

Chapter 5: Life Processes

Comprehensive Study Notes

Introduction

Life processes are the essential activities that maintain life in organisms. These processes must continue even when organisms appear inactive (sleeping, resting) to prevent breakdown of organized living structures.

Key Question: How do we distinguish between living and non-living things?

Criteria for Life:

- Visible movement (breathing, growth)
- Molecular movement (essential for maintenance)
- Response to environment
- Organized structure maintenance

Why are molecular movements necessary? Living organisms are highly organized structures that tend to break down over time due to environmental effects. Continuous molecular movement is required to repair and maintain these structures.

5.1 What are Life Processes?

Definition

Life Processes: Maintenance functions that prevent damage and breakdown of living structures

Essential Life Processes:

1. **Nutrition:** Obtaining energy and raw materials
2. **Respiration:** Breaking down food to release energy
3. **Transportation:** Moving materials within the body
4. **Excretion:** Removing waste products

Energy Requirements:

- Maintenance processes require continuous energy
 - Energy source comes from outside the body (food)
 - Food must be processed into usable forms
 - Complex organisms need specialized systems
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5.2 Nutrition

5.2.1 Types of Nutrition

Autotrophic Nutrition

Definition: Organisms synthesize food from simple inorganic substances

Characteristics:

- Use simple compounds (CO_2 , H_2O)
- Require external energy source (sunlight)
- Convert to complex organic molecules
- Examples: Green plants, some bacteria

Heterotrophic Nutrition

Definition: Organisms obtain complex food from other organisms

Types:

1. **Saprotrophic:** Break down food outside body (fungi, bacteria)
2. **Parasitic:** Derive nutrition without killing host (tapeworms, lice)
3. **Holozoic:** Ingest whole food and digest internally (animals)

5.2.2 Photosynthesis

Overall Equation: $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + \text{Energy (Sunlight + Chlorophyll)}$

Steps in Photosynthesis:

1. **Light absorption** by chlorophyll
2. **Light energy conversion** to chemical energy
3. **Water splitting** into hydrogen and oxygen
4. **CO₂ reduction** to carbohydrates

Essential Requirements:

- **Chlorophyll:** Present in chloroplasts (green organelles)
- **Sunlight:** External energy source
- **Carbon dioxide:** Raw material from atmosphere
- **Water:** Raw material from soil

Experimental Evidence:

Starch Test with Variegated Leaf:

- Only green parts (with chlorophyll) produce starch

- Iodine solution turns blue-black with starch
- Proves chlorophyll necessity for photosynthesis

CO₂ Requirement Test:

- Plant with KOH (CO₂ absorber) vs. without KOH
- No starch formation without CO₂
- Proves CO₂ necessity

5.2.3 Nutrition in Human Beings

Digestive System Components:

Alimentary Canal: Mouth → Oesophagus → Stomach → Small Intestine → Large Intestine → Anus

Digestive Process:

1. Mouth:

- **Mechanical breakdown:** Teeth crush food
- **Chemical breakdown:** Salivary amylase converts starch to simple sugars
- **Moistening:** Saliva makes food passage smooth
- **Movement:** Muscular tongue mixes food with saliva

2. Oesophagus:

- **Peristaltic movements:** Rhythmic muscle contractions push food
- **Transport:** Food moves from mouth to stomach

3. Stomach:

- **Storage:** Large expandable organ

- **Gastric juice secretion:**
 - HCl: Creates acidic medium (pH ~2)
 - Pepsin: Protein-digesting enzyme
 - Mucus: Protects stomach lining
- **Functions of HCl:**
 - Activates pepsin
 - Kills harmful bacteria
 - Breaks down food particles

4. Small Intestine:

- **Complete digestion** of carbohydrates, proteins, fats
- **Longest part** of alimentary canal
- **Length varies:** Herbivores > Carnivores (cellulose digestion needs)

Secretions in Small Intestine:

Bile (from Liver):

- Makes acidic food alkaline
- Emulsifies fats into smaller globules
- Increases enzyme efficiency

Pancreatic Juice:

- Trypsin: Digests proteins
- Lipase: Digests emulsified fats
- Amylase: Digests carbohydrates

Intestinal Juice:

- Final conversion to absorbable forms:
 - Proteins → Amino acids
 - Carbohydrates → Glucose
 - Fats → Fatty acids + Glycerol

5. Absorption:

- **Villi:** Finger-like projections increase surface area
- **Rich blood supply** carries absorbed food to all body cells
- **Functions:** Energy production, tissue building, repair

6. Large Intestine:

- **Water absorption** from undigested food
 - **Waste formation:** Remaining material becomes faeces
 - **Elimination:** Through anus via anal sphincter
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5.3 Respiration

5.3.1 Definition and Purpose

Respiration: Process of breaking down food to release energy for cellular activities

