



Senior 2 General Science (New curriculum)

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Senior 2

Term 2

THEME: SCIENCE IN AGRICULTURE

TOPIC 5: NUTRITION IN GREEN PLANTS

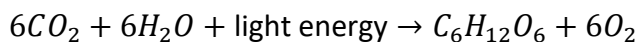
Competency: The learner should be able to understand that plants are capable of making their own food from simple compounds like water and carbon dioxide.



Photosynthesis

Photosynthesis is the process by which **green plants** use **sunlight, carbon dioxide, and water** to make **food (glucose)** and release **oxygen**. It happens in the **chloroplasts** of plant cells.

Equation:



Stages of Photosynthesis

- (i) **Light Stage** → Chlorophyll absorbs sunlight, water splits into hydrogen and oxygen, energy carriers (ATP, NADPH) are formed.
- (ii) **Dark Stage (Calvin Cycle)** → Carbon dioxide combines with hydrogen using energy from ATP/NADPH to form glucose.

Functions of Photosynthesis

Function	Contribution	Example
Food Production	Provides glucose for plants and animals	Starch in maize
Oxygen Supply	Releases oxygen for respiration	Humans breathe oxygen
Climate Regulation	Removes CO ₂ from atmosphere	Reduces greenhouse gases
Energy Source	Basis of food chains and fossil fuels	Sugarcane for biofuel

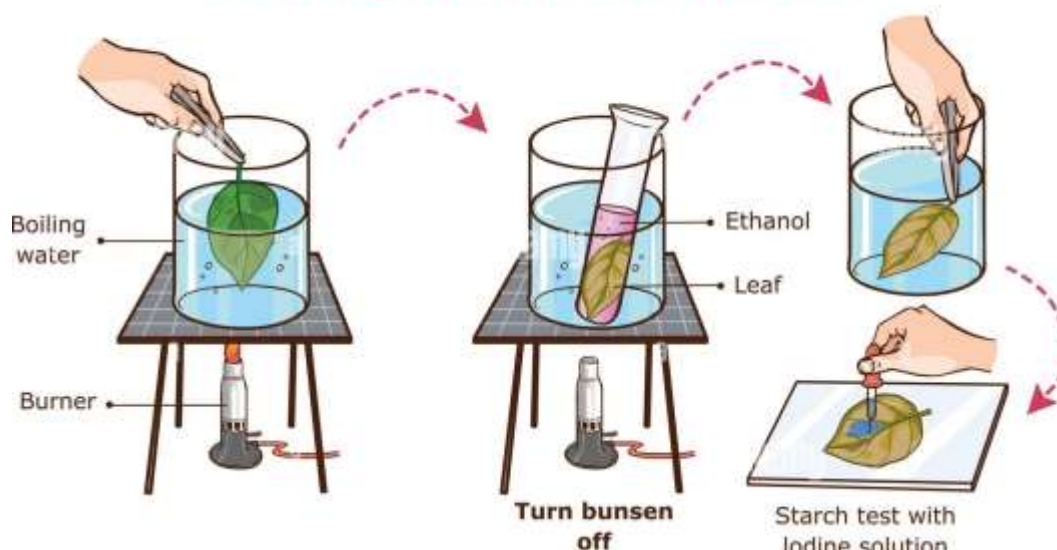
Importance in Everyday Life

- ❖ **Agriculture** → Crop growth and food supply.
- ❖ **Human Survival** → Provides oxygen and food.
- ❖ **Ecosystems** → Supports all food chains.

Testing for starch in leaves

- (i) Dip a leaf in boiling water for a few minutes to kill the cells.
- (ii) Then boil it in alcohol to remove chlorophyll until it is decolorized.
- (iii) Dip the decolorized leaf in warm water to soften it.
- (iv) Lay the soft leaf on a white tile and add drops of iodine solution

Testing a leaf for starch



Observation

When the leaf turns blue/black it indicates presence of starch. When it remains brown, it indicates absence of starch.

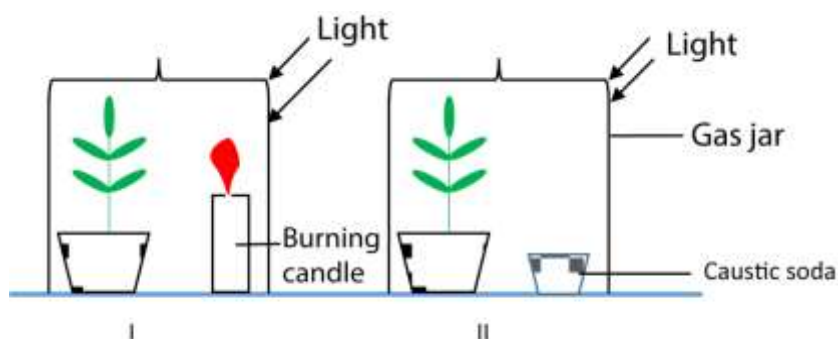
Exercise 5.1

- (a) What photosynthesis
- (b) State the importance of photosynthesis
- (c) Explain the process of testing for starch in the leaves.

Conditions necessary for photosynthesis

- (a) **Carbon dioxide:** is obtained from the atmosphere and water in case of aquatic plants. It is the source of carbon in carbohydrates.

Experiment to show that carbon dioxide is necessary for photosynthesis



The experiment is set up as shown above

- (i) Two younger seedlings growing in pots are kept in the dark for 3 days (to remove starch) and a leaf from each plant is tested to confirm absence of starch.
- (ii) In experiment I the burning candle supplies carbon dioxide while in experiment II carbon dioxide is absorbed by caustic soda.
- (iii) After 3 hours, a leaf is taken from each plant and tested for the presence of starch. Starch is found in the leaf of experiment I which had carbon dioxide. This shows that carbon dioxide is necessary for photosynthesis.
- (b) Water provides hydrogen that reduce carbon dioxide to form carbohydrates
- (c) Light usually from the sun is the source of energy for photosynthesizing tissues.
- (d) Chlorophyll: this is a green pigment which helps to trap light energy for photosynthesis.

Experiment to show that chlorophyll is necessary for photosynthesis

When a variegated leaf is picked from a plant on a sunny day and tested for starch. Starch is found only in parts that originally contained chlorophyll.

- (e) **A suitable temperature:** photosynthesis proceed by a series of chemical reactions controlled by enzymes which are sensitive to temperature. By comparing the rates of photosynthesis, at different temperatures, optimum temperatures for various plants are obtained.

Exercise 5.2

Explain the importance of conditions necessary for photosynthesis.

The leaf

In higher plant the major photo synthetic organ is the leaf.



Functions of the leaves

1. Carry out photosynthesis with subsequent production of organic materials
2. Carry out gaseous exchange through the stomata
3. Transpiration takes place mainly through the leaves resulting in the cooling of plant and absorption of mineral salts and water
4. Some leaves such as those of peas are modified by tendrils for support.
5. Some leaves such as those of bryophyllum are modified for storage
6. Some leaves such as those of bryophyllum are modified for vegetative reproduction
7. Some leaves possess itching hairs, thorns, spikes and poisonous substances for protection of plant.
8. Some leaves e.g. Venus fly trap are modified for capturing and extracting nitrogen from animals
9. Some produce substances that kill parasites.

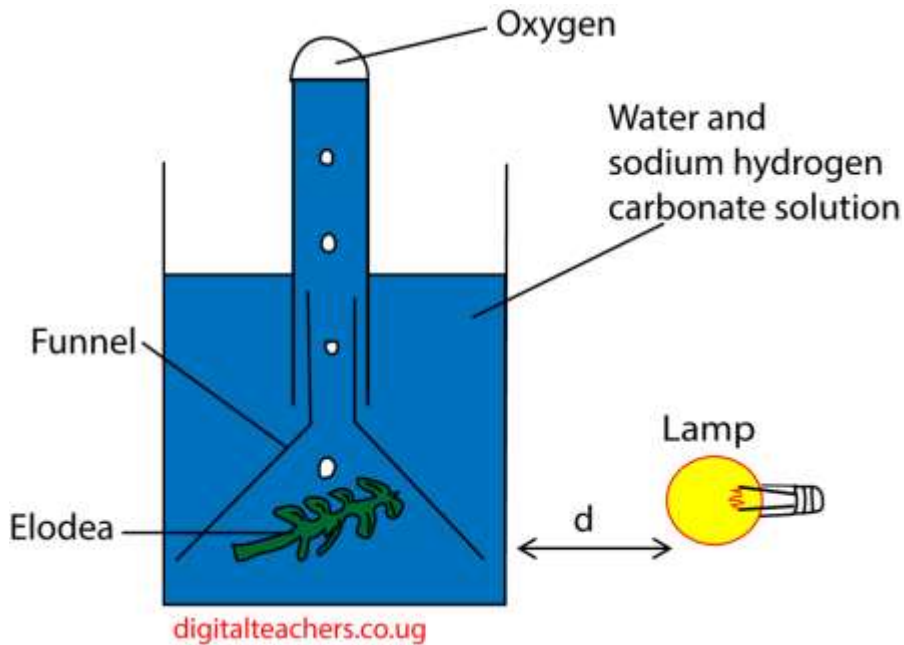
Adaptation of leaves to photosynthesis

1. The leaf is only a few cells thick for easy penetration of light and gases.
2. Wax cuticle prevent excessive water loss
3. The palisade cells that contain numerous chloroplasts are well positioned to receive light.
4. Presence of xylem that supply the leaf with water for photosynthesis
5. The spongy mesophyll has many air space. Gases can readily diffuse to all photosynthetic cells
6. They are broad and flat to offer a large surface area exposed to light and air
7. Stomata control passage of gases
8. The arrangement of leaves to the plant is such way that each leaf receives light.

Exercise 5.3

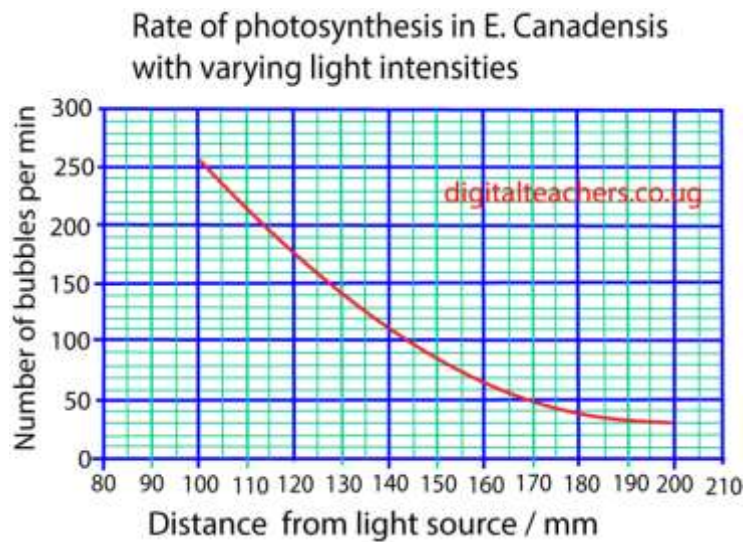
Suggest the adaptations of leaves to photosynthesis.

Measuring the rate of photosynthesis



Method

- (i) The apparatus is filled with carbonated water to enrich it with carbon dioxide.
- (ii) The setup is allowed to adjust to light intensity for 2-3 minutes. The rate of bubbling should be adequate such as 10 bubbles per minute.
- (iii) Light intensity is varied by increasing the distance, d , between the light source and the apparatus such as 10, 15, 20, 40 and 45cm. the bigger the distance, d , the lower the light intensity.
- (iv) The rate of formation of bubbles per minute at different distances, d , is an empirical measure of photosynthesis at a given light intensity.
- (v) Temperature change is buffered by using a beaker of bigger capacity.



The graph shows that the rate of photosynthesis decrease as the intensity of light decrease or as the distance between the bulb and the plant increases.

