Chapter 5 : Life Process

class10

1

Visible Signs of Life

Initially, we identify living beings through **visible movements**.

- **Animals:** Activities like running, chewing, or even the simple act of breathing.
- **Plants:** Often identified by their green color or growth over time.

The Limitation: Visible movement isn't a perfect rule.

a. A plant might not be visibly growing, or
b. an animal might be breathing silently while asleep, yet they are still alive.

Despite the lack of visible motion, both remain alive.

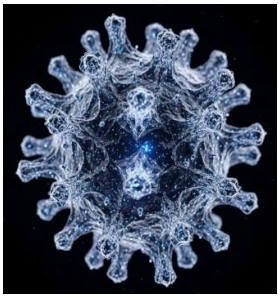
2

Molecular Movement: The "Invisible" Criteria

Biologists argue that the real evidence of life happens at a level we cannot see: the **molecular level**.

- All living things are made of molecules that are constantly moving.

- **The Virus as Exception:** Viruses do not show molecular movement until they infect a host cell. This is why there is a **controversy** over whether viruses are truly "alive" or not.



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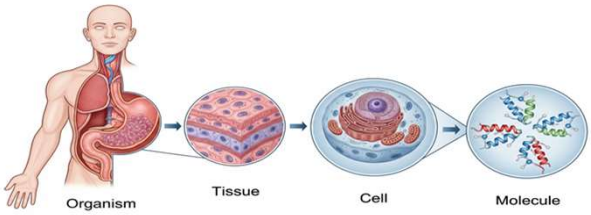
Structural Organization and Repair



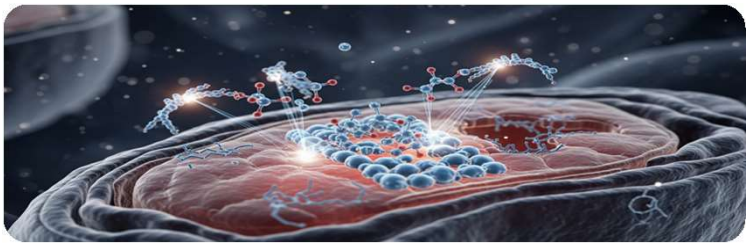
The Hierarchy

Organisms are highly **organized structures** built in a specific order:

Organism → Tissues → Cells → Molecules

The Threat

- Environmental stress (heat, chemicals) constantly acts to **break down** this order.
- Total structural collapse results in the **death** of the organism.



The Solution

- Living things must **repair & maintain** their structures constantly.
- Moving molecules is the essential engine of biological maintenance.

Defining Life Processes

- **Life Processes:** The collection of processes that work together to perform the essential maintenance job of keeping an organism alive.

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1.Why is diffusion insufficient to meet the oxygen requirements of multi-cellular organisms like humans?

- In multi-cellular organisms, the body size is large and the design is complex.
- Unlike single-celled organisms, all the cells in a multi-cellular body are not in direct contact with the surrounding environment.
- As most the cells are isolated from the outside air, simple diffusion cannot reach every cell to meet its oxygen requirements.

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2. What criteria do we use to decide whether something is alive?

The criteria's are:

- **Visible Movement:** Common signs include running, breathing, or shouting in animals, and green leaves or growth in plants.
- **Molecular Movement:** This is the invisible movement of molecules within the body, which biologists consider essential for life.
- **Maintenance and Repair:** Living beings must constantly repair and maintain their organized structures (cells and tissues) to prevent them from breaking down.
- **Life Processes:** The performance of essential functions like nutrition, respiration, transport, and excretion indicates an organism is alive.

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3. What are outside raw materials used for by an organism?

Raw materials are used for

1. **For maintenance functions:** Raw materials like food (which are mostly carbon-based) provide the energy needed to perform maintenance functions and prevent damage to the body.
2. **For Growth:** If an organism's body size is to increase, it requires additional raw materials from the outside to build new structures.
3. **For break down food molecules :** Many organisms take in oxygen from the environment to break down food molecules through chemical reactions to release energy.

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4. What processes would you consider essential for maintaining life?

The "life processes" essential for maintenance are:

- **Nutrition:** Transferring a source of energy (food) from the outside to the inside of the body.
- **Respiration:** Acquiring oxygen to break down food sources for cellular energy needs.
- **Transportation:** A system to carry food and oxygen from the point of intake to all cells in the body, and to carry waste away from them.
- **Excretion:** The removal of useless or harmful waste by-products created during chemical reactions in the body.

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Nutrition

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Autotrophic Nutrition

- **Autotrophic nutrition** is a process where an organism makes its own food using simple materials from the environment.
- In this process, simple inorganics substances(CO_2 and H_2O) are taken from the outside and converted into **stored forms of energy**.

- **Autotrophic organisms:** Are the organisms which fulfil their carbon and energy needs through the process of **photosynthesis**.

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Photosynthesis

- **Definition: Photosynthesis** is the process by which **autotrophs** (like plants) take in inorganic substances from the outside (specifically **carbon dioxide and water**) and convert them into stored forms of energy.

$$6CO_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2 + 6H_2O$$

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The Three Main Steps of photosynthesis are

1. **Absorption:** Chlorophyll (the green pigment in leaves) traps light energy from the sun.
2. **Conversion:** This light energy is converted into chemical energy. During this, water molecules are split into Hydrogen and Oxygen.
3. **Reduction:** Carbon dioxide is reduced (combined with hydrogen) to form **Carbohydrates** (Glucose).

Note: These steps may not happen one after the other immediately.
For example, **desert plants(Cactus)** take up CO_2 at night and prepare an intermediate, and on this intermediate the sunlight act during the day.

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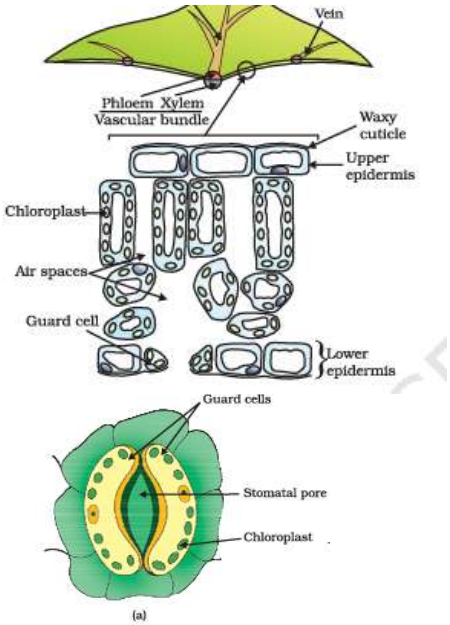
Stomata

- **Stomata** (singular: Stoma) are defined as the tiny pores or microscopic openings found primarily on the epidermis (surface) of leaves. They act as the "gateways" for the plant to interact with the atmosphere.
- Each stoma is surrounded by two kidney-shaped (or bean-shaped) cells called **Guard Cells**.
- **Guard Cells:** They control the opening and closing of the stomata.



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Energy Storage

- **In Plants the** excess-Glucose produced during photosynthesis are converted and stored as **starch**.
- **In Humans:** excess of glucose is stored as **glycogen**.
- Glycogen and starch both act as **backup energy source**.

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Heterotrophic Nutrition

Definition: Nutrition in which organisms cannot prepare their own food and must depend on other plants or animals for their energy.

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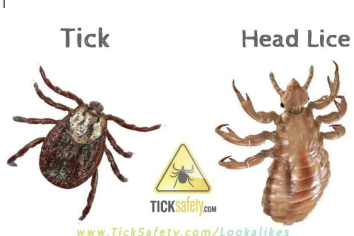
Types of Heterotrophic nutrition

base on the way they take their food

Nutrition	Description	Examples
Saprophytic (External Breakdown)	Organisms break down food material outside their body first and then absorb it.	Fungi (bread moulds, yeast, mushrooms).
Holozoic (Internal Breakdown)	Organisms take in the whole material and break it down inside their bodies.	Humans, cows, lions.
Parasitic (Directly from other living organism)	Organisms derive nutrition from plants or animals without killing them.	Cuscuta (Amar-bel), ticks, lice, leeches, tape-worms.



Saprophytes

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Parasites

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Diversity in Digestive Systems

- **Body Design and Function:** The type of digestive system an organism has depends on the nature of the food and the way it is obtained.
- **Example**
  - In **single-celled (unicellular)** organisms, food is taken in by the **entire surface** of the cell.
  - **In** multicellular, body parts become **specialized** to perform digestion.

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Nutrition in Unicellular Organisms

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Amoeba (steps of Nutrition)

1. **Ingestion:** *Amoeba* uses temporary, finger-like extensions called **pseudopodia** to reach out and take a food particle.
2. **Food Vacuole formation:** The Pseudopodia fuse over the food to form a **food-vacuole**.
3. **Digestion:** Inside this vacuole, **complex substances** are broken down into **simpler ones**.
4. **Absorption:** The digested simple nutrients **diffuse** directly into the surrounding **cytoplasm**.
5. **Egestion:** Any remaining undigested material is moved to the cell surface and **thrown out**.

