices:

- Live smoke-free.
- Wear sunscreen and sun protection.
- Maintain a healthy body.
- Get vaccinated.
- Check your family history.
- Get screened regularly.

1.10.3 Cancer Treatment

- **Surgery** to physically remove the tumour.
- **Chemotherapy** uses chemicals and drugs to kill cancer cells; taken orally to intravenously.
- **Radiation therapy** uses focused beams of radiation to target cancer cells.

1.11 Stem Cells

Definition 1.32 (Stem Cells). Cells that can self-renew and differentiate into many different types of cells in the body. Two types:

1. **Embryonic stem cells** are derived from embryos and can differentiate into any cells.
2. **Adult stem cells** are found in the body and can differentate into a limited number of cell types.

See Figure 1.22.

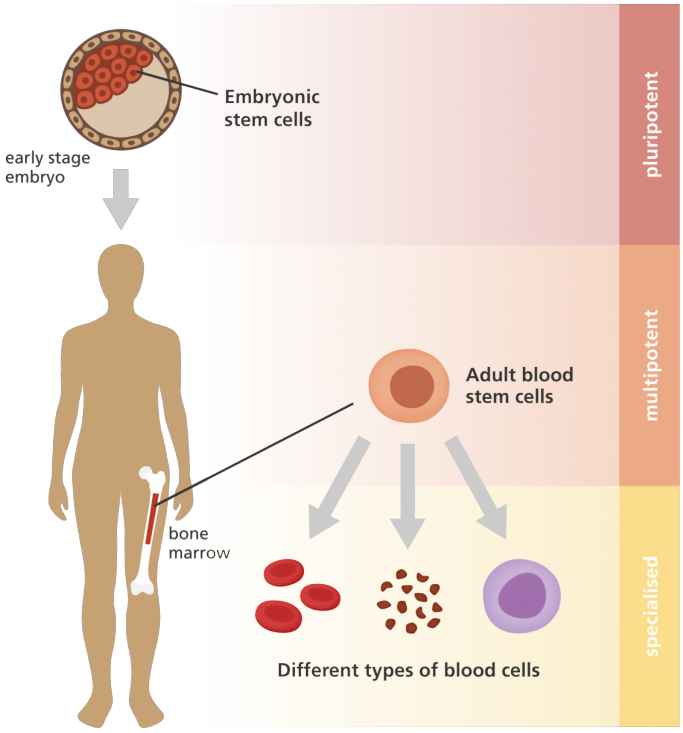


Figure 1.22: Stem Cells

Note: Embryonic stem cells are right after fertilization.

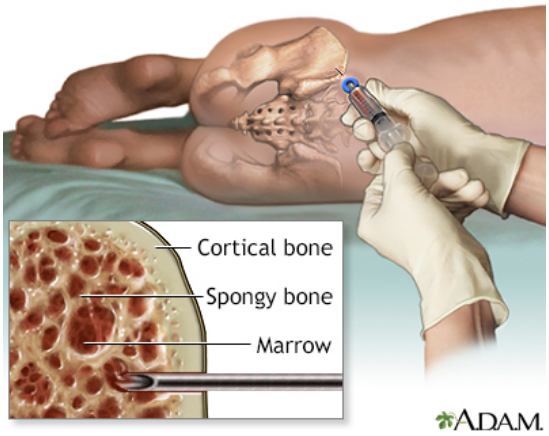
1.11.1 Stem Cell Transplant

Definition 1.33 (Stem Cell Transplant). Stem Cell Transplant replaces stem cells from

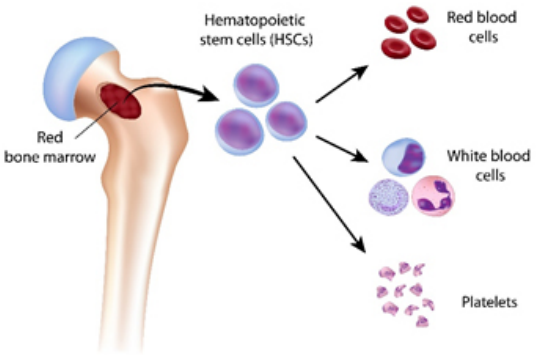
> a donor and is performed when a patient's stem cells or bone marrow have been damaged by disease, Chemotherapy, or radiation therapy.