Reasons for Spacing Crops in Relation to Photosynthesis

(i) Maximizing Sunlight Exposure

- Crowded plants shade each other, reducing the amount of light reaching leaves.
- Proper spacing ensures each plant gets enough sunlight for photosynthesis.

(ii) Efficient Carbon Dioxide Absorption

- Plants need CO_2 for photosynthesis.
- Adequate spacing allows free air circulation, ensuring leaves absorb sufficient CO_2 .

(iii) Reducing Competition for Nutrients and Water

- Closely packed crops compete for soil nutrients and water.
- Proper spacing ensures each plant has enough resources to support photosynthesis.

(iv) Preventing Disease Spread

- Crowded crops trap moisture, encouraging fungal growth.

- Spacing reduces humidity around leaves, keeping them healthy for photosynthesis.

(v) **Improved Growth and Yield**

- Healthy photosynthesis leads to stronger plants and higher yields.
- Balanced spacing optimizes both plant health and productivity.

Summary Table

Reason	Link to Photosynthesis	Benefit
Sunlight exposure	More light reaches leaves	Higher photosynthetic rate
CO₂ absorption	Better air circulation	Efficient gas exchange
Nutrient access	Less competition	Stronger growth
Disease control	Reduced leaf moisture	Healthy leaves
Yield improvement	Optimal photosynthesis	Better harvest

Key Takeaway

Crop spacing is not just about farm layout — it is a **scientific practice** that ensures plants perform photosynthesis effectively. By giving each plant enough room, farmers maximize sunlight, air, and nutrient use, leading to healthier crops and better yields.

Exercise 5.4

Explain why crops are spaced a garden.

THEME: SCIENCE FOR HEALTH AND SAFETY

TOPIC 6: HUMAN DIET

Competency: The learner should be able to understand the implication of their diet and plan the different diets for different categories of people



Nutrition

Nutrition is the science of how living organisms take in and use food substances to maintain life, growth, and health. It explains how the body obtains energy and essential materials from food.

Purpose of Nutrition

- (i) **Energy Supply** → Provides fuel for activities, movement, and body functions.
- (ii) **Growth and Development** → Supplies proteins and minerals for building new tissues.
- (iii) **Repair of Worn-out Cells** → Helps heal injuries and replace damaged cells.
- (iv) **Regulation of Body Processes** → Vitamins and minerals control metabolism, immunity, and hormonal balance.
- (v) **Storage of Energy** → Excess food stored as fat or glycogen for future use.
- (vi) **Maintenance of Health** → Prevents deficiency diseases and strengthens resistance to infections.

Summary Table

Purpose	Example	Importance
Energy supply	Carbohydrates → glucose	Fuels body activities
Growth	Proteins → muscles, bones	Builds body tissues
Repair	Proteins → healing wounds	Maintains body integrity
Regulation	Vitamins/minerals → enzymes	Controls body functions
Storage	Fats → long-term energy	Survival during scarcity
Health	Balanced diet	Prevents diseases

Key Takeaway

Nutrition is **life-supporting**: it provides energy, builds and repairs tissues, regulates body functions, and maintains health. Without proper nutrition, organisms cannot grow, reproduce, or survive effectively.

Exercise 6.1

Give the importance of nutrition.

Main Food Nutrients

(i) Carbohydrates

Sources: Maize, rice, cassava, bread, potatoes, bananas, sugar.

Uses: Provide **energy** for body activities, brain function, and muscle work.

(ii) Proteins

Sources: Beans, peas, groundnuts, milk, eggs, fish, meat, soy.

Uses: Build and **repair body tissues**, form enzymes and hormones, support growth.

(iii) Fats and Oils

Sources: Butter, margarine, cooking oil, nuts, avocado, animal fat.

Uses: Provide **concentrated energy**, insulate the body, protect organs, help absorb vitamins.

(iv) Vitamins

Sources: Fruits (oranges, mangoes), vegetables (carrots, spinach), milk, fish liver oil.

Uses: Regulate body processes, strengthen immunity, prevent deficiency diseases (e.g., Vitamin C prevents scurvy).

(v) Minerals

Sources: Salt, milk, fish, green vegetables, meat, cereals.

Uses: Build strong bones and teeth (calcium), form blood (iron), regulate water balance (sodium, potassium).

(vi) Water

Sources: Drinking water, fruits, vegetables, soups.

Uses: Maintains hydration, transports nutrients, regulates temperature, aids digestion.

(vii) **Dietary Fibre (Roughage)**

Sources: Vegetables, fruits, whole grains, beans.

Uses: Helps digestion, prevents constipation, keeps the gut healthy.

Summary Table

Nutrient	Sources	Uses
Carbohydrates	Maize, rice, cassava	Energy supply
Proteins	Beans, eggs, fish	Growth & repair
Fats & Oils	Butter, nuts, avocado	Energy, insulation
Vitamins	Fruits, vegetables	Regulation, immunity
Minerals	Milk, meat, cereals	Bones, blood, balance
Water	Drinking water, fruits	Hydration, transport
Fibre	Vegetables, grains	Digestion, gut health

Key Takeaway

A **balanced diet** must include all these nutrients in the right amounts. Carbohydrates and fats provide energy, proteins build the body, vitamins and minerals regulate processes, water sustains life, and fibre keeps digestion healthy.

Exercise 6.2

Describe the importance of major food nutrients in the body.

Common Food Deficiency Symptoms

(i) **Protein Deficiency**

Symptoms: Stunted growth, muscle wasting, swelling (kwashiorkor), weak immunity.

Cause: Lack of protein-rich foods (beans, fish, meat, milk).

(ii) **Iron Deficiency**

Symptoms: Fatigue, pale skin, dizziness, spoon-shaped nails (anemia).

Cause: Low intake of iron foods (meat, spinach, beans).

(iii) **Vitamin A Deficiency**

Symptoms: Poor night vision, dry eyes, risk of blindness.

Cause: Lack of vitamin A foods (carrots, mangoes, liver, milk).

(iv) **Vitamin C Deficiency**

Symptoms: Bleeding gums, slow wound healing, frequent infections (scurvy).

Cause: Low intake of fruits and vegetables (oranges, guavas, tomatoes).

(v) **Vitamin D & Calcium Deficiency**

Symptoms: Weak bones, rickets in children, osteoporosis in adults.

Cause: Lack of sunlight exposure and foods like milk, fish, eggs.

(vi) **Iodine Deficiency**

Symptoms: Goiter (swelling of the neck), poor mental development.

Cause: Lack of iodized salt or seafood.

(vii) **Zinc Deficiency**

Symptoms: Poor wound healing, hair loss, skin rashes, weak immunity.

Cause: Low intake of zinc foods (meat, nuts, legumes).

Summary Table of Deficiency Symptoms

Nutrient	Deficiency Symptoms	Example Foods
Protein	Stunted growth, swelling	Beans, fish, milk
Iron	Fatigue, pale skin, anemia	Spinach, meat
Vitamin A	Night blindness, dry eyes	Carrots, mangoes
Vitamin C	Bleeding gums, infections	Oranges, guavas
Vitamin D & Calcium	Weak bones, rickets	Milk, eggs, fish
Iodine	Goiter, poor brain growth	Iodized salt, seafood
Zinc	Hair loss, poor healing	Meat, nuts

Key Takeaway

Food deficiency symptoms are **warning signs of malnutrition**. A balanced diet with proteins, vitamins, minerals, water, and fibre prevents these conditions. In Uganda, where diets may rely heavily on starchy foods, it is crucial to include **beans, vegetables, fruits, milk, and fish** to avoid deficiencies.

Exercise 6.3

Identify any five food deficient diseases and their causes.

Balanced diet

A **balanced diet** means eating the right proportions of carbohydrates, proteins, fats, vitamins, minerals, fibre, and water to meet the body's needs. However, the exact requirements vary depending on **age, sex, and activity level**.

Balanced Diet and Age

- (i) **Children** → Need more proteins and calcium for growth and strong bones.

- (ii) **Teenagers** → Require extra energy (carbohydrates) and proteins due to rapid growth and hormonal changes.
- (iii) **Adults** → Need balanced nutrients but fewer calories to avoid obesity.
- (iv) **Elderly** → Require more vitamins, fibre, and easily digestible foods; less fat and sugar to prevent lifestyle diseases.

Balanced Diet and Sex

- (i) **Males** → Generally need more calories and proteins due to higher muscle mass and energy expenditure.
- (ii) **Females** → Require more iron (to replace blood lost during menstruation), calcium (for bone health), and folic acid (especially during pregnancy).

Balanced Diet and Activity

- (i) **Active individuals (farmers, athletes, manual workers)** → Need more carbohydrates for energy and proteins for muscle repair.
- (ii) **Moderately active individuals (teachers, office workers)** → Require balanced intake but fewer calories compared to heavy workers.
- (iii) **Sedentary individuals (little physical activity)** → Should reduce fats and sugars to prevent obesity and related diseases.

Summary Table

Factor	Nutrient Focus	Reason
Children	Proteins, calcium	Growth & development
Teenagers	Carbohydrates, proteins	Rapid growth & energy
Adults	Balanced diet, fewer calories	Maintenance & disease prevention
Elderly	Vitamins, fibre, less fat	Easy digestion & health
Males	Proteins, calories	Muscle mass & energy
Females	Iron, calcium, folic acid	Menstruation, pregnancy, bone health
Active workers	Carbohydrates, proteins	Energy & repair
Sedentary	Less fat & sugar	Prevent obesity

Key Takeaway

A balanced diet is **not one-size-fits-all**. It must be tailored to age, sex, and activity level to ensure proper growth, energy, and health. For example, a teenage boy needs more energy foods than an elderly woman, while a pregnant woman requires extra iron and folic acid.

Body Mass Index (BMI)

Body Mass Index (BMI) is a simple calculation used to assess whether a person's body weight is appropriate for their height. It helps identify risks related to being underweight, overweight, or obese.

How to Calculate BMI

The formula is:

$$BMI = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Example:

- Weight = 70 kg

- Height = 1.75 m

$$BMI = \frac{70}{1.75^2} = \frac{70}{3.06} \approx 22.9$$

BMI Categories

BMI Value	Category	Implication
< 18.5	Underweight	Risk of malnutrition, weak immunity, stunted growth
18.5 – 24.9	Normal	Healthy weight, lowest risk of lifestyle diseases
25 – 29.9	Overweight	Higher risk of diabetes, hypertension, heart disease
≥ 30	Obese	Serious risk of chronic diseases, reduced mobility

Implications of BMI

- **Underweight** → May indicate poor nutrition, eating disorders, or chronic illness.
- **Normal BMI** → Suggests balanced nutrition and healthy lifestyle.
- **Overweight** → Increases risk of cardiovascular diseases, joint problems, and diabetes.
- **Obesity** → Strongly linked to heart disease, stroke, certain cancers, and reduced life expectancy.

Key Takeaway

BMI is a **screening tool**, not a diagnostic test. It gives a quick estimate of body health in relation to weight and height. However, it does not measure body fat directly, so athletes or muscular individuals may have a high BMI but still be healthy.

Exercise 6.4

- What is a balanced diet?
- Explain why the composition of balanced diet changes with age.

Eating disorders and drug misuse to change body image

Eating disorders and drug misuse to change body image are dangerous because they disrupt normal nutrition and body functions, leading to serious health problems.

(i) **Obesity**

Causes: Excessive intake of energy foods (carbohydrates and fats) with little physical activity.

Dangers:

- High risk of diabetes, hypertension, and heart disease.
- Joint problems due to excess weight.
- Low self-esteem and social stigma.

(ii) **Bulimia**

Meaning: Eating large amounts of food (bingeing) followed by forced vomiting or misuse of laxatives.

Dangers:

- Damage to teeth and throat from stomach acid.
- Dehydration and electrolyte imbalance → heart problems.
- Depression and anxiety.

(iii) **Anorexia Nervosa**

Meaning: Extreme restriction of food intake due to fear of gaining weight.

Dangers:

- Severe malnutrition and stunted growth.
- Weak immunity and frequent illness.
- Organ failure and risk of death.