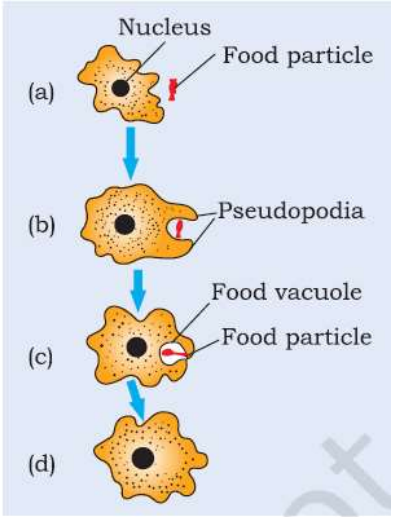

Figure 5.5
Nutrition in Amoeba

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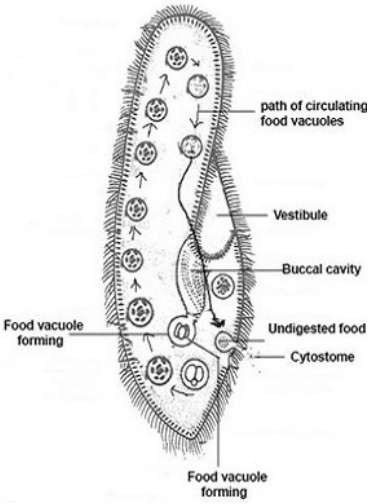
2. Paramoecium

- **Definite Shape:** Unlike the Amoeba, which changes shape, the *Paramoecium* has a **fixed, definite shape**.
- **Ingestion:** Food is taken in at a **specific spot** of the cell called **vestibule**.
- The entire surface of the cell is covered with hair-like structures called **cilia**. The cilia move in a coordinated way to push food particles toward the vestibule.



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Definitions

- **Pseudopodia:** Temporary "false feet" or extensions of the cell membrane used by organisms like Amoeba for movement and capturing food.
- **Food Vacuole:** A membrane-bound sac within a cell where food is digested.
- **Diffusion:** The process by which substances move from an area of high concentration to an area of low concentration.
- **Cilia:** Small, hair-like projections on the outside of some cells that move in waves to help the cell move or to move food toward it.

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Nutrition in Human Beings,

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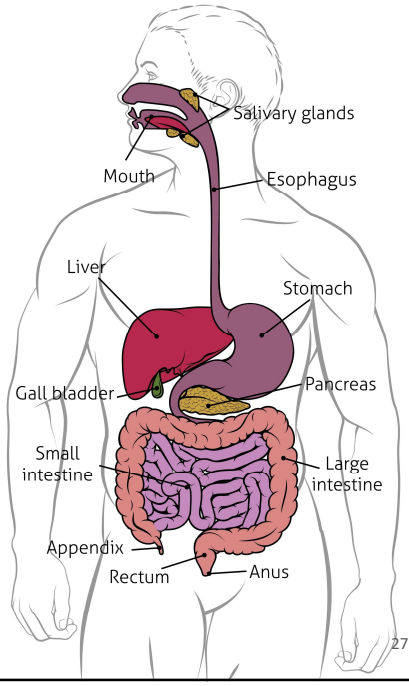
1. The Alimentary Canal

- **Structure:** It is a **long tube** that extends all the way from the **mouth** to the **anus**.
- **Specialization:** Different regions of this tube are specialized to perform unique functions to process the food we eat.



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2. Processing in the Mouth (Buccal Cavity)

1. **Mechanical Crushing:** Food is crushed into small particles using our **teeth**.
2. **Wetting the Food:** Food is mixed with **saliva** to help it slide smoothly down the throat..
3. **Molecular Digestion:** Saliva contains a **biological catalyst (enzyme)** called **salivary amylase**. It breaks down **starch** (a complex molecule) into **simple sugar**.
4. **Mixing:** The muscular **tongue** helps in mixing the food with saliva and moving it around while chewing.

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3. Moving Food Down the Canal(Mouth to Anus)

- **Oesophagus:** The food is taken from the mouth to the stomach through the **food-pipe**, which is also known as the **oesophagus**.
- **Peristaltic Movements:** The canal has circular muscles that contract **rhythmically** to push the food forward in a regulated manner. This movement is peristaltic movement and it occurs all along the gut.

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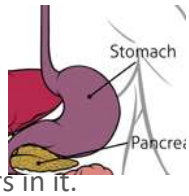
4. Processing in the Stomach



- **Expansion:** The stomach is a large organ that **expands** when food enters in it.
- **Mixing:** Muscular walls help in mixing the food thoroughly with various **digestive/gastric juices**.
- **Gastric Glands:** These are glands in the stomach wall which releases three important substances(called as gastric juices):
  - **Hydrochloric Acid (HCl):** Creates an **acidic medium** which is necessary
    - for the enzyme pepsin to work.
    - kills Micro-organisms.
  - **Pepsin:** A protein-digesting enzyme.
  - **Mucus:** Protects the **inner lining** of the stomach from being damaged by the acid.

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Key Definitions

- **Alimentary Canal:** The whole passage along which food passes through the body from mouth to anus during digestion.
- **Salivary Amylase:** An enzyme in saliva that converts starch into sugar.
- **Peristalsis:** The involuntary constriction and relaxation of the muscles of the intestine or another canal, creating wave-like movements that push the contents forward.
- **Pepsin:** An enzyme in the stomach that starts the digestion of proteins.

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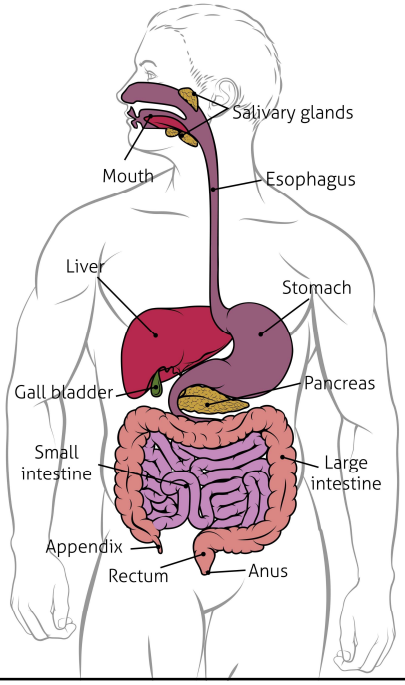

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The Small Intestine

- **Regulation:** Food leaves the stomach in small amounts regulated by a **sphincter muscle**.
- **Structure:** The small intestine is the **longest part** of the alimentary canal. It is highly **coiled** to fit into a compact space.

- **Dietary Differences and its relation with the size of intestine:**
  - **Herbivores** (grass-eaters) have a **longer** small intestine to help digest **cellulose**.
  - **Carnivores** (meat-eaters like tigers) have a **shorter** small intestine because meat is easier to digest.

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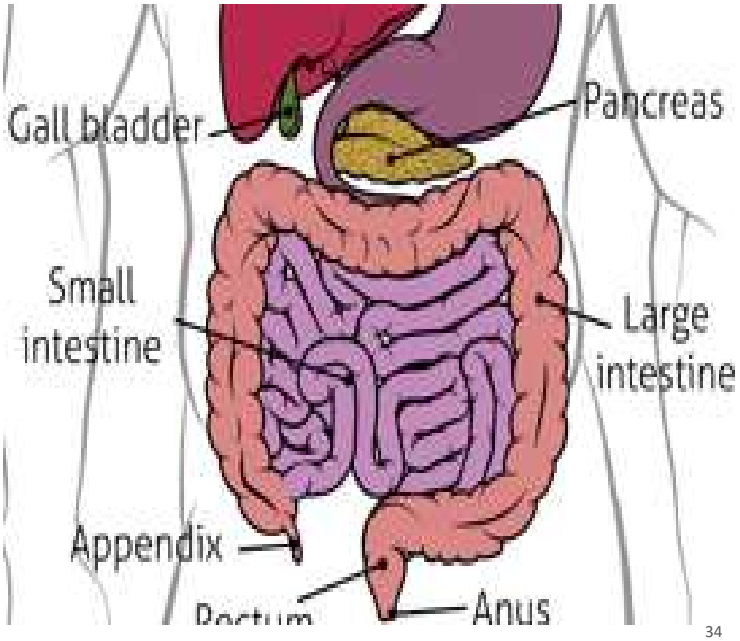
Site of Complete Digestion

- The **small intestine** is the site for the **complete digestion** of carbohydrates, proteins, and fats.
- It uses secretions from the **liver** and **pancreas** also.