Stem cells can be collected from the:

- Bone marrow
- Peripheral blood
- Umbilical cord



(a) Bone marrow biopsy



(b) Bone marrow stem cells

1.12 Hiearchy of an Organism

Definition 1.34 (Hiearchy of an Organism). The hiearchy is

$$\text{cell} \longrightarrow \text{tissue} \longrightarrow \text{organ} \longrightarrow \text{system} \longrightarrow \text{organism}$$

See Figure 1.23.

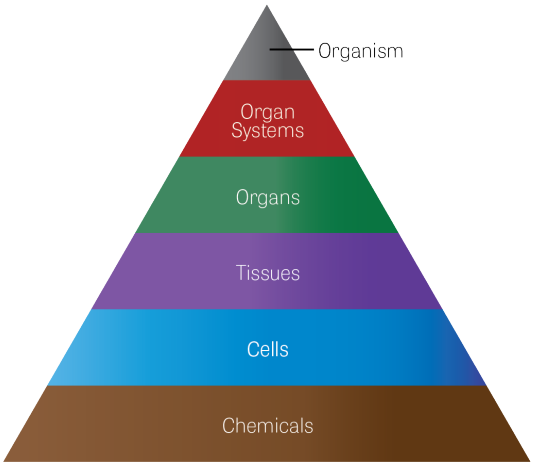


Figure 1.23: Hiearchy of an Organism

1. Cellular level heart muscle cell.
2. Tissue level heart muscle tissue.
3. Organ level heart.
4. Organ system level circulatory system.
5. Organism level deer.

- **Cell**: the smallest function unit of an organism.
- **Tissue**: a group of cells that perform a similar limited function.
  - Four main types: epithelial, connective, muscle, and nerve tissue
- **Organ**: a structure composed of different tissues to perform a complex function.
- **Organ system**: a system of one or more organs that work together to perform a vital body function.

1.13 Types of Tissues

1.13.1 Epithelial Tissue

Definition 1.35 (Epithelial Tissue)**.** A thin sheet that covers body surfaces and lining the internal organs.

- Skin and lining of the digestive system.
- Protection from hydration.
- Low friction surfaces.

1.13.2 Connective Tissue

Definition 1.36 (Connective Tissue)**.** Connective tissue are various types of cells and fibres held together by a liquid, solid, or a gel, known as a matrix.

- Bones, tendons, and blood.
- **Provides support and insulation.**

1.13.3 Muscle Tissue

Definition 1.37 (Muscle Tissue)**.** Muslce tissue contains proteins like actin and myosin that can contract and move.

- Muscles that make bones move.
- Muscles surrounding the digestive tract.
- Heart.

- Bundles of long cells called muscle fibres that contain specialized proteins capable of shortening or contracting.

- Movement.

1.13.4 Nerve Tissue

Definition 1.38 (Nerve Tissue)**.** Nerve tissue conducts electrical signals from one part of the body to another.

- Brain.
- Nerves in sensory organs.

- Long, thin cells with fine branches at the ends capable of conducting elelectrical impulses.

- Sensory.
- Communication within the body.
- Coordination of body functions.

1.14 Stem Cells Case Study Mini-Assignment

1. What is the difference between embryonic stem cells adn adult stem cells?

   Solution. Embryonic stem cells:

   - Embryonic stem cells exist only right after the fertilization of an egg.
   - Embryonic stem cells can specialize into any kind of body cell, be it epithelial cell, a red blood cell, nerve cell, bone cell, etc.
   - Adults don't have embryonic stem cells.