(iv) **Diet Pills**

Purpose: Used to suppress appetite or speed up metabolism.

Dangers:

- Can cause high blood pressure, heart problems, and addiction.
- Often lead to nutrient deficiencies.
- False sense of quick weight loss without lifestyle change.

(v) Steroids

Purpose: Used to build muscle quickly.

Dangers:

- Liver damage and heart disease.
- Hormonal imbalance → infertility, mood swings, aggression.
- Increased risk of cancer.

Summary Table

Disorder/Drug	Meaning	Dangers
Obesity	Excess body fat	Diabetes, heart disease, stigma
Bulimia	Binge eating + purging	Tooth decay, dehydration, depression
Anorexia	Extreme food restriction	Malnutrition, organ failure
Diet Pills	Appetite suppressants	Heart problems, addiction
Steroids	Muscle enhancers	Liver damage, infertility

Key Takeaway

Eating disorders and drug misuse for body image are **life-threatening**. A healthy body image should be achieved through **balanced diet, exercise, and positive self-esteem**, not harmful shortcuts.

Exercise 6.5

Explain examples of feeding disorders

Famine and hunger

Famine and hunger in communities are caused by overlapping factors such as conflict, climate shocks, economic collapse, and poor governance. These crises are preventable if early action is taken through food aid, sustainable farming, and peacebuilding.

Factors Leading to Famine and Hunger

(i) Conflict and Political Instability

Wars displace families, destroy crops, block food supplies, and disrupt markets.

Example: Sudan and Gaza famines driven by ongoing conflict.

(ii) Climate Change and Natural Disasters

Droughts, floods, and failed rainy seasons reduce harvests.

East Africa faced five failed rainy seasons in 2023, triggering widespread hunger.

(iii) Economic Collapse and Inflation

Rising food prices make staples unaffordable.

Example: Food prices spiked in Sudan in 2024, worsening famine conditions.

(iv) Poor Governance and Inequality

Weak policies, corruption, and unequal food distribution worsen hunger.

Historical example: Bengal famine linked to governance failures.

Consequences of Famine

(i) Malnutrition → Stunted growth, weakened immunity.

(ii) Disease outbreaks → Hunger weakens resistance to infections.

(iii) Social disruption → Migration, displacement, and breakdown of communities.

(iv) Death → Starvation and hunger-related illnesses.

How Famine May Be Minimized

(i) **Early Humanitarian Aid**

Food and cash assistance before hunger reaches catastrophic levels.

(ii) **Climate-Resilient Agriculture**

Drought-resistant crops, irrigation, and soil conservation.

(iii) **Peacebuilding and Conflict Resolution**

Ending wars and ensuring safe access to farms and markets.

(iv) **Economic Support**

Stabilizing food prices, subsidies for farmers, and fair trade policies.

(v) **Good Governance**

Transparent food distribution, investment in rural infrastructure, and social safety nets.

Key Takeaway

Famine is **not just a lack of food** but a breakdown of systems caused by conflict, climate shocks, and poor governance. It can be minimized through **early aid, sustainable farming, peacebuilding, and strong policies**. Communities in Uganda and East Africa must prioritize climate-smart agriculture and peace initiatives to reduce hunger risks.

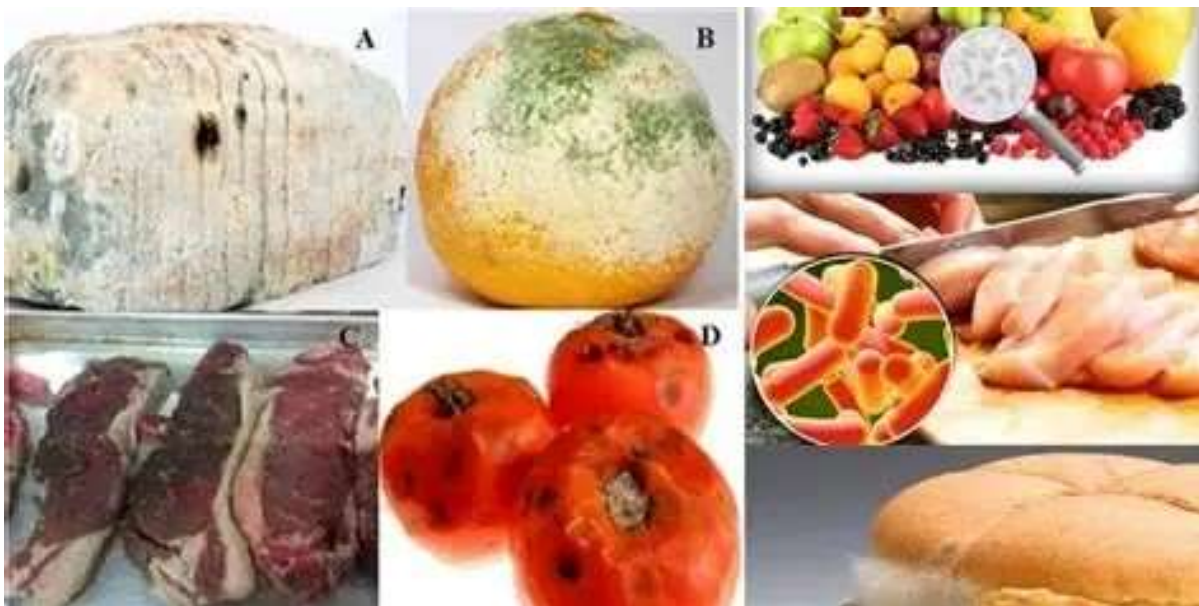
Exercise 6.6

Discuss the causes and consequences of hunger and famine.

THEME: SCIENCE FOR HEALTH AND SAFETY

TOPIC 7: FOOD SPOILAGE AND PRESERVATION

Competency: The learner should be able to explain how food goes bad and the various methods of preserving different kinds of food.



Causes of Food Spoilage

(i) **Microorganisms**

Bacteria, fungi, and yeasts break down food, producing toxins, bad smells, and slimy textures.

Example: *Salmonella* in meat, molds on bread.

(ii) **Enzymatic Activity**

Natural enzymes in food cause ripening and, later, rotting.

Example: Overripe fruits turning mushy.

(iii) **Chemical Reactions**

Oxidation of fats and oils leads to rancidity.

Example: Spoiled cooking oil or butter.

(iv) **Environmental Factors**

Heat, humidity, and light accelerate spoilage.

Example: Milk spoiling faster in warm conditions.

(v) **Insects and Pests**

Rodents, weevils, and flies contaminate food with droppings or eggs.

(vi) **Poor Handling and Storage**

Dirty utensils, unwashed hands, or improper packaging introduce contaminants.

Summary Table

Cause	Example	Effect
Microorganisms	Mold on bread	Bad smell, toxins
Enzymes	Overripe banana	Soft texture, rot
Chemical reactions	Rancid oil	Bitter taste
Environment	Warm milk	Quick spoilage
Pests	Weevils in maize	Contamination
Poor handling	Dirty utensils	Food poisoning

Key Takeaway

Food spoilage is mainly caused by **microbial growth, enzymes, chemical changes, and poor storage conditions**. Preventing spoilage requires **proper hygiene, refrigeration, airtight packaging, and pest control**.

Exercise 7.1

Explain the causes of food spoilage

Factors Promoting Growth of Micro-organisms on Food

(i) **Moisture**

Micro-organisms need water to grow. Foods with high water content (milk, fruits, cooked rice) spoil quickly.

(ii) **Temperature**

Warm conditions (20–40°C) are ideal for microbial growth.

Refrigeration slows growth, while cooking kills most microbes.

(iii) **Nutrients in Food**

Foods rich in proteins (meat, fish, milk) and carbohydrates (bread, fruits) provide excellent nutrients for microbes.

(iv) **pH Level**

Neutral or slightly acidic foods (meat, vegetables) favor microbial growth.

Highly acidic foods (lemon, vinegar) inhibit growth.

(v) **Oxygen Availability**

Aerobic microbes (molds, some bacteria) need oxygen.

Anaerobic microbes (like *Clostridium botulinum*) grow without oxygen, e.g., in canned foods.

(vi) **Time**

The longer food is left exposed, the more microbes multiply.

(vii) **Poor Hygiene and Handling**

Dirty utensils, unwashed hands, and contaminated surfaces introduce microbes.

Summary Table

Factor	Example	Effect
Moisture	Milk, fruits	Rapid spoilage
Temperature	Warm kitchen	Fast microbial growth
Nutrients	Meat, bread	Rich medium for microbes
pH	Neutral foods	Favorable growth
Oxygen	Exposed bread	Mold growth
Time	Leftovers overnight	Multiplication of microbes
Hygiene	Dirty utensils	Food poisoning risk

Key Takeaway

Micro-organisms grow best in **warm, moist, nutrient-rich, and poorly handled food**.

Preventing spoilage requires **proper storage, refrigeration, cooking, and hygiene practices**.

Exercise 7.2

Explain the factors that promote food spoilage

Methods of Preventing Food Spoilage

Food spoilage can be prevented by applying different preservation methods depending on the type of food. Each food has unique properties (moisture, nutrients, perishability), so the techniques vary.

(i) Milk

Boiling → Kills harmful bacteria.

Pasteurization → Heating milk to destroy microbes while keeping nutrients.

Refrigeration → Slows bacterial growth.

(ii) Fish

Smoking → Removes moisture and adds preservative compounds.

Salting → Draws out water, preventing bacterial growth.

Freezing → Keeps fish fresh for long periods.

(iii) Meat

Refrigeration/Freezing → Slows microbial activity.

Canning → Seals meat in airtight containers.

Drying/Smoking → Reduces moisture content.

(iv) Fruits

Refrigeration → Slows ripening and microbial growth.

Jam-making → Sugar preserves fruits.

Drying → Removes water, preventing decay.

(v) **Vegetables**

Refrigeration → Keeps vegetables fresh longer.

Pickling → Preserves with vinegar or brine.

Canning → Airtight storage prevents spoilage.

(vi) **Cereals**

Dry Storage → Keep cereals in cool, dry places.

Airtight Containers → Prevent insect infestation.

Fumigation → Controls pests in large storage facilities.

Summary Table

Food	Methods	Purpose
Milk	Boiling, pasteurization, refrigeration	Kill microbes, extend shelf life
Fish	Smoking, salting, freezing	Reduce moisture, preserve protein
Meat	Refrigeration, canning, drying	Prevent bacterial growth
Fruits	Refrigeration, jam-making, drying	Slow ripening, prevent decay
Vegetables	Refrigeration, pickling, canning	Maintain freshness
Cereals	Dry storage, airtight containers, fumigation	Prevent pests & mold

Key Takeaway

Food spoilage is prevented by **controlling moisture, temperature, and microbial activity**.

Traditional methods (smoking, salting, drying) and modern methods (refrigeration, pasteurization, canning) complement each other to keep food safe and nutritious.

Principles of Food Preservation

- (i) **Control of Micro-organisms** → Destroy or inhibit bacteria, fungi, and yeasts that cause spoilage.
- (ii) **Moisture Reduction** → Removing water prevents microbial growth.
- (iii) **Temperature Control** → Cooling slows spoilage, heating kills microbes.
- (iv) **Chemical Preservation** → Use of salt, sugar, vinegar, or preservatives to inhibit microbial activity.
- (v) **Exclusion of Oxygen** → Airtight storage prevents aerobic microbes from growing.
- (vi) **Enzyme Inactivation** → Heat or chemicals stop natural enzymes that cause ripening and decay.

Methods of Food Preservation

- (i) **Refrigeration and Freezing** → Slows microbial growth; used for milk, meat, fish, fruits, vegetables.
- (ii) **Drying** → Removes moisture; used for cereals, fruits, fish, meat.
- (iii) **Salting and Sugaring** → Draws water out of food and microbes; used for fish, meat, fruits (jam).
- (iv) **Smoking** → Preserves fish and meat by drying and adding antimicrobial compounds.
- (v) **Pasteurization and Boiling** → Heat treatment kills harmful microbes; common for milk and juices.
- (vi) **Canning and Bottling** → Airtight sealing prevents contamination; used for vegetables, fruits, meat, fish.
- (vii) **Pickling and Fermentation** → Vinegar, brine, or controlled fermentation inhibit microbial growth; used for vegetables and fruits.
- (viii) **Use of Preservatives** → Chemicals like sodium benzoate or citric acid extend shelf life.