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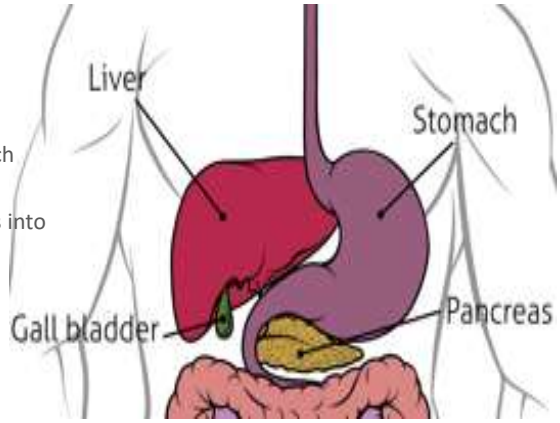
The Liver (provide Bile Juice):



Function of Bile Juice

1. **Neutralization:** Makes the acidic food from the stomach **alkaline** so pancreatic enzymes can work.
2. **Emulsification:** Bile salts break down large **fat globules** into smaller ones (similar to how soap acts on dirt).

The Pancreas (Provide Pancreatic Juice):

Pancreatic Juice provide enzymes like

1. **Trypsin:** Digest protein into peptides.
2. **Lipase:** Digest **emulsified fats into Fatty acids and glycerol**.

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Intestinal Juice: has enzymes which convert nutrients into simplest form

- Proteins → Amino acids
- Complex Carbohydrates → Glucose
- Fats → Fatty acids and Glycerol

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Absorption and Assimilation

- **Absorbtion:** The inner lining of the small intestine has finger-like projections called **villi**. These villi help in absorption of digested food as
  - They increase the **surface area** for absorption.
  - Villi are richly supplied with **blood vessels** that carry absorbed food to every cell in the body.

- **Assimilation:** The digested and absorbed food is used for obtaining **energy**, building or repairing c**ells** and the process is known as Assimilation.

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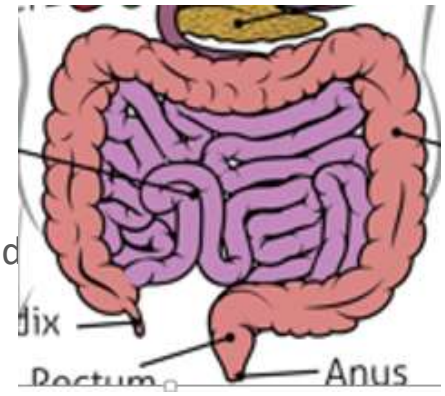
The Large Intestine and Egestion

- **Water Absorption:** Unabsorbed food moves to the large intestine where its walls absorb **more water**.
- **Egestion:** The remaining solid waste is removed from the body via the **anus** and the process is known as Egestion. Egestion is regulated by the **anal sphincter**.



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Definitions

- **Emulsification:** The process of breaking down large fat droplets into smaller ones to make it easier for enzymes to digest them.
- **Villi:** Tiny, finger-like structures in the small intestine that absorb nutrients into the bloodstream.
- **Sphincter Muscle:** A ring-like muscle that opens or closes a passage in the body to regulate the flow of food or waste

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Enzymes

- **Salivary Amylase**: Found in the saliva, this is an enzyme which breaks down **starch** (a complex molecule) into **simple sugar**.
- **Pepsin**: A protein-digesting enzyme released by the **gastric glands** in the **stomach wall**. It requires an **acidic medium** to function.
- **Trypsin**: A protein-digesting enzyme present in the **pancreatic juice**, this enzyme digest **proteins** in the small intestine.
- **Lipase**: it is a fat digesting enzyme present in the **pancreatic juice**, it is specialized for breaking down **emulsified fats**.
- **Intestinal Enzymes**: These are enzymes secreted by glands in the walls of the small intestine, these enzymes perform the **final conversion** of proteins into **amino acids**, complex carbohydrates into **glucose**, and fats into **fatty acids and glycerol**.

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Respiration

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Respiration

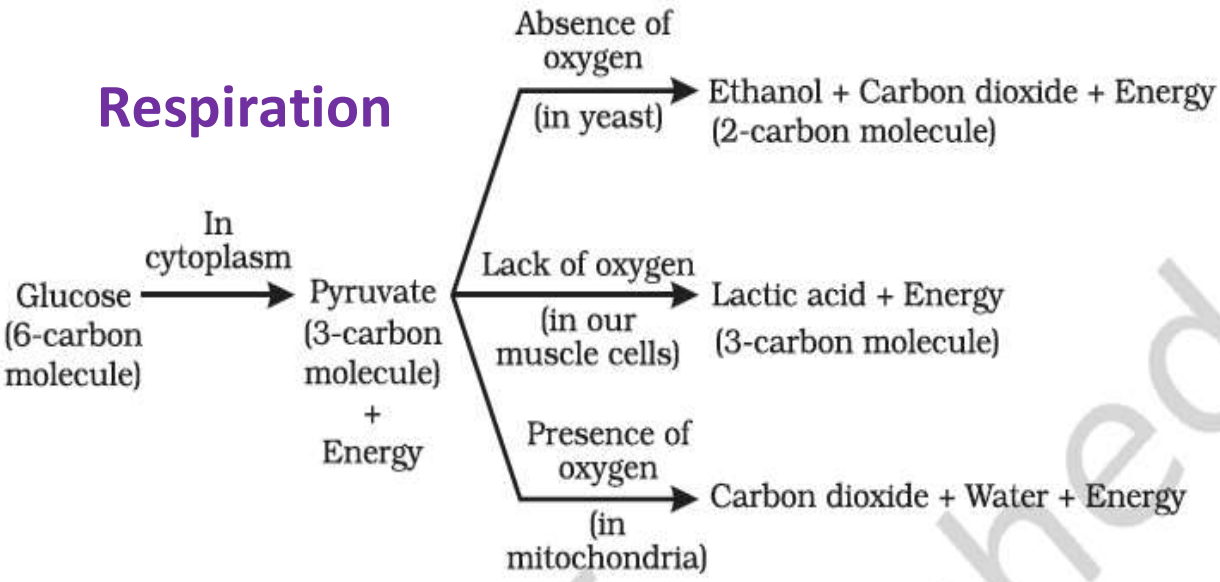

Figure 5.8 *Break-down of glucose by various pathways*

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Respiration

- Definition:
  Respiration is a vital biochemical process in which living cells break down food molecules (like glucose) to release **energy**, which the body then uses to perform various life activities.
- Chemical equation of respiration:
  - Glucose + Oxygen → Carbon Dioxide + Water + Energy (ATP)
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy\ (ATP)$

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Glycolysis

- It is the universal first step of respiration.
- In all organisms, the first stage of breaking down **Glucose** occurs.
- The glucose is broken down into **Pyruvate,** a three-carbon molecule.
- Glycolysis occur in the **Cytoplasm** of the cell.

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Fate of Pyruvate Breakdown

Depending on the availability of oxygen, pyruvate follows three different paths:

A. Anaerobic Respiration (Absence of Oxygen)

Definition: Anaerobic Respiration is the process of breaking down food to release energy in the absence of oxygen.

- This occurs in organisms like **yeast** during **fermentation**.
- The pyruvate is converted into **Ethanol** (2-carbon molecule) and **Carbon dioxide**.

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Lack of Oxygen (In Muscle Cells)

- This happens in our **muscle cells** during sudden, heavy physical activity.
- Pyruvate is converted into **Lactic acid** (a 3-carbon molecule).

Note: The Muscle Cramps: The accumulation of lactic acid in the muscles causes painful **Muscle cramps**.

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B. Aerobic Respiration (Presence of Oxygen)

Definition: Aerobic Respiration is the process of breaking down glucose completely by using oxygen to produce a high amount of energy.

- This process takes place in the **mitochondria**.
- Pyruvate is completely broken down into **Carbon dioxide** and **Water**.
- **Energy Release:** The amount of energy released in aerobic respiration(36-38 ATP) is **much greater** than in anaerobic respiration (2 ATP).

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3. Energy Storage and Usage

- The energy released during these processes is immediately used to make a molecule called **ATP** (Adenosine Triphosphate).
- **ATP** acts as the "energy currency" for the cell, fueling all other cellular activities.
- When the cell needs energy, ATP is broken down to drive **endothermic reactions** (reactions that require energy).

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Summary Table for Quick Revision

Pathway	Location	Oxygen Status	End Products
Step 1 (Glycolysis)	Cytoplasm	N/A	Pyruvate + Energy
Yeast Fermentation	Cytoplasm	Absent	Ethanol + CO_2 + Energy
Muscle Cells	Cytoplasm	Lack of	Lactic Acid + Energy
Aerobic Respiration	Mitochondria	Present	CO2 + Water + Energy

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1. Gas Exchange in Plants

Plants don't have lungs, but they are experts at moving gases through simple processes.