   Adult stem cells:

   - Adult blood stem cells are located in the bone marrow AND in the peripheral blood.
   - Adult blood stem cells can only differentiate into either red blood cells, white blood cells, or platelets.

2. Based on the article, how would you describe what cancer is?

   Solution. As a result of some kind of mutation in the cellular DNA, this causes healthy cell checkpoints to become dysfunctional and causes uncontrollable cell growth/division. This uncontrollable growth eventually materializes as a tumor in the healthy tissue

3. Conduct some research on the following cancer treatments: chemotherapy, radiation, therapy, and surgery. Do you think that differentiation therapy has any benefits over these known treatments? Explain your reasoning.

   Solution.

   - Chemotherapy is targeted to kill cancer cells, but in the administration of chemotherapy, the drugs are targeting the healthy cells as well. Though chemotherapy may be effective in killing the cancer cells, it also damages healthy cells, which can lead to adverse effects such as nausea, hair loss, and cdecreasing in immune function.
   - Radiation therapy, uinless specifically localized, can also have adverse effects on surrounding healthy tissue.
   - Differentiation therapy is much more targeted towards turning cancer cells back into normal cells, so the use of toxic chemical is not necessary. This can decrease the number of adverse effects as well as results of this treatment.

   With this new kind of treatment, it could open many doors to groundbreaking cancer research and therapy; possible high mobilization of this particular kind of research (can lead to scientific discoveries).

1.15 Digestive System

Definition 1.39 (Digestive System)**.** The digestives system is the organ system responsible for breaking up and digesting food, and secreting waste. The digestive tract is lined with epithelial tissue, goblet cells that release mucous, connective tissue, muscles, and nerves. See Figure 1.24.