- (ix) **Proper Storage and Hygiene** → Clean utensils, airtight containers, pest control for cereals and dry foods.

Summary Table

Principle	Method	Example Foods
Control microbes	Pasteurization, canning	Milk, meat
Reduce moisture	Drying, salting	Cereals, fish
Temperature control	Refrigeration, freezing	Vegetables, fruits
Chemical preservation	Pickling, sugaring	Fruits, vegetables
Exclude oxygen	Airtight packaging	Canned foods
Enzyme inactivation	Boiling, blanching	Vegetables

Key Takeaway

Food preservation combines **traditional methods** (drying, salting, smoking) and **modern techniques** (refrigeration, pasteurization, canning) to keep food safe, nutritious, and available year-round. It ensures food security, reduces waste, and supports trade.

Exercise 7.3

Describe the methods of food preservation.

Causes of Food Poisoning

- (i) **Bacteria** → e.g., *Salmonella*, *E. coli*, *Staphylococcus*.
- (ii) **Viruses** → e.g., Norovirus, Hepatitis A.
- (iii) **Parasites** → e.g., tapeworms, *Giardia*.
- (iv) **Toxins** → Produced by bacteria or fungi in spoiled food.
- (v) **Poor Hygiene** → Dirty utensils, unwashed hands, improper storage.

Symptoms of Food Poisoning

- (i) Nausea and vomiting
- (ii) Diarrhea (sometimes bloody)
- (iii) Stomach cramps and abdominal pain
- (iv) Fever and chills
- (v) Weakness, dehydration, dizziness

Ways of Helping Someone with Food Poisoning

Important: If symptoms are severe (persistent vomiting, bloody diarrhea, high fever, dehydration), the person should **see a qualified healthcare professional immediately**.

- (i) **Rehydration** → Give clean water or oral rehydration solution (ORS) to replace lost fluids.
- (ii) **Rest** → Allow the body to recover.
- (iii) **Avoid Solid Foods Initially** → Start with fluids, then introduce light foods like rice or bananas.
- (iv) **Maintain Hygiene** → Wash hands, clean utensils, and avoid contaminated food sources.
- (v) **Seek Medical Care** → If symptoms worsen or persist, professional treatment is necessary.

Ways to Prevent Food Poisoning

- (i) **Maintain Hygiene**

Wash hands before handling food.

Clean utensils, kitchen surfaces, and storage containers.

- (ii) **Proper Cooking**

Cook meat, fish, and poultry thoroughly to kill bacteria.

Boil milk or pasteurize to destroy harmful microbes.

(iii) **Safe Storage**

Refrigerate perishable foods like milk, meat, and vegetables.

Store cereals and dry foods in airtight containers to prevent pests.

(iv) **Avoid Cross-Contamination**

Use separate chopping boards for raw meat and vegetables.

Keep cooked food away from raw food.

(v) **Check Food Quality**

Avoid expired or spoiled foods.

Discard food with bad smell, mold, or unusual color.

(vi) **Safe Water Use**

Use clean, boiled, or treated water for cooking and drinking.

Summary Table

Aspect	Details
Causes	Bacteria, viruses, parasites, toxins, poor hygiene
Symptoms	Vomiting, diarrhea, cramps, fever, dehydration
Help	Rehydration, rest, light diet, hygiene, medical care

Key Takeaway

Food poisoning is preventable through **proper food handling, cooking, and storage**. Once it occurs, the priority is **rehydration and medical attention** if symptoms are severe.

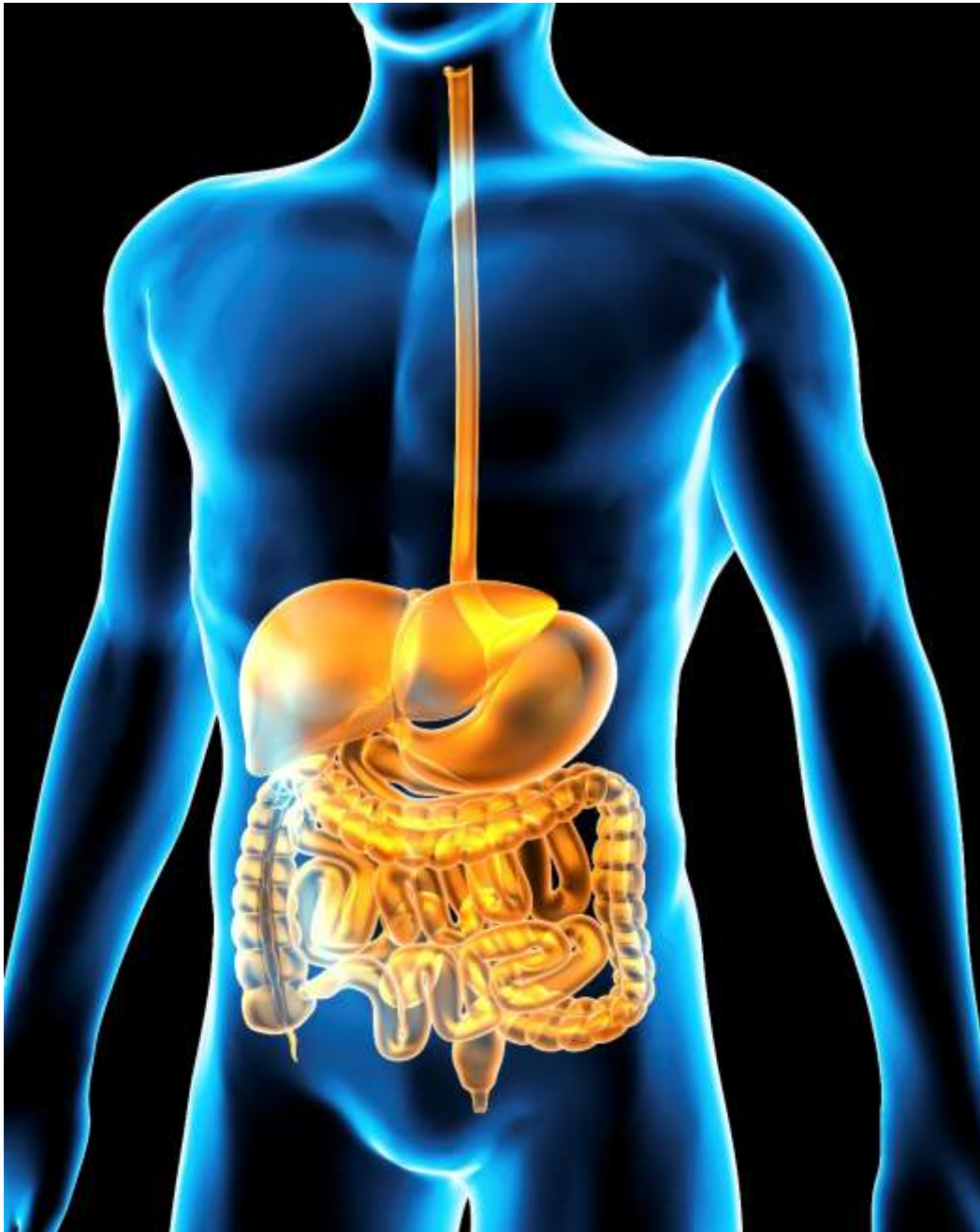
Explain 7.4

- (a) State the causes of food poisoning.
- (b) Suggest ways of help a victim of food poisoning
- (c) Explain ways of preventing food poisoning

THEME: SCIENCE OF THE HUMAN BODY

TOPIC 8: OUR BODY SYSTEMS AND THEIR FUNCTIONS I

Competency: The learner should be able to appreciate that digestive, circulatory and respiratory systems perform different functions to sustain life.



Enzymes

Enzymes are **proteins** that accelerate biochemical reactions.

They act on **substrates** (reactants) to form **products**.

Without enzymes, most life processes (digestion, respiration, DNA replication) would be too slow to sustain life.

Properties of Enzymes

- (i) **Catalytic Nature** → They speed up reactions by lowering activation energy.
- (ii) **Specificity** → Each enzyme acts on a particular substrate (lock-and-key model).
- (iii) **Efficiency** → They accelerate reactions millions of times faster than normal.
- (iv) **Reusable** → Enzymes are not consumed; they can be used repeatedly.
- (v) **Temperature Sensitivity** → Work best at optimum temperatures (usually 37°C in humans). Low temperature inactivates them while high heat denatures them.
- (vi) **pH Sensitivity** → Each enzyme has an optimum pH (e.g., pepsin works best in acidic stomach conditions).
- (vii) **Protein Nature** → Most enzymes are proteins, though some RNA molecules (ribozymes) also act as enzymes.
- (viii) **Regulation** → Enzyme activity can be controlled by inhibitors, activators, or feedback mechanisms.

Key Takeaway

Enzymes are **essential catalysts of life**. Their properties—specificity, efficiency, and sensitivity—make them vital in digestion, metabolism, and industrial processes like brewing, baking, and medicine. Without enzymes, biological reactions would be too slow to sustain living organisms.

Exercise 8.1

Explain the properties of enzymes

Effect of pH on Enzyme Activity

Each enzyme has an **optimum pH** where it works best.

Too acidic or too alkaline conditions alter the enzyme's shape (denaturation), reducing activity.

Example:

- **Pepsin** (stomach enzyme) works best in acidic pH (around 2).
- **Amylase** (saliva enzyme) works best near neutral pH (around 7).

Effect of Temperature on Enzyme Activity

Enzymes have an **optimum temperature** (usually around 37°C in humans).

Low temperatures → Slow reaction because molecules move slowly.

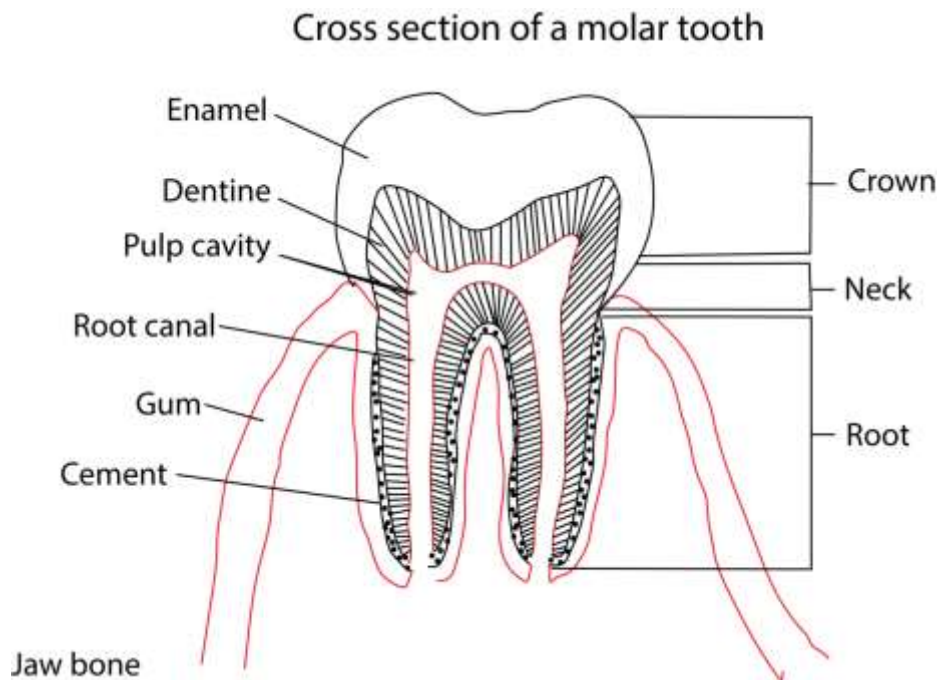
Optimum temperature → Maximum activity.