- **Mechanism of Exchange:** Plants exchange gases primarily through tiny pores called **stomata**.
- **Role of Spaces:** Large **inter-cellular spaces** (gaps between cells) inside the plant ensure that almost every cell stays in direct contact with air.
- **Method of Movement:** The movement of O_2 and CO_2 in and out of cells, happens through **diffusion**

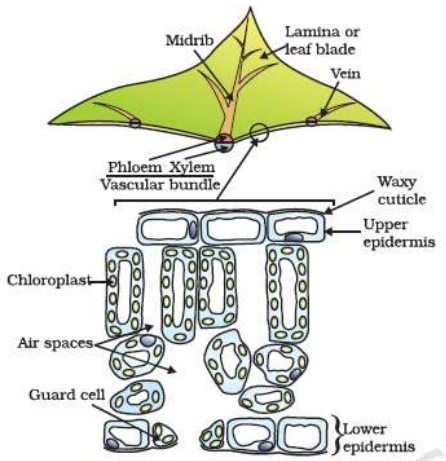

Figure 5.1
Cross-section of a leaf

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2. Night Diffusion Compared with Day Diffusion in Plants

The direction in which these gases move isn't fixed; it depends on the **time of day** and the **plant's needs**.

- **At Night:** Since there is no sunlight, **photosynthesis stops**.
  - The plant is only performing respiration (breathing).
  - Thus mainly Carbon dioxide (CO_2) is released in air.
- **During the Day:**
  - The CO_2 produced during respiration is immediately reused by the plant for **photosynthesis**.
  - Consequently, no CO_2 is released into the air.
  - Thus mainly Oxygen (O_2) is **released in air**.

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Gas Exchange in Animals

- Animals have developed specialized organs to handle gas exchange efficiently.
  - **Terrestrial Animals:** Those living on land breathe oxygen directly from the **atmosphere have lungs** for exchange of gases.
  - **Aquatic Animals:** Those living in water take the **dissolved oxygen** present in the water. Have **gills** for exchange of gases

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Respiration in Aquatic Organisms (Water Dwellers)

Living underwater requires a completely different strategy than breathing on land. As the amount of **dissolved oxygen** in water is fairly **low** compared to the high amount of oxygen present in the atmosphere.

- **Mechanism in Fish:**
  - Fishes take in water through their **mouths**.
  - They forcefully pump this water pass out though the **gills**.
  - As the water flows over the gills, the **dissolved oxygen is absorbed** by the blood.
- **Breathing Rate:** as the amount of oxygen is less in water, aquatic organisms breathe **much faster** than terrestrial organisms to get enough oxygen.

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Respiration in Terrestrial Organisms(Land Dwellers)

- **Source of Oxygen:** Air
- **Surface Area Adaptation:** Their respiratory organs are uniquely designed to **increase surface area**, maximizing contact with the oxygen-rich air.
- **Protection of Respiratory Surfaces:** The gas-exchange surfaces are incredibly **fine and delicate**.
  - To prevent damage, these surfaces are safely tucked **inside the body**.
  - Because they are internal, the body features specialized **passages (tracts)** to transport air inside,
  - A dedicated mechanism to move air in and out (breathing).

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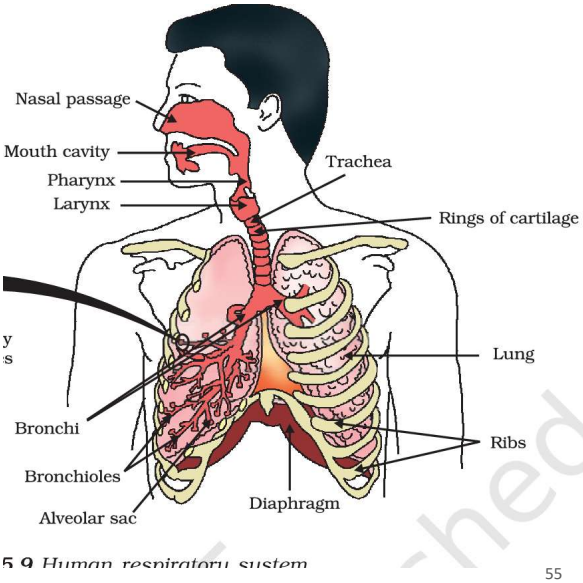
Human Respiratory System (The Initial Pathway)

- **Entry through Nostrils:** Air enters the body through the **nostrils(Nose)**.
- **Air Filtration:** The nasal passage is lined with **fine hairs** and **mucus**. Together, they act as a filter to trap dust particles, dirt, and foreign matter from the incoming air.
- **The Pathway:** Nose → **Pharynx (throat)** → Larynx (voice box) → Trachea → Bronchi → Lungs
- **Role of Cartilage:** The trachea contains **rings of cartilage**. These sturdy rings act as structural supports, ensuring that the **air-passage does not collapse** even when there is no air passing through it.



5.9 *Human respiratory system*

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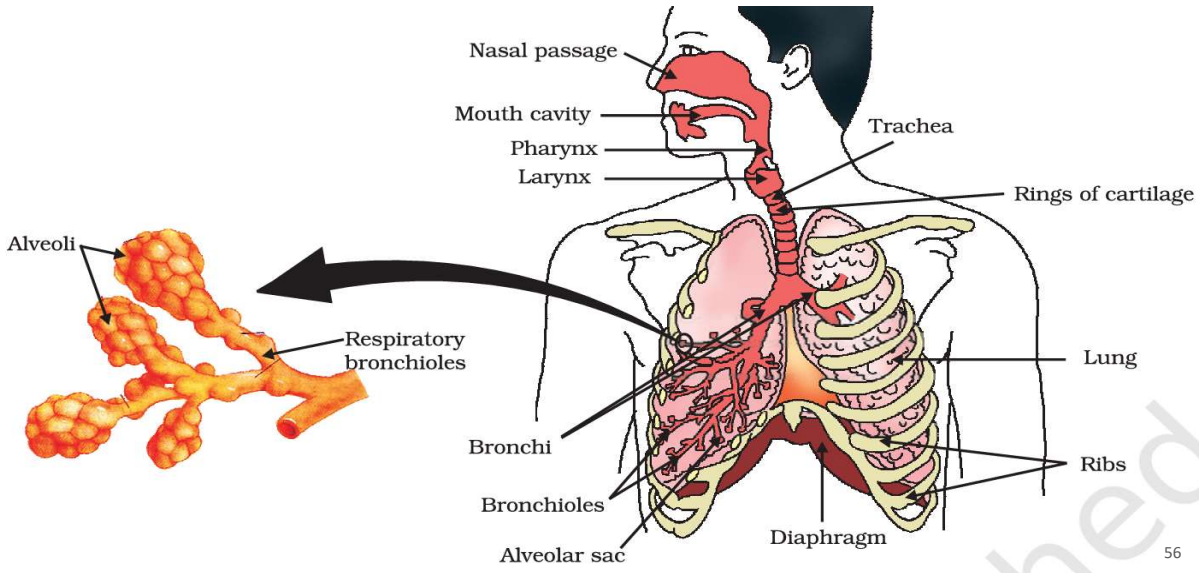
The Pathway: Nose → Pharynx throat) → Larynx (voice box) → Trachea → Bronchi → Lungs



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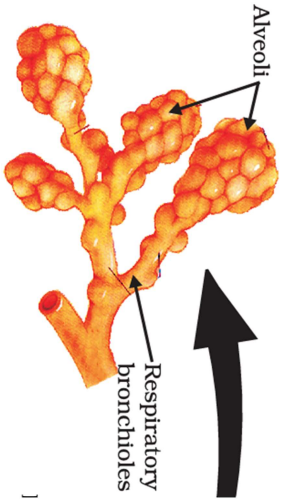
1. Structure and Function of Alveoli

Once air passes through the throat and enters the lungs, the pathway branches out like a tree.

- **Branching Network:** Inside the lungs, the air passage divides into smaller and smaller tubes (bronchi and bronchioles). These tiny tubes end in balloon-like structures called **alveoli** (singular: alveolus).
- **Site of Exchange:** The alveoli provide the actual **surface area** where the exchange of gases takes place.
- **Blood Supply:** The thin walls of the alveoli are covered by an **extensive network of blood vessels** (capillaries) to facilitate quick exchange of gases.



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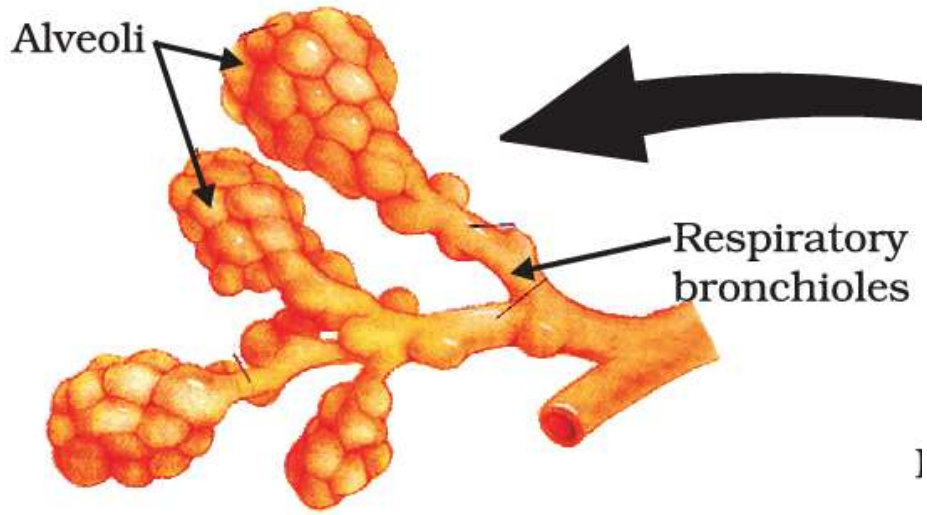
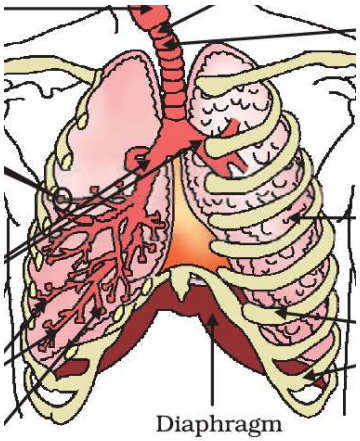


2. The Mechanism of Breathing (Inhalation)

The physical action our body performs to pull air into the lungs.