5.3.2 Types of Respiration

Aerobic Respiration (with oxygen)

Location: Mitochondria **Equation:** $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38 \text{ ATP}$ **Characteristics:**

- Complete breakdown of glucose
- High energy yield (38 ATP molecules)
- Products: CO₂ and H₂O

Anaerobic Respiration (without oxygen)

Location: Cytoplasm **Types:**

1. **Alcoholic Fermentation (in yeast):** $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 2\text{ ATP}$

2. **Lactic Acid Fermentation (in muscles):** $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3 + 2\text{ ATP}$

Characteristics:

- Incomplete breakdown of glucose
- Low energy yield (2 ATP molecules)
- Occurs when oxygen is insufficient

Common First Step:

Glycolysis: Glucose (6-carbon) → Pyruvate (3-carbon) + Energy

- Occurs in cytoplasm
- Does not require oxygen

5.3.3 Respiration in Human Beings

Respiratory System Structure:

Pathway: Nostrils → Throat → Bronchi → Bronchioles → Alveoli

Components:

- **Nostrils:** Filter air with hairs and mucus

- **Trachea:** Windpipe with cartilage rings (prevent collapse)
- **Bronchi:** Two main branches entering lungs
- **Bronchioles:** Smaller tubes within lungs
- **Alveoli:** Balloon-like structures for gas exchange

Breathing Mechanism:

Inspiration:

- Ribs lift up, diaphragm flattens
- Chest cavity expands
- Air pressure decreases
- Air rushes into lungs

Expiration:

- Ribs move down, diaphragm moves up
- Chest cavity contracts
- Air pressure increases
- Air pushed out of lungs

Gas Exchange:

- **Location:** Alveoli (millions of tiny air sacs)
- **Surface area:** $\sim 80 \text{ m}^2$ (very large for efficient exchange)
- **Mechanism:** Diffusion across alveolar walls
- **Blood transport:**
 - O_2 : Carried by haemoglobin in red blood cells
 - CO_2 : Mostly dissolved in blood plasma

5.4 Transportation

5.4.1 Transportation in Human Beings

Circulatory System Components:

1. **Heart:** Pumping organ
2. **Blood:** Transport medium
3. **Blood vessels:** Transport network

Blood Composition:

- **Plasma:** Liquid medium (55%)
 - Transports: Food, CO₂, nitrogenous waste, salts
- **Red Blood Cells:** Carry oxygen via haemoglobin
- **White Blood Cells:** Fight infections
- **Platelets:** Blood clotting

Heart Structure and Function:

Four Chambers:

- **Right Atrium:** Receives deoxygenated blood from body
- **Right Ventricle:** Pumps blood to lungs
- **Left Atrium:** Receives oxygenated blood from lungs
- **Left Ventricle:** Pumps blood to body

Double Circulation:

1. **Pulmonary circulation:** Heart → Lungs → Heart

2. **Systemic circulation:** Heart → Body → Heart

Advantages of Four-chambered Heart:

- Prevents mixing of oxygenated and deoxygenated blood
- Efficient oxygen supply
- Maintains high energy levels (birds, mammals)

Blood Vessels:

Arteries:

- Carry blood away from heart
- Thick, elastic walls (high pressure)
- No valves (except aorta and pulmonary artery)

Veins:

- Carry blood toward heart
- Thin walls (low pressure)
- Have valves to prevent backflow

Capillaries:

- One-cell thick walls
- Site of material exchange
- Connect arteries and veins

Blood Pressure:

- **Systolic:** Pressure during heart contraction (~120 mmHg)

- **Diastolic:** Pressure during heart relaxation (~80 mmHg)
- **Measurement:** Sphygmomanometer

5.4.2 Transportation in Plants

Transport Systems:

1. **Xylem:** Water and mineral transport
2. **Phloem:** Food transport

Water Transport (Xylem):

Mechanism:

1. **Root pressure:** Active ion uptake creates concentration gradient
2. **Transpiration pull:** Water evaporation from leaves creates suction

Transpiration Process:

- **Definition:** Loss of water vapor from aerial plant parts
- **Location:** Mainly through stomata
- **Functions:**
 - Water and mineral absorption
 - Upward transport
 - Temperature regulation
- **Driving force:** Major force during day when stomata open

Root Pressure vs Transpiration Pull:

- **Night:** Root pressure more important
- **Day:** Transpiration pull dominates

Food Transport (Phloem):

Translocation: Transport of photosynthesis products

Mechanism:

- **Energy-dependent process** (uses ATP)
- **Material loading:** Sucrose loaded into phloem using energy
- **Osmotic pressure:** Water enters, creating pressure
- **Direction:** From high pressure to low pressure areas
- **Bidirectional:** Up and down based on plant needs

Components Transported:

- Products of photosynthesis (mainly sucrose)
 - Amino acids
 - Other organic substances
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5.5 Excretion

5.5.1 Definition and Importance

Excretion: Removal of harmful metabolic waste products from the body

Why necessary?