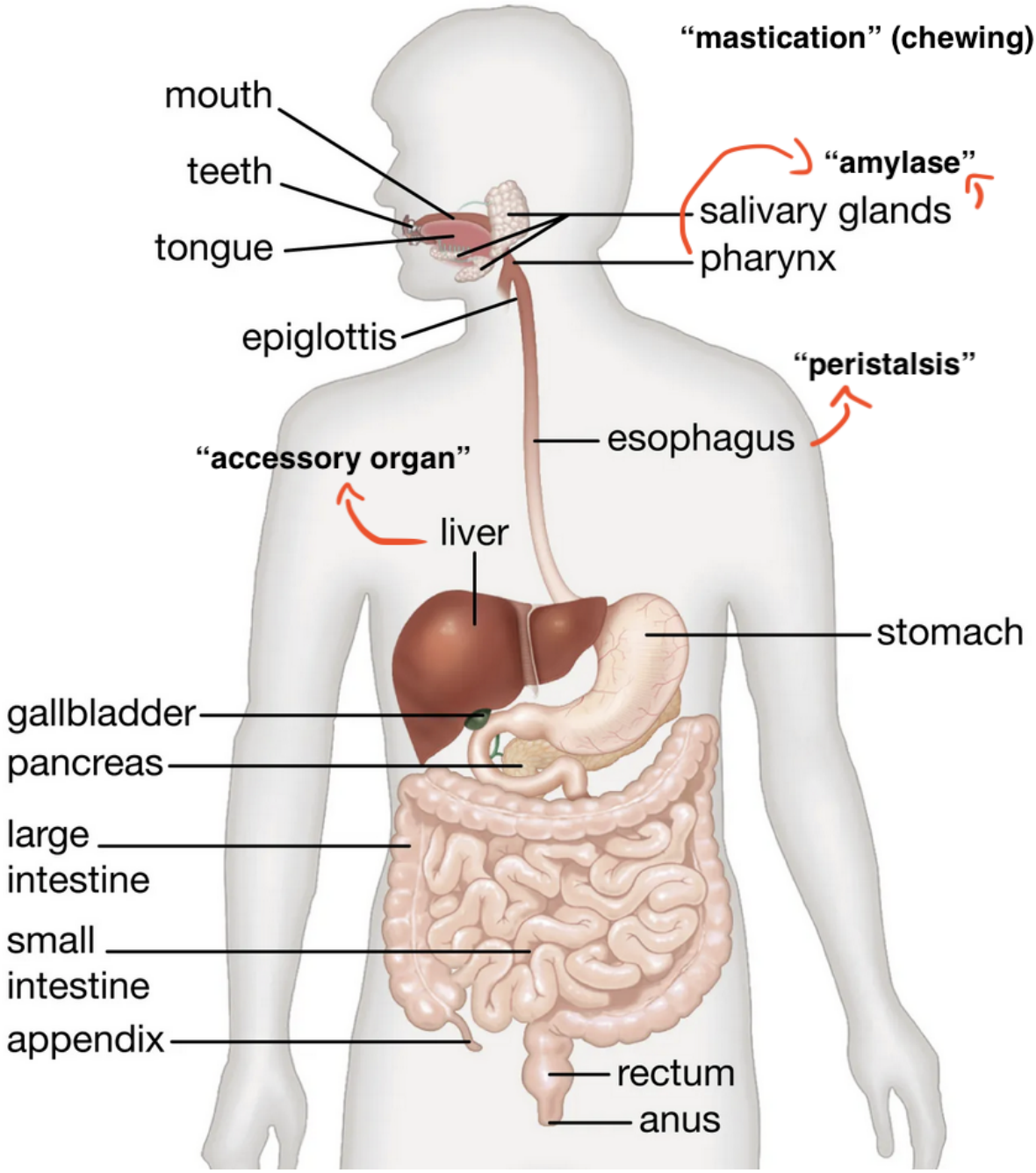


Figure 1.24: The digestive system.

1.15.1 Mouth

Definition 1.40 (Mouth). The mouth is where food enters and undergoes mechanical breakdown **(mastication)** and chemical breakdown through the saliva to form a **bolus**. The bolus is a ball-like mixture of food and saliva.

1.15.2 Esophagus

Definition 1.41 (Esophagus). A muscular tube that contracts through **peristalsis** to move the bolus to the stomach. See Figure 1.25.