- **Physical Changes:** When we breathe in (inhale):
  1. We **lift our ribs** upward and outward.
  2. We **flatten our diaphragm** (the muscular sheet below the lungs).
- **Pressure Drop:** These two actions make the **chest cavity larger**, creating a vacuum-like effect.
- **Air Entry:** Because of this increased volume, air is **sucked into the lungs** and completely fills the expanded alveoli.



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3. Gas Exchange and Residual Volume

What happens once the air fills up those tiny balloon-like alveoli?

- **The Swap: *Carbon Dioxide (CO_2):** The blood collects CO_2 from all over the body and brings it to the alveoli to be exhaled.
  - **Oxygen (O_2):** The oxygen present in the alveolar air is picked up by the blood in the blood vessels and sent to every cell in the body.
- **Residual Volume:** During the breathing cycle (inhaling and exhaling), the lungs **never empty completely**. The air which is left in lungs after exhale is called as **residual volume** of air.
- **Why is it important?**
  - This leftover air ensures there is **sufficient time** for oxygen to be absorbed continuously and for carbon dioxide to be released. Thus prevents a sudden drop in oxygen level in body.

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4. Transport of Gases in Large Animals

For larger organisms, simple diffusion is not enough to keep up with the body's demands.

- **The Limitation of Diffusion:** In large animals, the distance between the lungs and distant body cells is too great. If oxygen relied *only* on diffusion pressure to travel, it would take years to reach our toes!
- **Respiratory Pigments:** To solve this, large animals use specialized **respiratory pigments** that lock onto oxygen in the lungs and carry it efficiently to oxygen-deficient tissues.
- In human beings, this respiratory pigment is called **haemoglobin**.
  - It has a **very high affinity (attraction) for oxygen**.
  - It is located inside the **Red Blood Corpuscles (RBCs)**.
- **Transport of Carbon Dioxide:** Unlike oxygen, **carbon dioxide is more soluble in water**. Because of this high solubility, CO_2 doesn't need a heavy carrier like haemoglobin; it is mostly transported **dissolved in the liquid plasma of our blood**.

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Important Definitions for Exams

- **Alveoli:** Functional units of the lungs shaped like tiny balloons that drastically increase the surface area available for the exchange of respiratory gases.
- **Residual Volume:** The volume of air that remains inside the lungs even after a forceful, maximum exhalation.
- **Respiratory Pigment:** A specific molecule (like hemoglobin) inside an organism's blood that increases the oxygen-carrying capacity of the circulatory system.
- **Gills:** Highly vascularized (richly supplied with blood vessels) respiratory organs found in most aquatic organisms used to extract dissolved oxygen from water.
- **Rings of Cartilage:** C-shaped, flexible bony structures located in the throat and trachea (windpipe) that prevent the airway from flattening or collapsing during inhalation.

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Pro-Tip for Class 10 Board Exams:

***Question** 1: "What is the structural and functional unit of the human respiratory system?"*

Answer: Alveoli.

***Question 2**: "Why is haemoglobin necessary in large animals like humans?"*

Answer: *Haemoglobin necessary in large animals* because simple diffusion pressure alone cannot efficiently deliver oxygen to all parts of body. Haemoglobin is required to actively bind and transport oxygen to every tissue.

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TRANSPORTATION

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Composition of Blood

It is a complex connective tissue made up of Plasma and Cellular component.

- **Plasma:** Is the liquid, fluid medium of blood in which all blood cells float or are suspended.
- **Cellular Component:** The blood cells (like RBCs, WBCs, and platelets) that travel within the plasma.

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Transport Functions of Blood

- **Plasma:** Plasma carries substances that easily mix with water. Like
  - **Food** (nutrients),
  - **Carbon dioxide** (CO_2), and
  - **Nitrogenous wastes** (like urea) in a **dissolved form**.
  - **Salts** and minerals to where they are needed.
- **Red Blood Corpuscles (RBCs):**
  - Oxygen (O_2) does not dissolve easily in water, so it is bound to haemoglobin and carried by the **RBCs**.

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Components of Circulatory System

1. **The heart:** It pumps to push the blood all around the body.
2. **A Network of Tubes** (**blood vessels** like arteries, veins, and capillaries): they act as as transport pipeline to reach all the tissues and cells.
3. **The Blood (The Transport Medium):** Its is the liquid portion which flows
4. **A Repair System:** A built-in maintenance system (managed by **platelets**) to repair the network if any blood vessel gets damaged or punctured.

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Important Definitions for Exams

- **Plasma:** The straw-coloured, liquid component of blood that makes up about 55% of total blood volume and is responsible for transporting dissolved nutrients and wastes.
- **Red Blood Corpuscles (RBCs):** Disc-shaped cells containing haemoglobin that specialize in binding and transporting oxygen from the lungs to the tissues.
- **Nitrogenous Wastes:** Toxic waste products (like urea and uric acid) produced by cellular breakdown that are carried by plasma to the kidneys for filtration.

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Pro-Tip for Class 10 Board Exams:

Question: Differentiate how O_2 and CO_2 are transported in humans.
Answer: Carbon dioxide is highly soluble in water and is transported mostly in the **dissolved form within the plasma**, whereas oxygen is carried by **binding to haemoglobin inside the Red Blood Corpuscles (RBCs)**.

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Structure of the Human Heart

The heart is a muscular pump. Designed to handle two different types of blood(Oxygenated and deoxygenated) simultaneously without letting them mix.

- **Size:** as big as our **fist**.
- **Chambers:** It is divided into **four chambers**:
  - Two upper chambers: **Right Atrium** and **Left Atrium** (thin-walled).
  - Two lower chambers: **Right Ventricle** and **Left Ventricle** (thick-walled).

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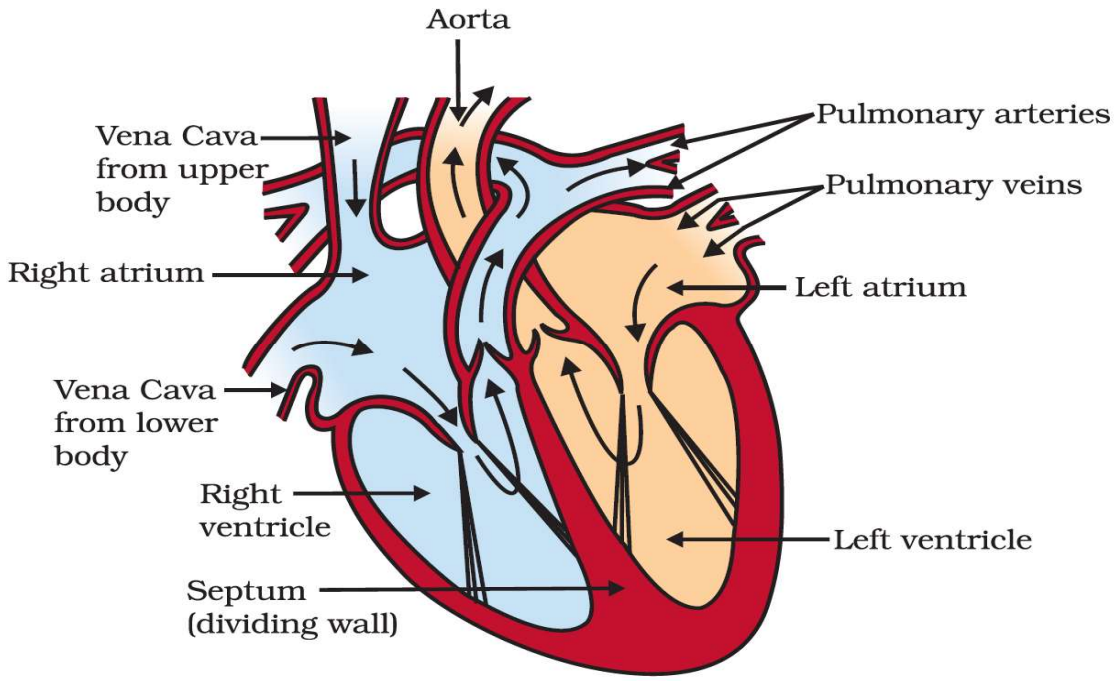

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Some more important points on Heart

- **Prevention of Mixing:** Because both oxygen (O_2) and carbon dioxide (CO_2) are transported by the blood, the heart is split into a left side and a right side by a dividing wall called the **septum**. This keeps oxygenated (oxygen-rich blood) away from mixing with de-oxygenated blood.
- **Wall Thickness: Ventricles have thicker muscular walls** than the atria because ventricles pump blood with high pressure into various distant organs, whereas atria only push blood down into the ventricles.
- **Valves:** The heart contains specialized **valves** that act like one-way doors. They **ensure that blood does not flow backwards** when the atria or ventricles contract.