- Metabolic activities generate toxic wastes
- Accumulation can harm or kill organism
- Maintains internal chemical balance

5.5.2 Excretion in Human Beings

Excretory System:

Components:

- 2 Kidneys: Filter blood
- 2 Ureters: Transport urine
- 1 Urinary bladder: Store urine
- 1 Urethra: Release urine

Kidney Structure and Function:

Nephron: Functional unit of kidney

Parts of Nephron:

1. **Bowman's capsule:** Cup-shaped structure
2. **Glomerulus:** Cluster of capillaries
3. **Tubule:** Long coiled tube for reabsorption

Urine Formation Process:

1. **Filtration:** Blood filtered in glomerulus
2. **Reabsorption:** Useful substances reabsorbed
 - Glucose, amino acids, salts, water
3. **Excretion:** Waste products (urea, uric acid) removed

Daily Statistics:

- **Initial filtrate:** ~180 L per day
- **Final urine:** 1-2 L per day

- **Reabsorption:** ~99% of filtrate

Artificial Kidney (Hemodialysis):

When needed: Kidney failure **Process:** Blood passed through semi-permeable tubes **Function:**

Removes nitrogenous wastes by diffusion **Difference from natural kidney:** No reabsorption

5.5.3 Excretion in Plants

Strategies:

1. **Gas exchange:** O₂ (photosynthesis waste) and CO₂ removed through stomata
 2. **Transpiration:** Excess water removal
 3. **Storage in vacuoles:** Waste products stored in cell vacuoles
 4. **Leaf fall:** Waste stored in leaves that are shed
 5. **Gums and resins:** Stored in old xylem tissue
 6. **Soil excretion:** Some wastes released into surrounding soil
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5.6 Detailed Process Mechanisms

5.6.1 Photosynthesis Requirements

Stomatal Function:

- **Guard cells:** Control opening and closing
- **Open when:** Guard cells swell (water enters)
- **Close when:** Guard cells shrink (water exits)
- **Purpose:** Gas exchange while minimizing water loss

Raw Material Sources:

- **CO₂:** Atmosphere through stomata
- **H₂O:** Soil through roots
- **Minerals:** Nitrogen, phosphorus, iron, magnesium from soil
- **Nitrogen:** Uptake as nitrates, nitrites, or organic compounds

5.6.2 Respiratory Gas Exchange

In Plants:

- **Day:** CO₂ used in photosynthesis, O₂ released
- **Night:** CO₂ released, O₂ consumed
- **Mechanism:** Simple diffusion through stomata

In Animals:

Aquatic Animals:

- Extract dissolved oxygen from water
- Faster breathing rate (low O₂ concentration in water)
- Gills: Large surface area for gas exchange

Terrestrial Animals:

- Use atmospheric oxygen
- Specialized respiratory organs (lungs)
- Protected internal surfaces

Human Respiratory Features:

- **Large surface area:** Alveoli provide ~80 m²

- **Thin walls:** Single-cell thick for easy diffusion
 - **Rich blood supply:** Extensive capillary network
 - **Residual volume:** Lungs never completely empty
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5.7 Comparative Biology

5.7.1 Heart Structures Across Species

Organism	Chambers	Circulation	Energy Needs
Fish	2	Single	Moderate
Amphibians/Reptiles	3	Mixed blood tolerance	Variable body temperature
Birds/Mammals	4	Double, separated	High (constant body temperature)

5.7.2 Digestive System Variations

Herbivores vs Carnivores:

- **Herbivores:** Longer small intestine (cellulose digestion)
- **Carnivores:** Shorter small intestine (meat easier to digest)
- **Example:** Cow vs Tiger intestine length difference

5.7.3 Single-celled vs Multi-cellular

Single-celled Organisms:

- **Nutrition:** Entire surface absorbs nutrients
- **Gas exchange:** Direct diffusion with environment
- **Excretion:** Simple diffusion
- **Example:** Amoeba uses pseudopodia, Paramecium uses cilia

Multi-cellular Organisms:

- **Specialized organs** for each function
 - **Transport systems** to connect organs
 - **Complex coordination** between systems
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5.8 ATP - The Energy Currency

Definition and Function

ATP (Adenosine Triphosphate): Universal energy currency of cells

ATP Cycle:

- **Formation:** $\text{ADP} + \text{P}_i + \text{Energy} \rightarrow \text{ATP}$ (during respiration)
- **Utilization:** $\text{ATP} \rightarrow \text{ADP} + \text{P}_i + \text{Energy}$ (for cellular work)
- **Energy released:** 30.5 kJ/mol when ATP breaks down

Applications:

- Muscle contraction
 - Protein synthesis
 - Active transport
 - Nerve impulse conduction
 - All endothermic cellular processes
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Practice Questions and Answers

Q1. What are the differences between aerobic and anaerobic respiration? Give examples of organisms using each type.