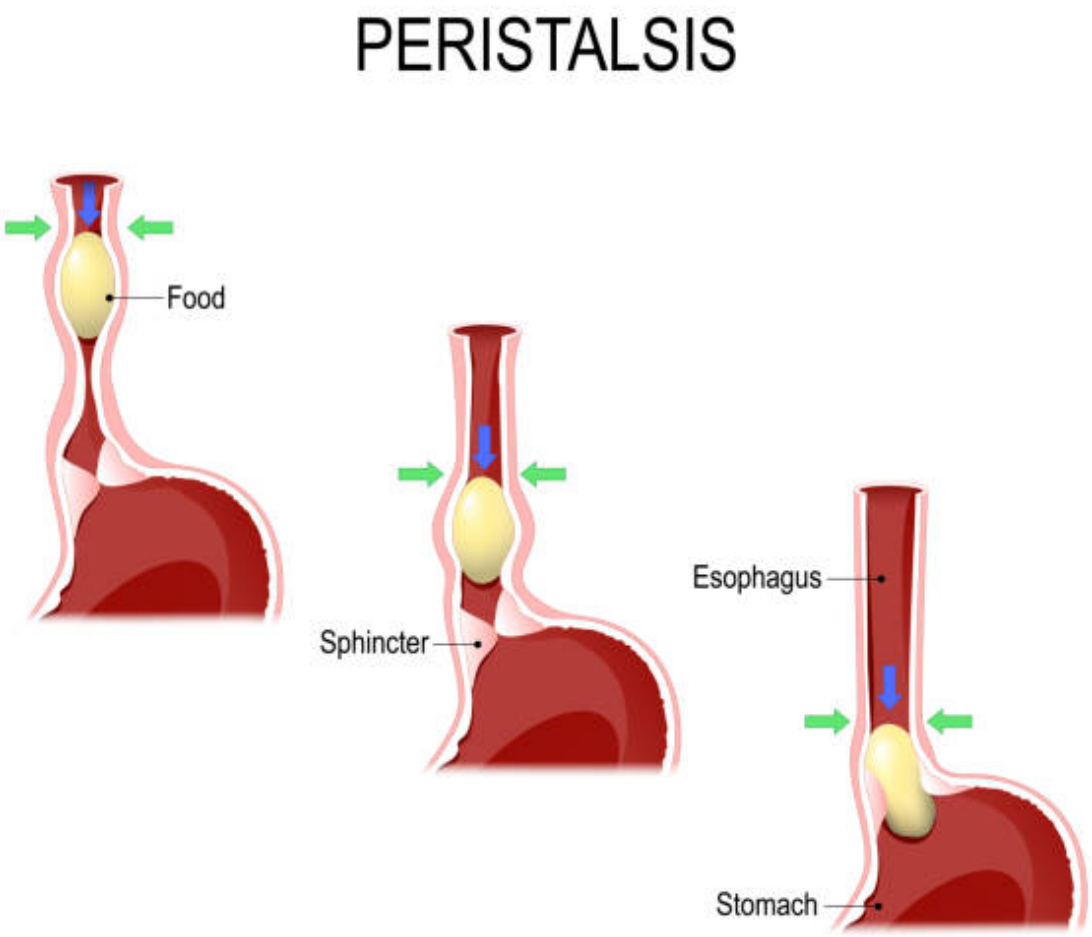


Figure 1.25: Peristalsis the **smooth muscles** create a pinch that pushes the bolus down into the stomach..

1.15.3 Epiglottis

Definition 1.42 (Epiglottis). Is a flap that seals off the trachea during swalloing to direct the bolus to the esophagus.

1.15.4 Stomach

Definition 1.43 (Stomach). A J-shaped organ that holds, churns, and adds acids and enzymes to turn the bolus into **chyme**. Chyme is the partially digested food that contains acids and enzymes. See Figure 1.26.

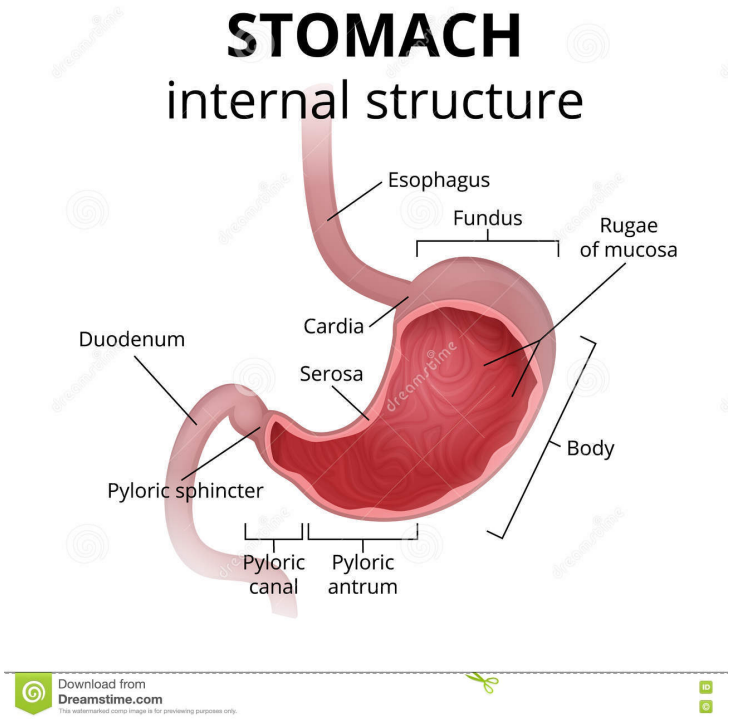


Figure 1.26: The stomach.