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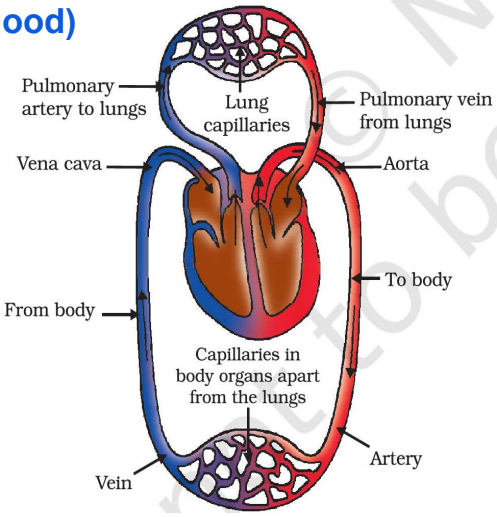
Blood Circulation Pathway

The Right Side (Handles De-oxygenated Blood)

1. **From Body to Heart:** the de-oxygenated blood comes from body tissues via the **vena cava** and enters the upper right chamber, the **right atrium**, (during relaxation of atria).
2. **Atrium to Ventricle:** The right atrium contracts, pass the blood to lower right **ventricle**(during relaxation of ventricle)
3. **From Heart to Lungs:** The right ventricle contracts, and pumps the deoxygenated blood to lungs through the **pulmonary arteries**, where the CO_2 is removed and fresh O_2 is absorbed.



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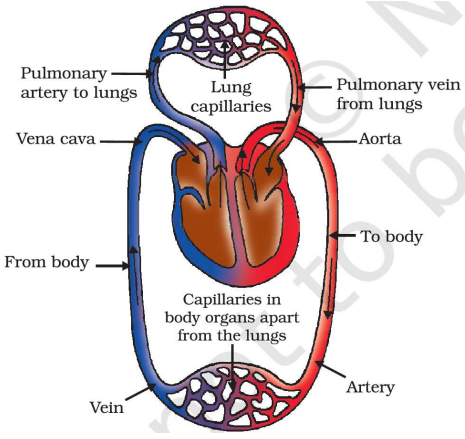
The Left Side (Handles Oxygenated Blood)

1. **From Lungs to Heart:** Oxygenated blood travels from the lungs via the **pulmonary veins** and enters the **left atrium**.
2. **Atrium to Ventricle:** The left atrium contracts, while the lower chamber, the **left ventricle**, relaxes. This transfers the oxygenated blood down into the left ventricle.
3. **From Heart to Body:** Left ventricle contracts to forcefully pump the blood out of the heart through the **aorta** to supply the rest of the body.



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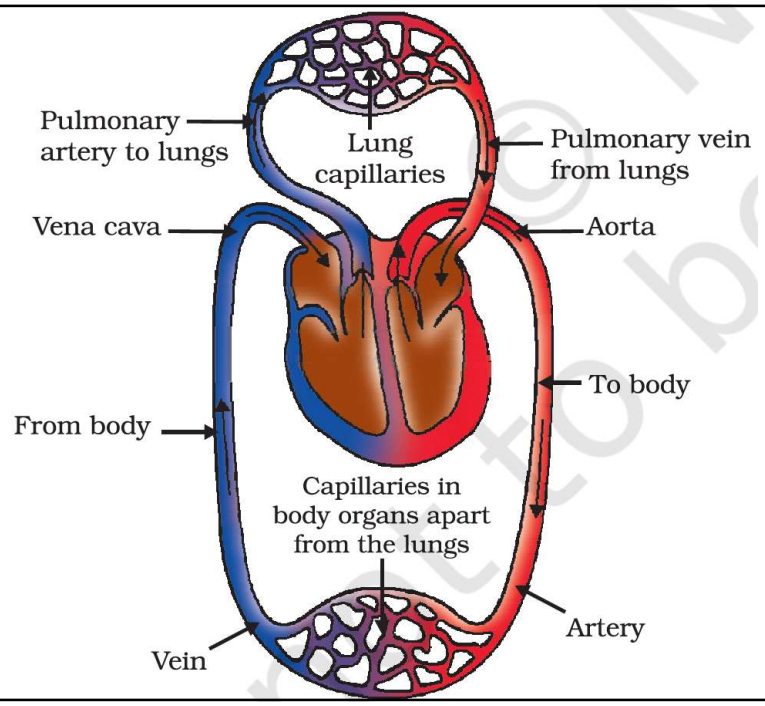

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3. Circulation Patterns Across Different Animals

Evolution has shaped the heart differently depending on an animal's metabolic and energy demands.

- **Mammals and Birds (Have 4-Chambered Heart):**
  - Complete separation of oxygenated and de-oxygenated blood.
  - Highly efficient oxygen delivery system.
  - **Purpose:** Provides the massive amounts of energy needed to **maintain a constant internal body temperature** (warm-blooded animals).

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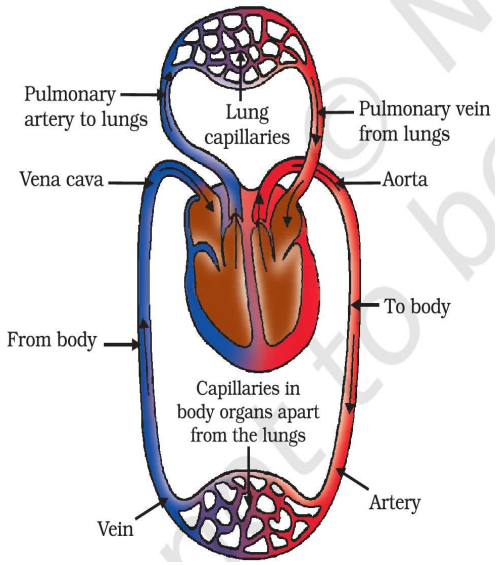

- **Double Circulation:** In birds and mammals (including humans), blood travels through the heart **twice** during each complete cycle through the body.

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- **Amphibians and Many Reptiles (3-Chambered Heart):**
  - They possess two atria but only one shared ventricle, thus **mixing** of oxygenated and de-oxygenated blood occurs in ventricle.
  - **Purpose:** They do not use energy to maintain body temperature; their body temperature depends entirely on the environment (cold-blooded animals), so their energy requirement is much lower.
- **Fishes (2-Chambered Heart):**
  - They have only two chambers (one atrium and one ventricle).
  - **The Pathway:** Blood is pumped from the heart to the **gills**, where it grabs oxygen, and then flows **directly to the rest of the body** before returning to the heart.
  - **Single Circulation:** Blood goes through the heart **only once** during a single complete cycle through the body.

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Important Definitions for Exams

- **Septum:** The muscular dividing wall that separates the right side of the heart from the left side to prevent the mixing of oxygenated and de-oxygenated blood.
- **Double Circulation:** A type of circulatory system where blood passes through the heart twice in one complete circuit around the body (consisting of pulmonary circulation to the lungs and systemic circulation to the body).
- **Valves:** Muscular folds or structures present in the heart and veins that permit the flow of blood in one direction only, preventing backflow.

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Practice Questions for Class 10 CBSE Board Exam

Very Short Answer Questions (1 Mark)

1. What is the structural significance of the septum in the human heart?
2. Name the structural component of the heart that ensures blood does not flow backwards when ventricles contract.

Short Answer Questions (2 or 3 Marks)

1. Reason out why the muscular walls of ventricles are thicker than those of the atria.
2. Distinguish between the circulatory pathway of a fish and a mammal. Why is a fish's system referred to as "single circulation"?
3. Why do warm-blooded animals like birds and mammals require a strict 4-chambered heart setup, whereas amphibians tolerate some mixing of blood?

Long Answer Question (5 Marks)

1. Trace the movement of a drop of de-oxygenated blood from the time it enters the right side of the human heart from the body until it leaves the left side to go back out to the body tissues. Represent this path using a clear flow chart. Include a definition and description of why this process is called **Double Circulation**.

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Very Short Answer Answers (1 Mark)

Answer 1

- The **septum** acts as a complete barrier that separates the left side (oxygen-rich blood) from the right side (carbon dioxide-rich blood). Its significance is that it **prevents the mixing of oxygenated and de-oxygenated blood**, ensuring a highly efficient supply of oxygen to the body.

- **Answer 2**
  - **Valves** (such as the tricuspid, bicuspid, and semilunar valves) ensure that blood does not flow backwards when the heart muscles contract.