High temperatures → Enzymes denature (lose shape), stopping activity.

Example: Amylase works fastest at body temperature but is destroyed at boiling point.

Teeth

Teeth are hard, calcified structures found in the mouth, anchored in the jawbone, and adapted for cutting, tearing, and grinding food. They play a vital role in digestion, speech, and maintaining facial structure.



Structure of a Tooth

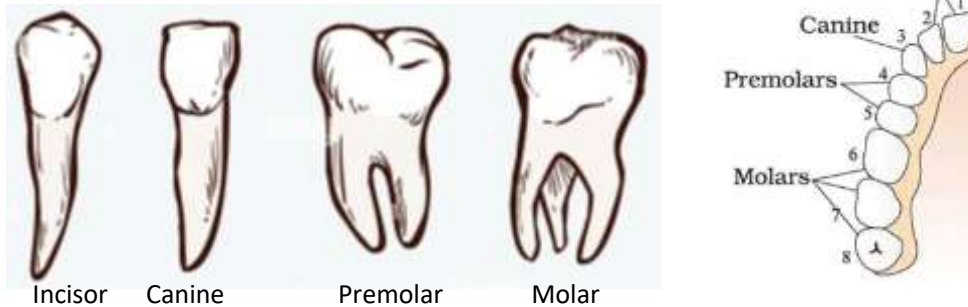
Each tooth has three main parts:

- **Crown** → Visible part above the gum, covered with enamel (hardest substance in the body).
- **Neck** → Junction between crown and root.
- **Root** → Anchors tooth into jawbone.

Layers inside the tooth:

- **Enamel** → Hard protective covering.
- **Dentine** → Tough, bone-like tissue beneath enamel.
- **Pulp cavity** → Contains nerves and blood vessels.
- **Cement** → Fixes root to jawbone.

Types of teeth in humans



- (i) **Incisors** → 8 in total (4 upper, 4 lower); flat and sharp for cutting food.
- (ii) **Canines** → 4 in total; pointed for tearing flesh.
- (iii) **Premolars** → 8 in total; broad surfaces for crushing food.
- (iv) **Molars** → 12 in total (including wisdom teeth); large, flat surfaces for grinding food.

Arrangement of Teeth

- (i) Humans have **two sets of teeth**:

Milk teeth (deciduous) → 20 teeth in children.

Permanent teeth → 32 teeth in adults.

- (ii) Arranged in two arches (upper and lower jaws) forming a dental formula:

$$\text{Adult dental formula} = \frac{2.1.2.3}{2.1.2.3} \times 2 = 32$$

(Incisors, Canines, Premolars, Molars per half jaw).

Functions of Teeth

- (i) **Incisors** → Cutting food.
- (ii) **Canines** → Tearing food.
- (iii) **Premolars** → Crushing food.
- (iv) **Molars** → Grinding food. Together, they prepare food for swallowing and digestion.

Adaptations of Human Teeth

- (i) **Variety of shapes** → Adapted for omnivorous diet (plants + meat).
- (ii) **Strong enamel** → Protects against wear and tear.
- (iii) **Roots anchored in jawbone** → Provide stability during chewing.
- (iv) **Dental formula** → Balanced number of cutting, tearing, and grinding teeth.

Summary Table

Type	Number	Structure	Function	Adaptation
Incisors	8	Flat, sharp	Cutting	Slice plant material
Canines	4	Pointed	Tearing	Grip and tear meat
Premolars	8	Broad surface	Crushing	Adapted for mixed diet
Molars	12	Large, flat	Grinding	Break down tough food

Key Takeaway

Human teeth are **heterodont** (different types) and **diphyodont** (two sets in a lifetime). Their arrangement and structure reflect adaptation to an **omnivorous diet**, enabling efficient cutting, tearing, crushing, and grinding of food before digestion.

Exercise 8.2

- (a) Draw and label part of a generalized tooth.
- (b) State the types and function of teeth in human body.

Dental care

Dental care refers to the practices and habits that keep teeth, gums, and the entire mouth healthy. It prevents dental diseases such as tooth decay, gum infections, and bad breath, while also maintaining strong teeth for chewing and clear speech.

Principles of Dental Care

- (i) **Hygiene** → Regular cleaning of teeth, gums, and tongue.
- (ii) **Diet Control** → Limiting sugary foods and drinks that cause cavities.
- (iii) **Regular Checkups** → Visiting the dentist for cleaning and early treatment.
- (iv) **Preventive Measures** → Use of fluoride, sealants, and protective habits.

Daily Dental Care Practices

- (i) Brush teeth **twice daily** with fluoride toothpaste.
- (ii) Floss to remove food particles between teeth.
- (iii) Rinse mouth with clean water or mouthwash.
- (iv) Clean the tongue to prevent bad breath.
- (v) Replace toothbrush every 3–4 months.

Diet and Lifestyle for Dental Health

- (i) Eat calcium-rich foods (milk, cheese, leafy greens) for strong teeth.
- (ii) Avoid excessive sugary snacks and carbonated drinks.
- (iii) Drink plenty of clean water to wash away food particles.
- (iv) Avoid harmful habits like smoking and chewing tobacco.

Professional Dental Care

- (i) Regular dental checkups (at least twice a year).
- (ii) Scaling and polishing to remove plaque and tartar.
- (iii) Fillings, crowns, or root canal treatment for damaged teeth.
- (iv) Orthodontic care (braces) for proper alignment.

Exercise 8.3

Explain how you can care for structure in your mouth.

Common Dental Diseases

(i) **Dental Caries (Tooth Decay)**

Caused by bacteria breaking down sugars into acids that erode enamel.

Symptoms: Toothache, cavities, sensitivity to hot/cold foods.

(ii) **Gingivitis**

Inflammation of gums due to plaque buildup.

Symptoms: Red, swollen, bleeding gums.

(iii) **Periodontitis**

Advanced gum disease where infection spreads to bone supporting teeth.

Symptoms: Loose teeth, receding gums, bad breath.

(iv) **Halitosis (Bad Breath)**

Often caused by poor oral hygiene, gum disease, or decaying food particles.

Symptoms: Persistent foul odor from mouth.

(v) **Tooth Sensitivity**

Caused by worn enamel or exposed dentine.

Symptoms: Sharp pain when eating hot, cold, or sweet foods.

Prevention of Dental Diseases

(i) **Proper Brushing and Flossing**

Brush twice daily with fluoride toothpaste.

Floss to remove food particles between teeth.

(ii) **Healthy Diet**

Reduce sugary foods and drinks.

Eat calcium-rich foods (milk, cheese) for strong teeth.

(iii) **Regular Dental Checkups**

Visit dentist at least twice a year for cleaning and early detection.

(iv) **Use of Fluoride**

Strengthens enamel and prevents decay.

(v) **Avoid Harmful Habits**

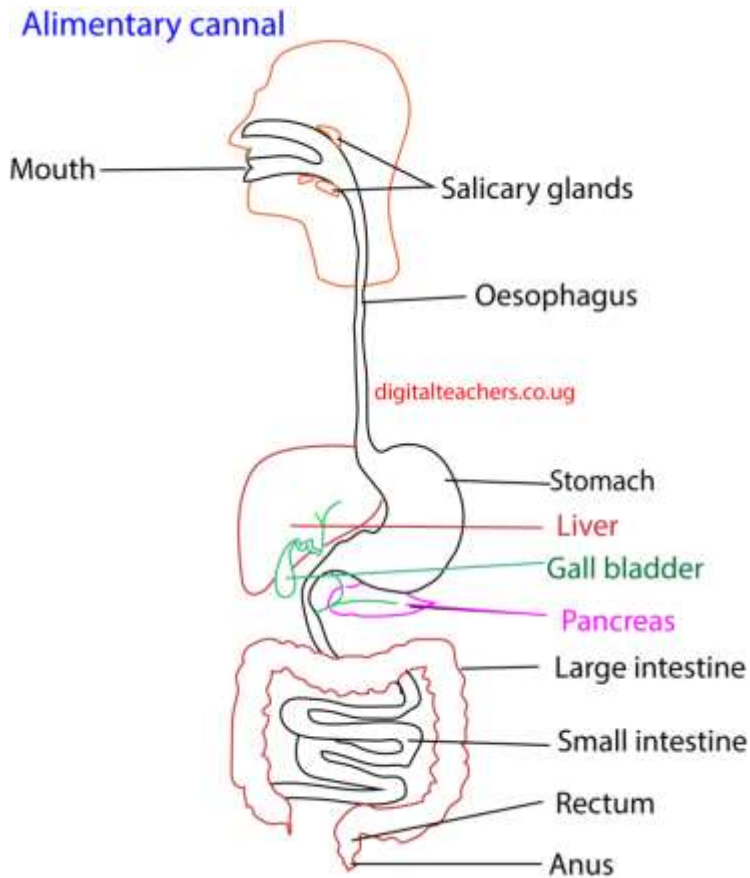
Stop smoking and chewing tobacco, which damage gums and teeth.

(vi) **Proper Cleaning of Tongue**

Removes bacteria that cause bad breath.

Exercise 8.4

Describe the common disease to our teeth and how these can be prevented.



Summary of the functions of the different parts of the human digestive system.

SPECIALISED PART	FUNCTION
Buccal cavity	Ingestion, mastication.
Pharynx	Swallowing.
Oesophagus	Links pharynx to stomach
Stomach	Food storage and digestion of proteins.
Duodenum	Digestion and absorption.
Liver (bile)	Emulsification of fats.
Pancreas (pancreatic juice)	Digestion of starch, proteins and fats.
Ileum	Completion of digestion & absorption of food
Colon	Absorption of water.
Rectum	Formation and storage of faeces.
Anus	Egestion

Digestion in the buccal cavity

The food is broken up into smaller pieces by the chewing action of the teeth (**mastication**) and moistened by **saliva** from the salivary glands.

Digestion in the stomach

The stomach is a dilated part of the gut where the food remains for two or more hours. Once in the stomach the food gastric gland in gastric wall secretes **gastric juice**

Gastric juice contains

- (i) **Hydrochloric acid** that kills germs and provides pH for the action of pepsin
- (ii) Enzyme **pepsin** which breaks down proteins into short polypeptide chains. Pepsin is secreted as an inactive precursor **pepsinogen** to prevent the gastric gland being destroyed by its own enzyme (auto-digestion).
- (iii) Enzyme **renin** coagulates casein, the soluble protein of milk, forming insoluble curd which is then attacked by pepsin.

Digestion in duodenum

Duodenum receives secretion from pancreas and gall bladder

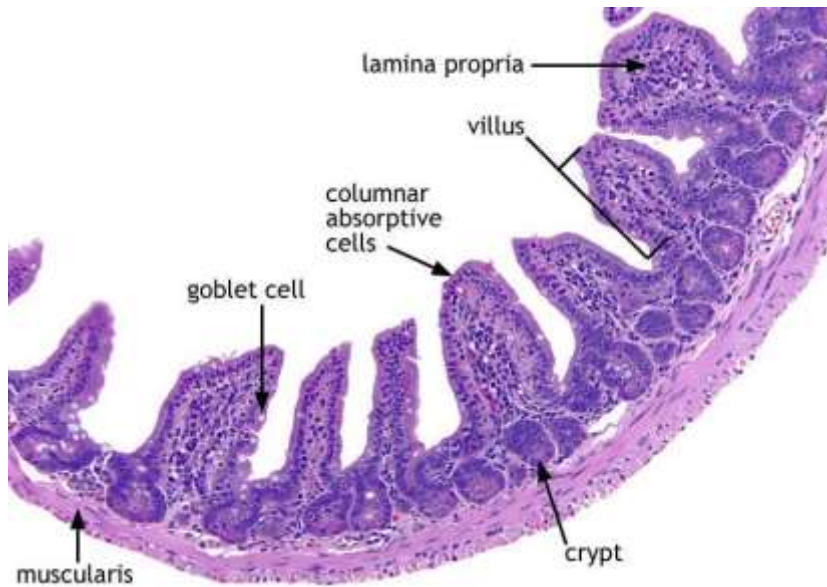
- (a) Gall bladder produces bile that emulsifies fats.
- (b) Pancreas produces pancreatic juice that contains.
 - (i) **Pancreatic amylase**: breaks down starch to disaccharide maltose.
 - (ii) **Pancreatic lipase**: breaks down tri-glycerides in the emulsified fat into mono-glyceride and fatty acids.
 - (iii) **Protease**: (Protein - splitting enzymes) which include **trypsin, chymotrypsin, carboxy-peptidase** and **elastase**).
 - (iv) **Bicarbonate** neutralise acidic chyme from the stomach

Digestion in small intestines

It is done by the following enzymes

- **Maltase**: hydrolyses maltose to glucose, thus completing digestion of starch.
- **Sucrase** hydrolyses sucrose (Sugar cane) to glucose & fructose.
- **Lactase** hydrolyses lactose (Milk sugar) to glucose & galactose.