1.15.5 Small Intestine

Definition 1.44 (Small Intestine). The small intestine continues to digest and is the main site of absorption of nutrients. Consists of **villi** and **microvilli** to increase surface area for absorption. See Figure 1.27.

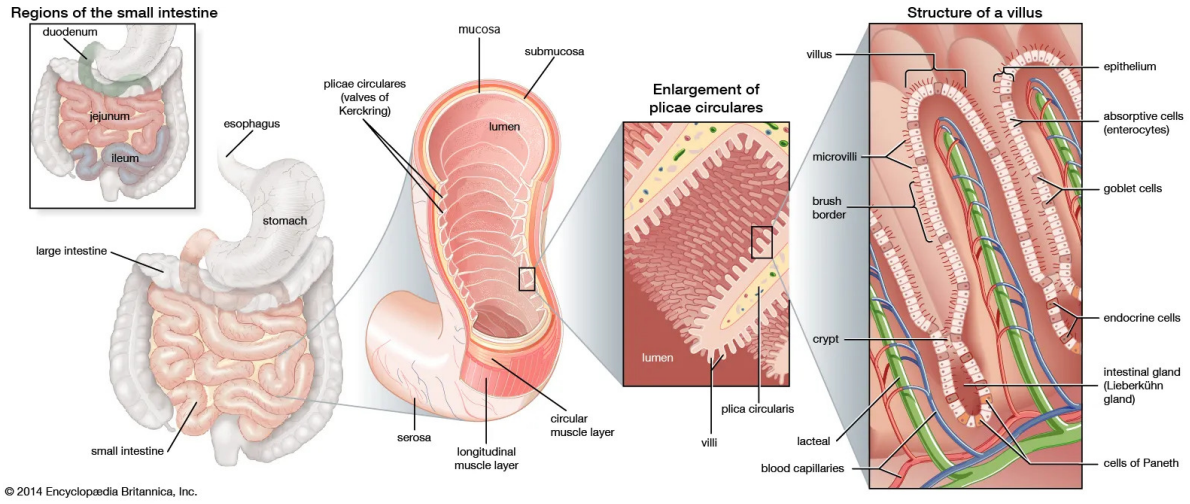


Figure 1.27: The small intestine have small villi and further microvilli which ensures that you obtain all the nutrients from the food.

1.15.6 Large Intestine

Definition 1.45 (Large Intestine). Aprobiotic environment that mainly absorbs water and minerals.

1.15.7 Appendix

Definition 1.46 (Appendix). May house beneficial gut bacteria.

1.15.8 Rectum

Definition 1.47 (Rectum). The end of the large intestine that temprarily stores feces.

1.15.9 Anus

Definition 1.48 (Anus). An opening where feces is excreted.

1.15.10 Accessory Organs: Liver

Definition 1.49 (Liver). Produces **digestive enzymes** and **bile**; also removes toxins from the blood. See Figure 1.28.

1.15.11 Gall Bladder

Definition 1.50 (Gall Bladder). Stores the **bile**, which is used to emsulify fats. See Figure 1.28.

1.15.12 Pancreas

Definition 1.51 (Pancreas). Produces insulin, which is a hormone that regulates blood glucose concentration after a meal. See Figure 1.28.