Short Answer Answers (2 or 3 Marks)

- **Answer 3**
  - **Atria** only need to pump blood down into the very next lower chambers (the ventricles), which requires very little force.
  - **Ventricles**, on the other hand, must forcefully pump blood out of the heart to distant destinations (the right ventricle pumps blood to the lungs, and the left ventricle pumps blood to the entire body).
  - Therefore, **ventricles have thicker muscular walls** to withstand and generate the high pressure needed to push blood throughout the body.

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Answer 4

The main differences are:

- **Fish (Single Circulation):** The heart has only **two chambers** (1 atrium, 1 ventricle). Blood passes through the heart **only once** during a complete circuit. The heart pumps de-oxygenated blood to the gills for cleaning, and from there, the fresh blood goes *directly* to the body organs without coming back to the heart first.
- **Mammals (Double Circulation):** The heart has **four chambers**. Blood must pass through the heart **twice** during each complete cycle (once to get pumped to the lungs, and a second time to get pumped to the rest of the body).

Answer 5

- **Birds and Mammals** are warm-blooded animals. They constantly use a massive amount of energy to maintain a steady internal body temperature, regardless of how cold or hot it is outside. To produce this high amount of energy, they need a perfect, unmixed supply of oxygen via a **4-chambered heart**.
- **Amphibians and Reptiles** are cold-blooded animals. Their body temperature changes with the environment. Since they don't spend energy maintaining a constant internal temperature, their energy needs are much lower. Therefore, they can tolerate a **3-chambered heart** where some mixing of blood occurs.

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Long Answer Answer (5 Marks)

Answer 6

Part 1: Detailed Trace of Blood Flow

1. De-oxygenated blood from the upper and lower body tissues enters the **Right Atrium** through the **Vena Cava**.
2. The Right Atrium contracts, pushing this blood down into the **Right Ventricle**.
3. The Right Ventricle contracts and pumps the de-oxygenated blood out through the **Pulmonary Artery** to the **Lungs** (where CO_2 is removed and O_2 is picked up).
4. Freshly oxygenated blood returns from the lungs through the **Pulmonary Veins** into the **Left Atrium**.
5. The Left Atrium contracts, transferring the blood into the **Left Ventricle**.
6. The thick, muscular Left Ventricle contracts forcefully, pumping the oxygen-rich blood out through the main artery (**Aorta**) to supply all the cells and organs of the body.

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Part 2: Flow Chart Representation

[Body Tissues (De-oxygenated blood)]
↓
Vena Cava
↓
Right Atrium
↓
Right Ventricle
↓
Pulmonary Artery
↓
[LUNGS] ← (Gas Exchange: CO2 out, O2 in)
↓
Pulmonary Veins
↓
Left Atrium
↓
Left Ventricle
↓
Aorta
↓
[Body Tissues (Oxygenated blood)]

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Explanation: Why it is called "Double Circulation"

It is called **Double Circulation** because blood passes through the human heart exactly **twice** to complete one full journey around the body. It consists of two separate loops working together:

1. **Pulmonary Circulation:** The journey of blood from the heart → to the lungs → and back to the heart.
- **Systemic Circulation:** The journey of blood from the heart → to the rest of the body tissues → and back to the heart.

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The Tubes – Blood Vessels

Our body uses three distinct types of pipes to route blood to every cell.

A. Arteries (The Outgoing Pipes)

- **Function:** They carry blood **away from the heart** to various body organs.
- **Structural Adaptation:** Because blood leaves the heart immediately after a big pump, it travels under **high pressure**. To handle this force without bursting, arteries have **thick, elastic walls**.

B. Veins (The Return Pipes)

- **Function:** They collect blood from different organs and bring it **back to the heart**.
- **Structural Adaptation:** By the time blood reaches the veins, it is **no longer under high pressure**. Therefore, veins have **thin walls**.
- **Special Feature:** Veins contain internal **valves** that act as one-way gates, ensuring blood travels **only in one direction** (toward the heart) and doesn't pool backward.

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C. Capillaries (The Exchange Network)

- When an artery reaches an organ, it splits into smaller and smaller tubes to reach every individual cell. These ultra-thin, microscopic vessels are called **capillaries**.
- **Structural Adaptation:** Their walls are incredibly thin—just **one-cell thick**. This ultra-thin barrier allows nutrients, oxygen, and wastes to easily pass (exchange) between the blood and the surrounding tissues.
- **Re-joining:** After completing the exchange, these capillaries join back together to form veins, which carry the blood away.

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Maintenance by Platelets

- **The Problem with Leaks:** When we get injured and bleed, lot of blood is lost from the circulatory system. As a result It drops the internal fluid volume and reduces blood **pressure**, which reduces the efficiency of the heart.
- **The Solution:** The blood contains specialized cell fragments called **platelets**. They circulate everywhere and automatically cluster at a wound site to **plug the leak by clotting the blood** at the point of injury.

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Lymph (Tissue Fluid)

Apart from blood, our body uses a second fluid system for transportation.

- **How it Forms:** Capillary walls have tiny microscopic pores. As blood flows through under pressure, some amount of **plasma, proteins, and blood cells escape** through these pores into the spaces between the cells (**intercellular spaces**). This escaped fluid is called **lymph** or tissue fluid.
- **Properties:** It is very similar to blood plasma, but it is **colourless** (it has no RBC) and contains **less protein**.
- **The Pathway:** Lymph drains from the tissue spaces into tiny lymphatic capillaries. These join to form larger lymph vessels, which finally empty their contents right **back into the large veins** near the heart.

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Functions of Lymph (Extremely Important for Exams):

- It carries **digested and absorbed fats** away from the small intestine.
- It collects excess fluid from the extracellular spaces and **drains it back into the blood** so our tissues don't swell up.

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Important Definitions for Exams

- **Capillaries:** Microscopic, one-cell-thick blood vessels that connect arteries to veins and serve as the actual site for material exchange between blood and tissues.
- **Blood Clotting:** A protective mechanism triggered by platelets to form a gel-like plug at a wound site, stopping blood loss and maintaining system pressure.
- **Lymph:** A colourless fluid containing white blood cells and less protein than plasma, which drains from the tissue spaces back into the bloodstream and aids in fat absorption.

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Pro-Tip for Class 10 Board Exams:

- The structural differences between arteries and veins. This is a classic 3-mark question:

Feature	Artery	Vein
Direction of Flow	Away from the heart	Toward the heart
Wall Thickness	Thick and elastic	Thin and less elastic
Valves	Absent	Present (to prevent backflow)
Blood Pressure	Very High	Low

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Transportation in Plants

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Need for a Transportation System in Plants

- **Raw Material Sources:** Plants absorb CO_2 through their leaves for photosynthesis, while other essential raw materials like nitrogen, phosphorus, and minerals are absorbed from the soil through the roots.
- **The Distance Problem:** If the distance between the roots and leaves is small, raw materials and energy can move easily through simple diffusion. However, if these distances are large (as in tall trees), diffusion is way too slow to supply materials to the leaves and energy to the roots. Therefore, a proper transport system is essential.
- **Low Energy Needs:** Plants do not move and their tissues contain a large proportion of dead cells. Because of this, plants have low energy needs and can get by with relatively slow transport systems.

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The Two Independent Transport Pathways

Plants use **two separate sets** of conducting tubes to run their transport pipelines:

- **Xylem**: Moves water and minerals upwards from the soil/roots to the rest of the plant body.
- **Phloem**: Transports the soluble products of photosynthesis (food/sugar) from the leaves downward and upward to all other parts of the plant.

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Mechanism of Water Transport (Xylem Pathway)

Water transport involves an interconnected channel system stretching from the root tips all the way up to the leaves, using two physical forces:

1. Root Pressure
2. Transpiration Pull.

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A. Step 1: Entry of Water at the Roots (Root Pressure)

- **Active Ion Uptake:** Cells in the roots that touch the soil actively take up minerals/ions using cellular energy.
- **Concentration Difference: Active Ion Uptake** creates a difference in ion concentration between the inside of the root and the surrounding soil.
- **Water Movement:** To balance this difference, water naturally moves into the roots from the soil. This creates a steady, continuous column of water inside the root xylem that is steadily pushed upwards.

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B. Step 2: Reaching the Highest Points (Transpiration Pull)

Root pressure alone is not strong enough to lift water to the tops of tall trees. Plants use a secondary strategy driven by evaporation:

- **Transpiration pull:** When water molecules evaporate through open stomata into the air, it creates a vacancy which in turn creates a powerful suction pull (Transpiration Pull) that drags the column of water up from the root xylem cells to the leaves.

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C. Functions and Importance of Transpiration

1. It aids in the absorption **and upward movement of water and dissolved minerals** from roots to leaves.
2. It helps the plant with **temperature regulation** (cooling the plant down on hot days).
3. **Day vs. Night Dynamics:** At night, because stomata are closed and there is no evaporation, root pressure is the main driving force moving water. **During the day, when stomata are wide open, transpiration pull becomes the major driving force.**

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Transport of Food and Other Substances (Phloem Pathway)

Moving food requires a completely active system that relies on biological energy, unlike the passive physical forces used by xylem.