Absorption of digested food

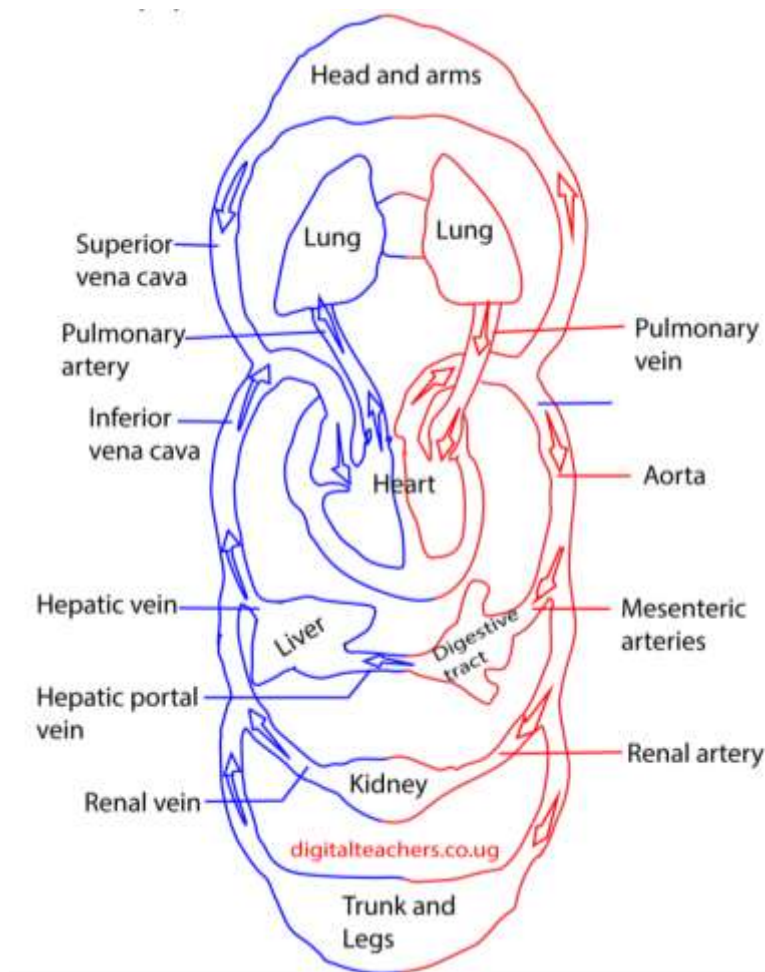


It occurs in small intestines

Adaptation of small intestine for absorption of food

- (i) Long to allow food enough time for absorption
- (ii) Villi and microvilli increase surface area for absorption
- (iii) Well supplied by blood to carry away absorbed food so as to maintain diffusion gradient
- (iv) The villi have thin membrane to reduce diffusion gradient
- (v) Villi have high concentration of mitochondria to provide energy for active transport.
- (vi) **circular fold** increase surface area for absorption
- (vii) Villi contain lacteal for absorption of fats

Circulatory system in man



The **human circulatory system** is a network of organs and vessels that transports blood, nutrients, gases, and wastes throughout the body. It ensures that every cell receives oxygen and food while removing carbon dioxide and other waste products.

Main Organs of the Circulatory System

(i) Heart

Muscular organ that pumps blood.

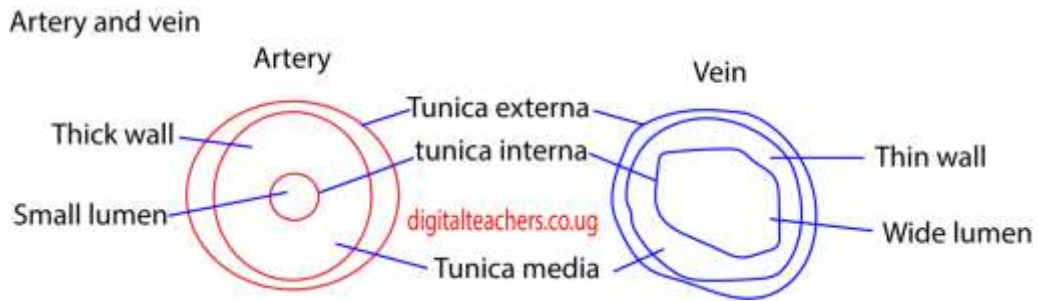
Divided into four chambers: right atrium, right ventricle, left atrium, left ventricle.

Acts as the central pump of the system.

(ii) Blood Vessels

Arteries → Carry oxygenated blood away from the heart (except pulmonary artery).

Veins → Carry deoxygenated blood back to the heart (except pulmonary vein).



Adaptation of the artery

- thick wall to accommodate high pressure
- have narrow lumens to maintain high pressures
- some arteries like aorta valves to prevent back flow of blood.

Adaptation of veins

- wide lumen to lower resistance to blood flow
- valves allow blood to flow in one direction

Differences between arteries and veins

	Arteries	veins
1.	Thick wall	Thin walls
2.	Narrow lumen	Broad lumen
3.	Have no valves except pulmonary artery and aorta	Have valves
4.	Carry oxygenated blood except pulmonary artery	Carry deoxygenated blood except
5.	Pulse detectable	Pulse not detectable
6.	Empty at time of death	Get filled up at death.

Capillaries

Is where exchange between blood and cell takes place

Adaptation of capillaries

- thin walls for fast diffusion
- Ramify the body to increase surface area for exchange

(iii) **Blood**

Fluid tissue that transports oxygen, nutrients, hormones, and wastes.

Components:

- **Red blood cells** → Carry oxygen.
- **White blood cells** → Defend against infections.
- **Platelets** → Help in clotting.
- **Plasma** → Liquid medium carrying dissolved substances.

Arrangement of the Circulatory System

- (i) **Pulmonary circulation** → Blood flows from the heart to the lungs and back, exchanging carbon dioxide for oxygen.
- (ii) **Systemic circulation** → Blood flows from the heart to the rest of the body and back, delivering oxygen and nutrients.

Summary Table

Part/Organ	Structure	Function
Heart	4 chambers	Pumps blood
Arteries	Thick, elastic walls	Carry blood away from heart
Veins	Thin walls, valves	Return blood to heart
Capillaries	Very thin walls	Exchange gases & nutrients
Blood	RBCs, WBCs, platelets, plasma	Transport & defense

Key Takeaway

The human circulatory system is made up of the **heart, blood vessels, and blood**. Together, they form a transport network that sustains life by delivering oxygen and nutrients while removing wastes.

Blood Groups

Human blood groups are classifications based on the presence or absence of specific antigens on the surface of red blood cells. Knowing one's blood group is essential for safe transfusions, pregnancy care, and medical emergencies.

Human Blood Groups

(i) ABO System

- **Group A** → Has A antigens on red cells, anti-B antibodies in plasma.
- **Group B** → Has B antigens, anti-A antibodies in plasma.
- **Group AB** → Has both A and B antigens, no antibodies (universal recipient).
- **Group O** → Has no antigens, both anti-A and anti-B antibodies (universal donor).

(ii) Rh Factor

- **Rh positive (Rh⁺)** → Has the Rh antigen.
- **Rh negative (Rh⁻)** → Lacks the Rh antigen.
- Important in pregnancy: Rh incompatibility can cause complications.

Importance of Knowing One's Blood Group

(i) Safe Blood Transfusion

Prevents dangerous reactions when receiving blood.

Example: Group A cannot receive Group B blood.

(ii) Pregnancy Care

Rh incompatibility between mother and baby can cause hemolytic disease of the newborn.

Early detection allows preventive treatment.

(iii) **Medical Emergencies**

Quick access to correct blood saves lives during accidents or surgeries.

(iv) **Organ Transplantation**

Matching blood groups reduces risk of rejection.

(v) **Disease Susceptibility**

Some blood groups are linked to higher or lower risks of certain diseases (e.g., Group O less prone to severe malaria).

Summary Table

Blood Group	Antigens	Antibodies	Transfusion Notes
A	A	Anti-B	Receives A, O
B	B	Anti-A	Receives B, O
AB	A & B	None	Universal recipient
O	None	Anti-A & Anti-B	Universal donor

Key Takeaway

Human blood groups are classified under the **ABO system and Rh factor**. Knowing your blood group is crucial for **safe transfusions, pregnancy health, emergency care, and organ donation compatibility**.

Gaseous exchange

The **gaseous exchange in humans** is the process by which oxygen is taken into the body and carbon dioxide is removed. It occurs mainly in the **lungs**, specifically in the **alveoli**, and is vital for respiration and energy production.

Why Gas Exchange is Needed

(i) Supply of Oxygen

Oxygen is essential for **cellular respiration**, the process that releases energy (ATP) from food.

Muscles, brain, and organs cannot function without a constant oxygen supply.

(ii) Removal of Carbon Dioxide

Carbon dioxide is a waste product of respiration.

If not removed, it accumulates in blood, making it acidic and harmful.

(iii) Energy Production

Oxygen enables glucose breakdown to release energy for movement, growth, repair, and maintaining body temperature.

(iv) Maintaining Homeostasis

Gas exchange keeps blood pH stable by balancing oxygen and carbon dioxide levels.

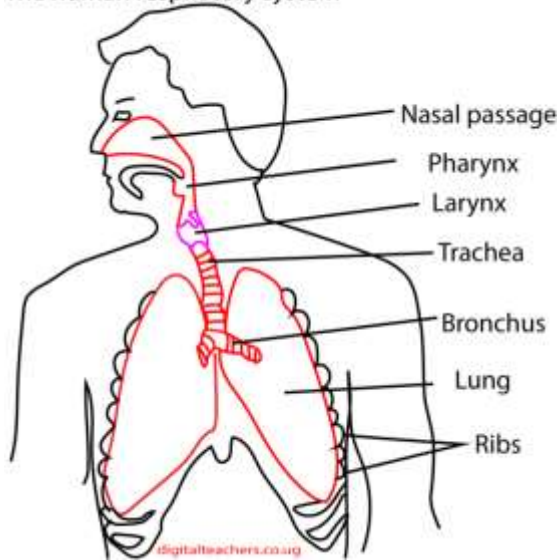
Prevents conditions like acidosis (too much CO₂).

(v) Support for Vital Functions

Breathing ensures organs like the heart, brain, and muscles receive oxygen continuously.

Without gas exchange, cells die within minutes.

The human respiratory system



The human lungs and associated structure are shown in figure above. The **lungs** are situated in the **thorax**, the walls of which are formed by the **ribs** and **intercostal muscles** and the floor of the **diaphragm**. The lungs are surrounded by a very narrow **pleural cavity** lined by **pleural membranes**. The pleural cavity contains a thin layer of lubricating which allows the pleural membranes to slide easily over each other as the thorax expands and contracts during breathing.

Inspiration

Air is drawn into the lungs via the **trachea** and bronchi.