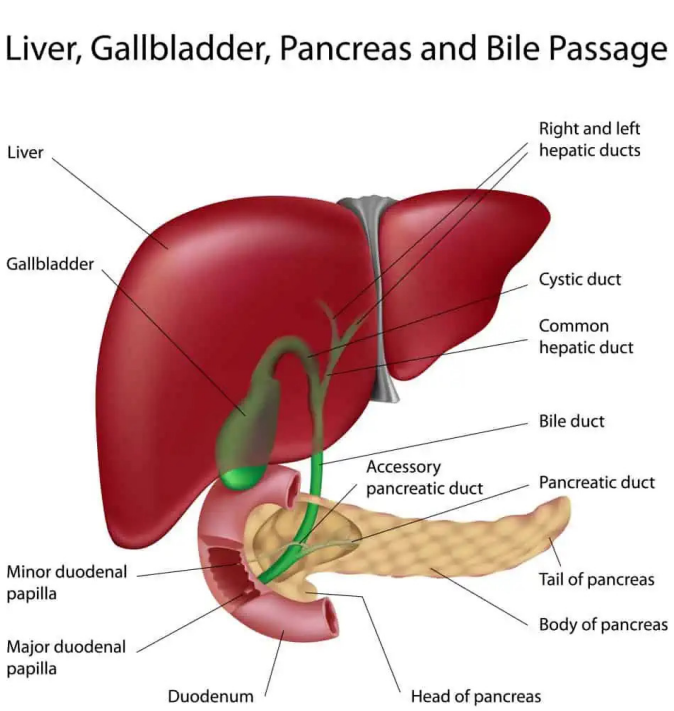


Figure 1.28: The accessory organs: the liver, gall bladder, and pancreas.

1.15.13 Diseases of the Digestive System

	Gastroesophageal Reflux Disease (GERD)
Description	Irration of the esopghageal lining due to acid from the stomach.
Symptoms	Heartburn, chest pain, bitter taste
Causes	Weakening or abnormalities of the esopghageal sphincter
Treatment	Antacids, drugs to reduce acid production, surgery

Table 1.15.1: Gastroesophageal Reflux Disease (GERD)

	Gastric Ulcer
Description	Open sores that develop in the stomach lining
Symptoms	Stomach pain, vomiing blood, dark blood in stool
Causes	Helicobacter pylori infection NSAIDS (i.e. ibuprofen)
Treatment	Antibiotics if H. pyroli infection, alternative medication

Table 1.15.2: Gastric Ulcer disease.

1.16 Circulatory System

Definition 1.52 (Circulatory System)**.** The organ system responsible for the

- Delivery of nutrients and gases.
- Regulation of body temperature.
- Defense against invading organisms.

Components:

- Heart.
- Blood vessels.
- Blood.

1.16.1 Heart

Definition 1.53 (Heart)**.** A pump that distributes nutrients and gases to every cell in the body. The heart is composed of three kinds of tissues:

- **Cardiac muscle tissue** contracts synergistically (at the same time) to pump blood throughout the body.
- **Nerve tissue** is responsible for the heart rate and can respond to stress, temperature, and physical activity.
- **Epithelial tissue** lines the inner surface of the heart to allow blood to flow freely; smooth layer of epithelial tissue on the outside reduces friction and protects the heart from damage.

1.16.2 Blood vessels

Definition 1.54 (Blood vessels)**.** There are three kinds of blood vessels:

- **Artery** carries blood away from the heart; have thick, muscular walls to withstand high blood pressure. See Figure 1.29.
- **Vein** carries blood through the heart; have thinner walls with valves to pump blood back to the heart. See Figure 1.29.
- **Capillary** connects arteries to veins; have one-cell thick walls to maximize diffusion of susbstance between blood and tissues. See Figure 1.30.

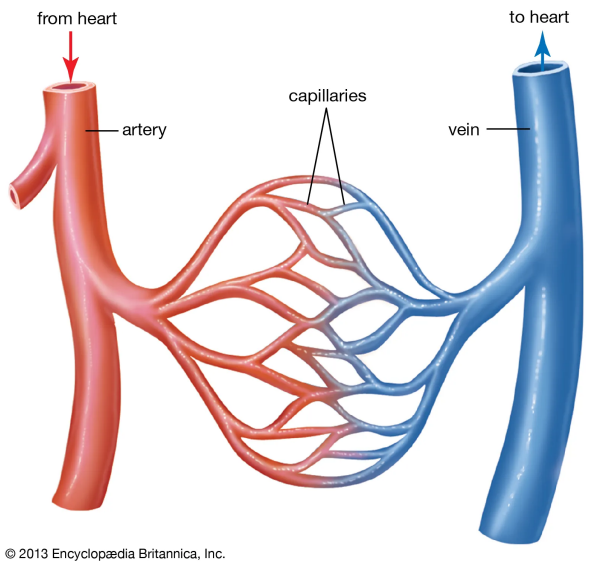


Figure 1.29: The artery (red) and the vein (blue). The connect part are referred as the capillaries.