- **Translocation:** The transport of soluble products of photosynthesis (like sucrose/sugar) through the phloem tissue.
- **What Else is Transported?** Along with food, phloem delivers amino acids and other substances to storage organs (roots, fruits, seeds) and growing points (like buds).
- **Structural Components:** Translocation happens inside specialized tubes called sieve tubes with the help of adjacent companion cells.
- **Bidirectional Movement:** Unlike xylem (which only moves water upward), **phloem can move food in both upward and downward directions** based on where the plant needs it.

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How Translocation Works (The Osmotic Mechanism)

1. Loading Energy: Food materials like sucrose are actively loaded into the phloem tissue using energy from ATP.
2. Water Inflow: Loading sugar increases the concentration inside the phloem, causing water from nearby cells to move into the phloem via osmosis. This build-up creates high osmotic pressure inside the tissue.
3. Pressure-Driven Movement: This high pressure forces the food material to move along the phloem tubes to neighboring tissues that have less pressure.
4. Seasonal Adaptability: In early spring, sugar stored inside root or stem tissues is actively pushed upward through the phloem to the dormant buds to give them the energy required to sprout and grow.

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Important Definitions for Exams

- **Transpiration**: The loss of water in the form of water vapour from the aerial parts (like leaves) of a plant through stomata.
- **Translocation**: The transport of soluble food materials (like sucrose) and amino acids from the leaves where they are made to other parts of the plant through the phloem.
- **Sieve Tubes:** Slender, elongated cells in the phloem tissue that are connected end-to-end to form the continuous pipeline responsible for transporting food.

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Difference between Xylem Phloem

Feature	Xylem Transport	Phloem Transport (Translocation)
Material Carried	Water and dissolved minerals	Soluble food (sucrose) and amino acids
Direction of Flow	Unidirectional (only upward from roots)	Bidirectional (both upward and downward)
Energy Consumption	Uses passive physical forces (no ATP used)	Uses active transport (utilizes ATP energy)

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Excretion

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1. Introduction to Excretion

- **The Need:** Metabolic activities inside the body generate harmful byproduct chemicals, particularly toxic nitrogenous materials, which must be removed to avoid poisoning the organism.
- **Unicellular Organisms:** Simple single-celled animals (like Amoeba) do not have complex organs. They remove metabolic wastes through simple diffusion from their outer body surface straight into the surrounding water.
- **Multicellular Organisms:** Large, complex animals cannot rely on simple diffusion because their inner cells are not in direct contact with the outside environment. They have specialized organs to carry out excretion.

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2. Excretion in Human Beings

The human excretory system specializes in filtering blood and stripping away liquid chemical wastes.

A. Organs of the Human Excretory System

The human excretory system consists of four primary structural components:

- **A pair of kidneys:** Two bean-shaped organs located in the abdomen, one on either side of the backbone. They act as the primary blood filters.
- **A pair of ureters:** Long tubes that connect each kidney to the urinary bladder.
- **A urinary bladder:** A muscular storage bag that holds liquid waste (urine) until it can be disposed of.
- **A urethra:** A narrow canal or passage through which urine is finally expelled out of the body.

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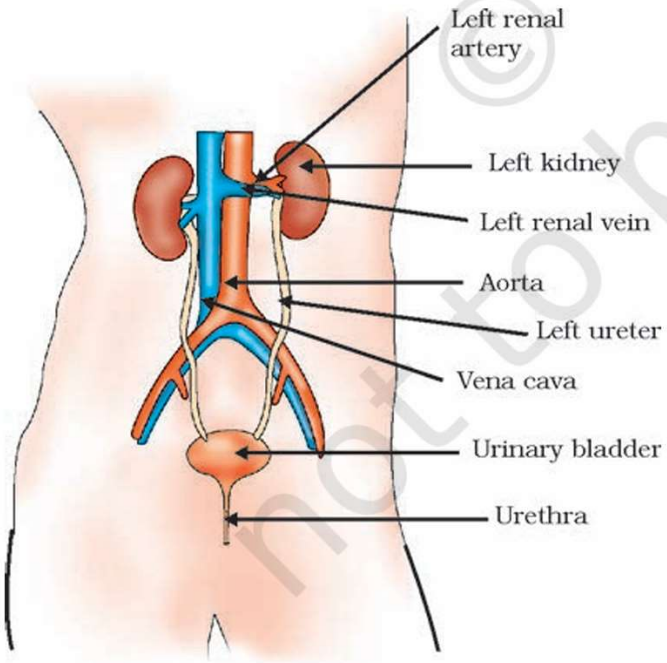

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Basic Filtration Unit of the Kidney

- The **basic filtration unit** of the kidney is called a **Nephron**.
- **Definition: Nephron** is the **structural and functional unit of the kidney** that filters blood and forms urine.
- Each kidney contains **a large number of nephrons** packed closely together.

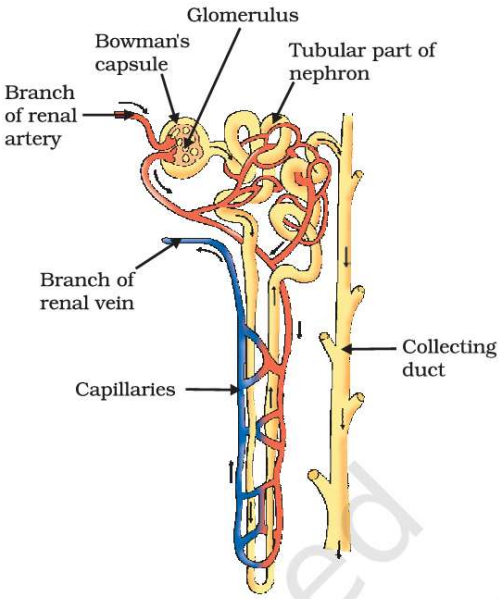

Figure 5.14

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2. Structure of a Nephron

- A nephron consists of:
  - A **cluster of very thin-walled blood capillaries**.
  - A **cup-shaped structure called Bowman's capsule**.
- **Bowman's capsule** is a **cup-shaped structure that surrounds the capillary cluster and collects the filtrate** formed from blood.

3. Formation of Filtrate

- Blood enters the **capillary cluster** inside the nephron.
- Water and small dissolved substances are filtered out from the blood.
- This filtered liquid is called the **filtrate**.
- The **Bowman's capsule collects this filtrate**.

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Reabsorption and Urine formation

Selective Reabsorption

- As the filtrate moves through the nephron tubule some important molecules like :
  - **Glucose**.
  - **Amino acids**.
  - **Salts**.

  Are are reabsorbed with **Most of the water** back into the blood.

This process is called **Selective Reabsorption**.

- **Selective reabsorption** is the process by which useful substances are absorbed back into the blood from the filtrate.

Water Reabsorption Depends On

- The amount of water reabsorbed depends upon:
  - **The amount of excess water present in the body.**
  - **The amount of dissolved waste that needs to be removed.**
- This helps the body maintain **water balance**.

Formation and Transport of Urine

- After reabsorption, the remaining filtrate becomes **urine**.
- Urine formed in each kidney enters a **long tube called the ureter**.
- The **ureter carries urine from the kidney to the urinary bladder**.

- **Urinary bladder:** A muscular sac that stores urine until it is expelled from the body.
- **Urethra:** The tube through which urine passes out of the body.

Nervous Control of Urination

- The **urinary bladder is muscular**.
- Its activity is **controlled by the nervous system**.
- Therefore, humans can **usually control the urge to urinate** until an appropriate time.

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B. Purpose and Pathway of Urine

- **The Goal:** The core purpose of making urine is to filter out toxic waste products from the blood stream.
- **What is removed?** Just as our lungs clean out gaseous CO_2 from the blood, our kidneys filter out dangerous liquid nitrogenous wastes like urea or uric acid.
- **The Flow Pathway:**
  - **Kidneys (Urine Produced) → Ureters (Passed Down) → Urinary Bladder (Stored) → Urethra (Released Out)**

111

Excretion in Plants

Plants use completely unique, passive, and brilliant strategies to discard waste products such as:

- **Gaseous Wastes:** Oxygen (O_2) produced during daytime photosynthesis and carbon dioxide (CO_2) produced during respiration are treated as waste gases and are released into the air through stomata.
- **Excess Water:** Surplus water inside the plant body is eliminated in the form of water vapor through the process of transpiration.
- **Using Dead Tissues:** Since plant bodies contain a large amount of dead cells, they can pack waste materials into parts they no longer need, such as old leaves that eventually fall off.
- **Cellular Storage:** Many cellular wastes are safely locked away inside giant storage bubbles called **cellular vacuoles** within individual cells.
- **Resins and Gums:** Other complex metabolic waste products are stored permanently inside old, non-functional xylem tissue in the form of sticky resins and gums.
- **Soil Excretion:** Plants can also seep and excrete some waste materials directly into the soil immediately surrounding their root systems.

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The End