1. External intercostal muscles contract and rise the ribs upwards and outwards.
2. The radial and circular muscles of the diaphragm contract and diaphragm flattens.
3. There is an increase in volume of the thoracic cavity and a decrease in pressure in the lungs.
4. Air is drawn into the lungs to equalise the pressure to atmospheric pressure.

Expiration

- This is a reverse of the inspiration process; air being expelled from lungs.
- It is mainly a passive process resulting from elastic recoil of the tissues that have been stretched during inspiration.
- However, in forced breathing or when breathing tubes are blocked, expiration is aided by contraction of the internal intercostal muscles and **abdominal muscles**.
- Contraction of the latter raises the pressure in the abdominal cavity, forcing the diaphragm upwards.

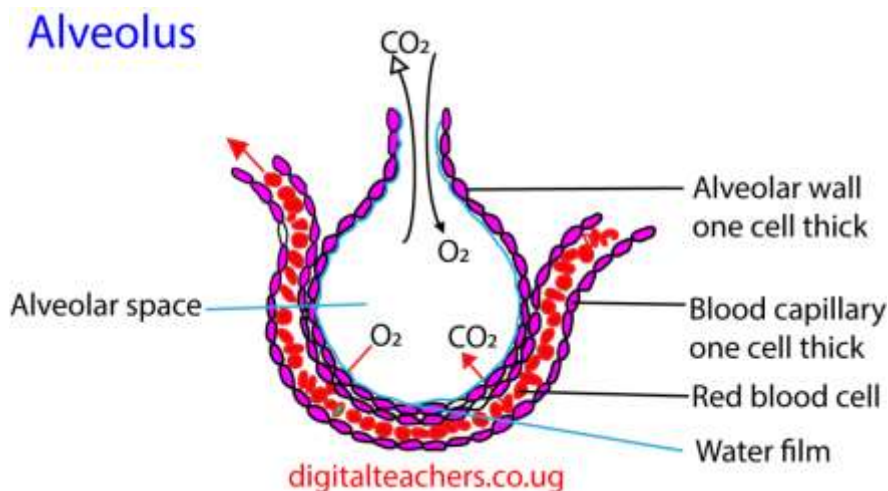
Alveoli.

Alveoli (singular alveolus) are numerous hollow, lobed air sacs that form the gaseous exchange surface in the lungs.

They occur at the terminal end of the tracheal branching and come in close association with extensive capillary system.

This makes them efficient apparatus for gaseous exchange.

Diagram of alveolus showing intimate association between alveoli and blood capillaries.



Adaptations of the alveolus to efficient gaseous exchange

- (i) They are very numerous that they offer a big surface area for gaseous exchange
- (ii) Alveolar epithelium is covered internally with a thin layer of fluids in which oxygen dissolves before diffusing into the blood which create high diffusion gradient.
- (iii) Alveolar fluid contains surfactants that prevent alveolar form collapsing
- (iv) Alveolus is separated form blood capillaries by thin membrane that offer minimum resistance to diffusion of gases.
- (v) The blood capillaries of the alveolus are smaller than the red blood cells such that when cell squeeze through the capillaries, they make intimate contact with capillary membranes that ease gaseous diffusion.

Variation in the percentage composition of gases in inhaled and exhaled air

The **variation in the percentage composition of gases in inhaled and exhaled air** reflects the exchange of oxygen and carbon dioxide during respiration. When we breathe in, air enters the lungs with a certain composition; after gaseous exchange in the alveoli, the composition changes before it is breathed out.

Composition of Inhaled vs Exhaled Air

Gas	Inhaled Air (%)	Exhaled Air (%)	Reason for Change
Oxygen	~21	~16	Oxygen diffuses into blood for respiration
Carbon dioxide	~0.03	~4	Produced during cellular respiration and diffuses out into alveoli
Nitrogen	~78	~78	Remains unchanged; not used in respiration
Water vapor	Variable (depends on humidity)	Higher	Moisture added in respiratory tract
Other gases	Traces	Traces	Minimal change

Analysis of Variation

- (i) **Decrease in oxygen** → Because it is absorbed into the bloodstream and used in cellular respiration.
- (ii) **Increase in carbon dioxide** → Because it is a waste product of respiration released into alveoli.
- (iii) **Nitrogen remains constant** → It is not metabolized or absorbed significantly.
- (iv) **Increase in water vapor** → Air picks up moisture as it passes through the respiratory tract.

Key Takeaway

The difference between inhaled and exhaled air shows the **function of the lungs in gas exchange**: oxygen is taken in for energy production, while carbon dioxide and excess water vapor are expelled as waste. This variation is proof of respiration occurring in the body.

Respiration

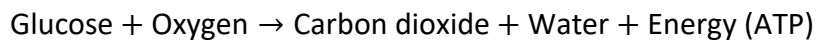
This is the oxidation of organic substance to liberate energy in the body.

Types of Tissue Respiration

Tissue respiration occurs inside cells, and it has two main types:

(i) **Aerobic Respiration**

- Requires oxygen.
- Glucose is completely broken down into carbon dioxide, water, and energy.
- Equation:

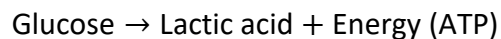


Produces large amounts of energy.

Example: Muscle cells during normal activity.

(ii) **Anaerobic Respiration**

- Occurs without oxygen.
- Glucose is only partially broken down.
- In humans: produces **lactic acid** and small amounts of energy.
- Equation:



Less efficient than aerobic respiration.

Example: Muscle cells during intense exercise when oxygen supply is limited.

Comparison Table

Feature	Aerobic Respiration	Anaerobic Respiration
Oxygen use	Requires oxygen	No oxygen
Products	CO ₂ , water, energy	Lactic acid, energy
Energy yield	High (36–38 ATP per glucose)	Low (2 ATP per glucose)
Efficiency	Very efficient	Less efficient
Example	Normal muscle activity	Vigorous exercise

Key Takeaway

Respiration is the **release of energy from glucose in cells**. Aerobic respiration is more efficient and sustainable, while anaerobic respiration provides emergency energy when oxygen is scarce but leads to lactic acid buildup (causing muscle fatigue).

Importance of Aerobic Respiration

(i) **High Energy Yield**

Produces up to 36–38 ATP molecules per glucose, far more than anaerobic respiration.

Supports energy-demanding activities like movement, growth, and repair.

(ii) **Efficient Breakdown of Food**

Glucose is completely oxidized into carbon dioxide and water.

Prevents accumulation of harmful by-products like lactic acid.

(iii) **Supports Vital Organs**

Provides continuous energy for the brain, heart, and muscles.

Essential for maintaining body temperature and homeostasis.

(iv) **Waste Removal**

Produces carbon dioxide and water, which are easily expelled.

Helps maintain blood pH balance.

(v) **Sustained Activity**

Enables long-term activities like walking, studying, and working.

Unlike anaerobic respiration, it does not cause fatigue quickly.

Process of Aerobic Respiration

(i) **Glycolysis**

- Occurs in the cytoplasm.
- Glucose (6-carbon) is broken down into 2 molecules of pyruvate (3-carbon).
- Produces 2 ATP and NADH.

(ii) **Link Reaction**

- Pyruvate enters mitochondria and is converted into Acetyl-CoA.
- Carbon dioxide is released.

(iii) **Krebs Cycle (Citric Acid Cycle)**

- Acetyl-CoA enters the cycle in the mitochondrial matrix.
- Produces CO₂, NADH, FADH₂, and a small amount of ATP.

(iv) **Electron Transport Chain (ETC)**

- Occurs in the inner mitochondrial membrane.
- NADH and FADH₂ release electrons that pass through protein complexes.
- Energy from electrons pumps protons, creating a gradient.
- Oxygen acts as the final electron acceptor, forming water.
- ATP synthase uses the proton gradient to produce ~34 ATP.

Main Substrates for Respiration

In respiration, the substrate is the substance that is broken down to release energy. In humans, the main substrate is glucose, but other molecules like fats and proteins can also serve as substrates when needed.

(i) Glucose

- Primary substrate for respiration.
- Broken down during glycolysis, Krebs cycle, and electron transport chain.
- Provides the highest yield of ATP efficiently.

(ii) Fats (Lipids)

- Broken down into fatty acids and glycerol.
- Fatty acids enter the Krebs cycle after conversion to Acetyl-CoA.
- Used when glucose is scarce (e.g., fasting).

(iii) Proteins

- Broken down into amino acids.
- Amino acids are deaminated (removal of amino group) and enter respiration pathways.
- Used only in extreme conditions (starvation).

Relative Importance of Substrates

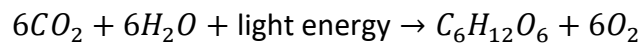
- (i) Glucose → **Preferred substrate** because it is easily metabolized and provides quick energy.
- (ii) Fats → Provide more energy per molecule but are slower to break down.
- (iii) Proteins → Least preferred, as they are mainly needed for growth and repair, not energy.

Interdependence of Respiration and photosynthesis

The relationship between **plants and animals** in terms of **respiration and photosynthesis** is a perfect example of biological interdependence. Each process complements the other, creating a continuous cycle that sustains life on Earth.

Photosynthesis in Plants

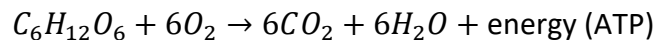
- Occurs in the **chloroplasts** of plant cells.
- Plants use **carbon dioxide, water, and sunlight** to produce **glucose and oxygen**.
- Equation:



- Oxygen released is essential for animals.

Respiration in Animals

- Occurs in the **mitochondria** of animal cells.
- Animals use **glucose and oxygen** to produce **energy (ATP), carbon dioxide, and water**.
- Equation:



- Carbon dioxide released is essential for plants.

Interdependence Between Plants and Animals

- **Plants provide oxygen** → Needed by animals for respiration.
- **Animals provide carbon dioxide** → Needed by plants for photosynthesis.
- **Energy cycle** → Plants make glucose (food), animals consume it for energy.
- **Balance of gases** → Maintains atmospheric oxygen and carbon dioxide levels.

Summary Table

Process	Organism	Inputs	Outputs	Importance to Other
Photosynthesis	Plants	CO ₂ , H ₂ O, sunlight	Glucose, O ₂	Provides oxygen & food for animals
Respiration	Animals	Glucose, O ₂	CO ₂ , H ₂ O, energy	Provides CO ₂ for plants

Key Takeaway

Plants and animals are **mutually dependent**: plants supply oxygen and food through photosynthesis, while animals return carbon dioxide and water through respiration. This cycle maintains the balance of life and energy flow in ecosystems.

Gaseous exchange in Insects

Occurs in tracheal system made of spiracles, tracheae and tracheole. Gaseous exchange occurs in tracheoles with thin membranes

Gaseous exchange in Frog

It occurs through:

- Skin (cutaneous surface)
- Buccal cavity (mouth lining)
- Lungs

Anaerobic respiration

Anaerobic respiration is the breakdown of glucose without oxygen. It produces less energy compared to aerobic respiration and results in different by-products in plants and animals.

Anaerobic Respiration in Plants

Occurs when oxygen is absent (e.g., waterlogged soils).

Glucose is broken down into **ethanol (alcohol), carbon dioxide, and a small amount of energy**.

Equation:



Example: Yeast cells during fermentation.

Anaerobic Respiration in Animals

Occurs in muscle cells during vigorous exercise when oxygen supply is insufficient.

Glucose is broken down into **lactic acid and a small amount of energy**.

Equation:



Leads to muscle fatigue and cramps due to lactic acid buildup.

Comparison Table

Feature	Plants	Animals
Substrate	Glucose	Glucose
Products	Ethanol + CO ₂ + energy	Lactic acid + energy
Energy yield	Low	Low
Example	Yeast fermentation	Muscle activity during exercise
Effect	Useful in brewing/baking	Causes fatigue & oxygen debt

Key Takeaway

Anaerobic respiration is a **backup energy process** when oxygen is unavailable. In plants (and yeast), it produces ethanol and carbon dioxide, while in animals it produces lactic acid.