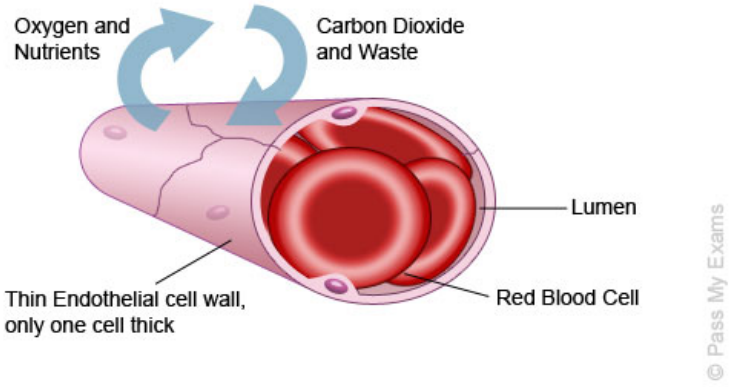


Figure 1.30: The cappilary.

1.16.3 Blood

Definition 1.55 (Blood). A connective tissue that consists of the following main cells:

- **Erythrocytes** are red blood cells that are biconcave in shape and contain hemoglobin that attaches to oxyge and carbon dioxide.
- **Leukocytes** are white blood cells that are defending the body against pahtogens.
- **Platelets** help ion blood clotting.

- **Plasma** is protein rich liquid that suspends the cells.

See Figure 1.31 and Figure 1.32.

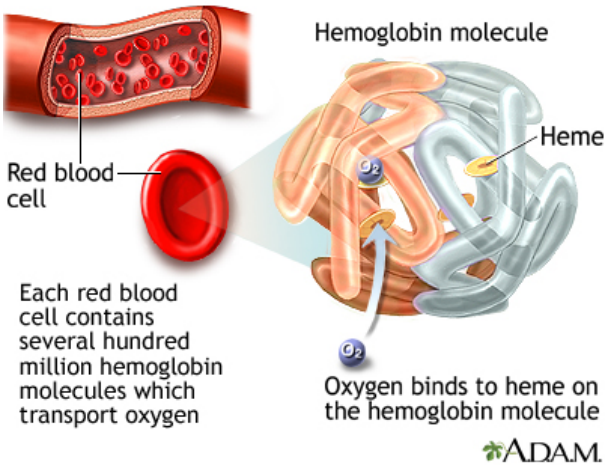


Figure 1.31: Hemoglobin.

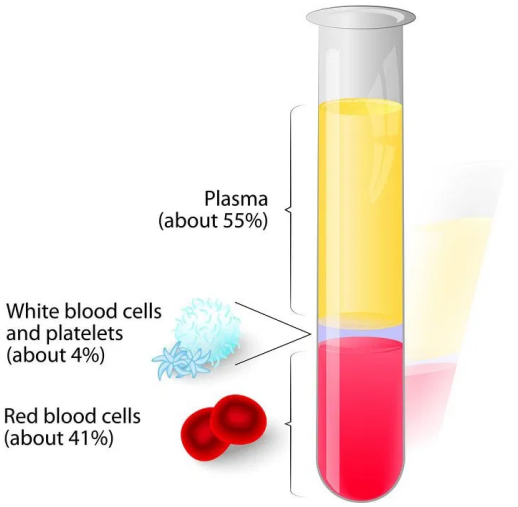


Figure 1.32: A centrifuge for separating blood plasma. This is known as **hematocrit**.

List of Theorems