Answer: Aerobic Respiration:

- Occurs in presence of oxygen
- Complete breakdown of glucose
- High energy yield (38 ATP)
- Products: $\text{CO}_2 + \text{H}_2\text{O}$
- Location: Mitochondria
- Examples: Humans, most animals, plants

Anaerobic Respiration:

- Occurs without oxygen
- Incomplete breakdown of glucose
- Low energy yield (2 ATP)
- Products: Alcohol + CO_2 (yeast) or Lactic acid (muscles)
- Location: Cytoplasm
- Examples: Yeast, bacteria, muscle cells during exercise

Q2. How are alveoli designed to maximize gas exchange efficiency?

Answer: Alveoli are designed for maximum efficiency through:

1. **Large surface area:** $\sim 80 \text{ m}^2$ total surface
2. **Thin walls:** Single-cell thick for easy diffusion

3. **Rich blood supply:** Extensive capillary network
4. **Moist surface:** Facilitates gas dissolution
5. **Large number:** Millions of alveoli in each lung
6. **Residual air:** Ensures continuous gas exchange

Q3. Explain double circulation in human beings and why it's necessary.

Answer: Double circulation means blood passes through heart twice in one complete cycle:

Circuit 1 (Pulmonary): Right ventricle → Lungs → Left atrium **Circuit 2 (Systemic):** Left ventricle → Body → Right atrium

Necessity:

- Prevents mixing of oxygenated and deoxygenated blood
- Ensures efficient oxygen delivery to all body parts
- Maintains high blood pressure for effective circulation
- Supports high metabolic rate needed for constant body temperature
- Essential for active lifestyle of birds and mammals

Q4. How do stomata help in photosynthesis and transpiration?

Answer: Stomata are essential for both processes:

For Photosynthesis:

- Allow CO₂ entry from atmosphere
- Permit O₂ exit (waste product)
- Enable gas exchange necessary for the process

For Transpiration:

- Allow water vapor exit from leaves
- Create transpiration pull for water transport
- Help in temperature regulation

Smart Regulation: Guard cells control opening/closing based on:

- Light conditions (open during day)
- Water availability (close when water scarce)
- CO₂ concentration needs

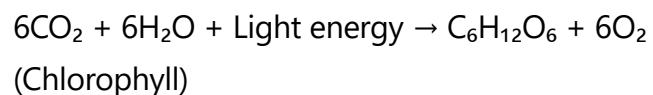
Q5. Compare transportation in xylem and phloem.

Answer:

Aspect	Xylem	Phloem
Materials	Water, minerals	Organic food (sucrose), amino acids
Direction	Unidirectional (upward)	Bidirectional (up and down)
Energy	No energy required	Energy required (ATP)
Driving Force	Transpiration pull, root pressure	Osmotic pressure
Structure	Dead cells (tracheids, vessels)	Living cells (sieve tubes, companion cells)
Process	Physical process	Active process
Speed	Faster	Slower

5.9 Key Equations and Processes

Photosynthesis:



Aerobic Respiration:



Anaerobic Respiration:

- **In yeast:** $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 + 2 \text{ ATP}$
 - **In muscles:** $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_3\text{H}_6\text{O}_3 + 2 \text{ ATP}$
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5.10 Health and Life Processes

Disease Prevention:

- **Dental caries:** Brush teeth to remove bacterial plaque
- **Respiratory problems:** Avoid tobacco and smoking
- **Kidney disease:** Adequate water intake, avoid toxins
- **Heart disease:** Regular exercise, healthy diet

Lifestyle Connections:

- **Exercise:** Increases respiratory and circulatory efficiency
 - **Diet:** Provides raw materials for all life processes
 - **Water intake:** Essential for excretion and transportation
 - **Sleep:** Allows maintenance and repair processes
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Chapter Summary

Life processes are interconnected systems that maintain life through nutrition, respiration, transportation, and excretion. These processes work together to provide energy, raw materials, and

waste removal essential for survival.

Understanding these processes helps explain how organisms adapt to their environment and maintain complex internal organization. The efficiency of these systems determines an organism's survival capacity and evolutionary success.

From single-celled organisms with simple diffusion to complex multi-cellular organisms with specialized organ systems, life processes show remarkable diversity while serving the same fundamental purpose - maintaining life.

The study of life processes connects molecular biology with whole-organism physiology, showing how chemical reactions in cells support the activities of entire living beings.

Study Strategy:

- Understand the interconnections between all life processes
- Practice drawing and labeling system diagrams
- Focus on experimental evidence for each process
- Connect structure to function in all systems
- Relate life processes to health and disease

Source: NCERT Science Textbook

Complete coverage for comprehensive understanding