Though less efficient, it allows survival under oxygen-limited conditions.

Applications of Anaerobic Respiration

(i) **Alcoholic Fermentation**

Yeast carries out anaerobic respiration to produce **ethanol**.

Used in brewing beer, wine, and spirits.

(ii) **Baking Industry**

Yeast produces **carbon dioxide** during fermentation.

CO₂ makes dough rise, giving bread its soft texture.

(iii) **Dairy Industry**

Bacteria use anaerobic respiration to produce **lactic acid**.

Important in making yogurt, cheese, and sour milk.

(iv) **Biogas Production**

Anaerobic bacteria break down organic waste to produce **methane gas**.

Used as fuel for cooking and electricity generation.

(v) **Muscle Activity in Humans**

During vigorous exercise, muscles respire anaerobically, producing **lactic acid**.

Provides emergency energy when oxygen is insufficient.

(vi) **Industrial Uses**

Production of organic acids, solvents, and biofuels.

Used in biotechnology and pharmaceuticals.

Summary Table

Application	Organism	Product	Everyday Use
Alcoholic fermentation	Yeast	Ethanol	Brewing beer, wine
Baking	Yeast	CO ₂	Bread rising
Dairy	Bacteria	Lactic acid	Yogurt, cheese
Biogas	Anaerobic bacteria	Methane	Fuel & energy
Muscle activity	Human muscle cells	Lactic acid	Emergency energy
Industry	Microbes	Organic acids, solvents	Biofuels, pharmaceuticals

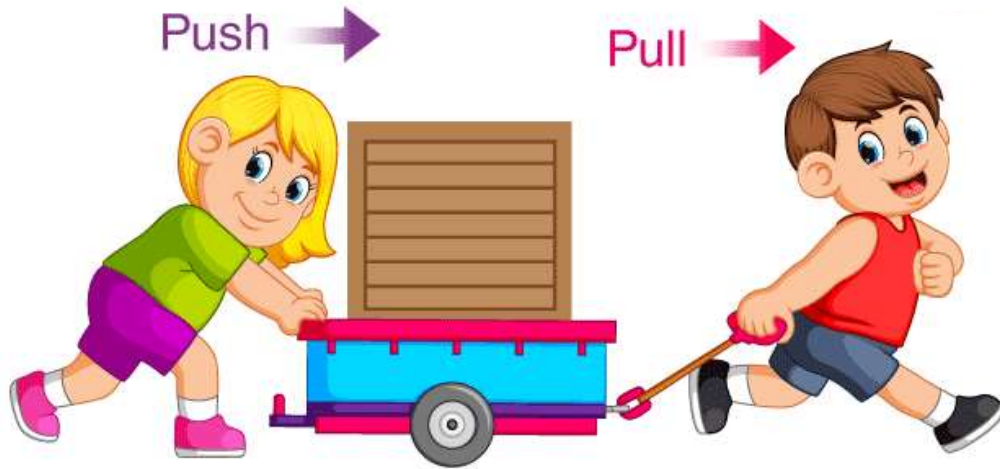
Key Takeaway

Anaerobic respiration is not just a biological backup process—it is **central to food production, energy generation, and industry**. From bread and beer to biogas and biofuels, it underpins many everyday products and technologies.

THEME: SCIENCE AND TECHNOLOGY

TOPIC 9: FORCES

Competency: The learner should be able to explore the nature and types of force and describe how forces affect objects and the use of some common forces.



Forces

In physics, forces are classified into two main groups: contact forces (like friction, tension, and normal force) and non-contact forces (like gravity, electromagnetism, and nuclear forces). At the deepest level, all forces trace back to the four fundamental forces: gravitational, electromagnetic, strong nuclear, and weak nuclear.

What Is a Force?

A **force** is a **push or pull** that changes an object's motion or shape.

It is a **vector quantity** (has both magnitude and direction).

Measured in **newtons (N)**, following Newton's second law: $F = m \cdot a$.

Effects of force on bodies

- (i) **Causes Motion:** A force applied to a stationary object can **make it move**. Example: Pushing a ball makes it roll.
- (ii) **Changes the Speed of an Object:** A force can **increase or decrease** an object's speed. Example: Pressing the brakes slows down a car.
- (iii) **Changes the Direction of Motion:** When force acts at an angle, it can alter the **direction** of movement. Example: A football changes direction when kicked in a different way.
- (iv) **Causes Deformation (Changes Shape or Size):** Force can **compress, stretch, or bend** an object. Example: Squeezing a sponge changes its shape.
- (v) **Can Cause Rotation:** If a force is applied off-center, it can make an object **rotate**. Example: Turning a wrench to tighten a bolt.
- (vi) **Affects Pressure:** Force exerted over an area influences **pressure**. Example: Pressing harder on a knife increases its cutting ability.

Categories of Forces

(i) Contact Forces

These require physical contact between objects:

Friction – opposes motion between surfaces.

Tension – force in ropes, strings, or cables.

Normal force – support force from a surface.

Applied force – push or pull by a person/object.

Spring force – restoring force in stretched/compressed springs.

Air resistance – drag force opposing motion in air.

Buoyancy – upward force in fluids.

(ii) Non-Contact (Field) Forces

Act across distance without touching:

Gravitational force – attraction between masses.

Electromagnetic force – attraction/repulsion of charges.

Strong nuclear force – binds protons and neutrons in nuclei.

Weak nuclear force – responsible for radioactive decay.

The Four Fundamental Forces

Force	Relative Strength	Range	Examples
Strong nuclear	Strongest	Very short ($\sim 10^{-15}$ m)	Holds atomic nuclei together
Electromagnetic	2nd strongest	Infinite	Electricity, magnetism, chemical bonding
Weak nuclear	Weak	Very short ($\sim 10^{-18}$ m)	Radioactive decay, nuclear fusion in stars
Gravitational	Weakest	Infinite	Planetary orbits, falling objects

Everyday Examples

- ❖ Picking up a phone: **friction** grips it, **tension** holds the charging cable, **gravity** pulls it down.
- ❖ Walking: **friction** between shoes and ground prevents slipping.
- ❖ Swimming: **buoyancy** keeps you afloat, **drag** slows you down.
- ❖ Satellites: stay in orbit due to **gravitational force**.

Risks & Misconceptions

- ❖ **Weight vs. mass:** Mass is constant; weight changes with gravity.
- ❖ **Friction:** Often seen as “bad,” but it’s essential for walking, driving, and holding objects.
- ❖ **Gravity’s weakness:** Though the weakest fundamental force, it dominates at large scales because it always attracts and never cancels out.

Exercise 9.1

- (a) What is a force
- (b) With examples write five effects of forces on a body.

Balanced and unbalanced forces

Balanced forces keep objects at rest or moving steadily, while unbalanced forces cause changes in motion such as starting, stopping, speeding up, or changing direction. In everyday life, balanced forces explain why a book stays on a table, while unbalanced forces explain why a football moves when kicked.

Balanced Forces

Definition: Forces of equal magnitude acting in opposite directions, resulting in **net force = 0**.

Effects:

- No change in motion (object stays at rest or continues uniform motion).
- Can change shape without moving position.

Everyday Examples:

- **Book on a table:** Gravity pulls down, table pushes up.
- **Tug of war:** Equal pulls keep rope still.
- **Person pushing a wall:** Wall doesn't move because forces cancel.
- **Car cruising steadily:** Engine force forward equals friction backward.

Unbalanced Forces

Definition: Forces that are unequal or not opposite, resulting in **net force $\neq 0$** .

Effects:

- Cause acceleration, deceleration, or change in direction.
- Start or stop motion.

Everyday Examples:

- **Kicking a football:** Foot applies greater force, ball moves.
- **Cycling uphill:** Gravity pulls stronger than pedaling, slowing the rider.
- **Car braking:** Brakes apply force greater than motion, car stops.
- **Opening a door:** Push force overcomes friction, door swings.

Comparison Table

Aspect	Balanced Forces	Unbalanced Forces
Net Force	Zero	Non-zero
Motion	No change	Change occurs
Effect	Stability, equilibrium	Acceleration, deceleration, direction change
Example	Book on table	Football being kicked

Everyday Life Applications

- (i) **Balanced forces in construction:** Buildings stand firm because forces balance.
- (ii) **Unbalanced forces in transport:** Cars, bicycles, and planes move due to unbalanced forces.
- (iii) **Sports:** Running, jumping, and throwing all rely on unbalanced forces.
- (iv) **Household activities:** Opening jars, pushing furniture, or pulling curtains involve unbalanced forces.

Key Insight

Balanced forces explain **stability and rest**, while unbalanced forces explain **motion and change**. In daily life, both are constantly at play — from the stillness of a hanging picture frame to the dynamic motion of vehicles and sports.

Resultant force

A force is a vector in that it has magnitude and direction. This helps is in addition, subtraction and manipulation of forces on an object.

A **resultant force** is the overall force acting on an object when multiple forces are applied. It is found by combining all the forces acting on the object, taking both **magnitude** and **direction** into account.

If forces are balanced (equal and opposite), the resultant force is **zero**, meaning the object stays at rest or moves at a constant speed.

If forces are unbalanced, the object accelerates in the direction of the resultant force.

How to Calculate Resultant Force

- (a) If forces act in the **same direction**, add them together.
For example, if two people push a box with forces of **30 N** and **50 N** in the same direction, the resultant force is: $30\text{N} + 50\text{N} = 80\text{ N}$
- (b) If forces act in **opposite directions**, subtract the smaller force from the larger force.

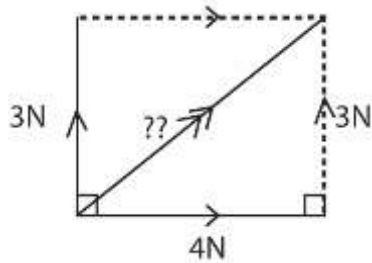
For example, when person pushes a box with 30N to the left while another pushing the box at 50N to the right; the resultant force = $50 - 30 = 20\text{N}$ to the right

Or

For example, when person pushes a box with 50N to the left while another pushing the box at 30N to the right; the resultant force = $50 - 30 = 20\text{N}$ to the left.

- (c) If forces act at angles, use vector addition (like the Pythagorean Theorem or trigonometry) to find the net force.

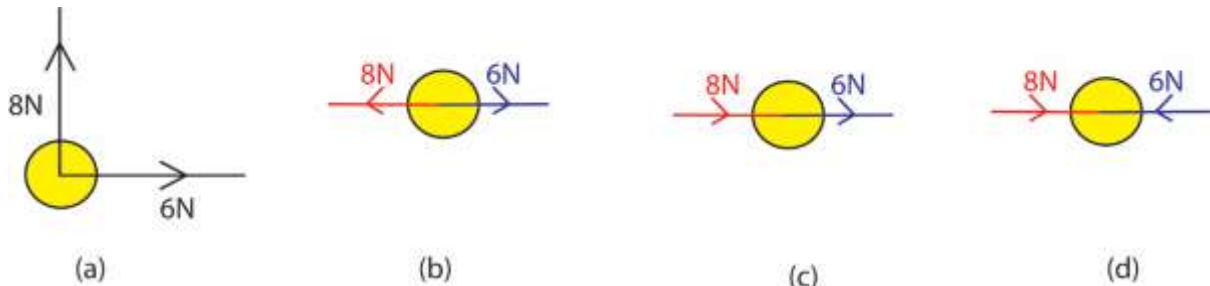
For example, find the resultant force when two forces of 3N and 4N act on an object at right angles



Using Pythagorean Theorem the resultant force $\sqrt{3^2 + 4^2} = 5\text{N}$

Exercise 9.2

Find the resultant forces on each object in the figure below.



Answers to exercise 9.2: (a) 10N, (b) 2N to left, (c) 14N to right, (d) 2N to right

Frictional force

It is a force that opposes relative motion between two bodies in contact.

Types of friction

- (i) **Static friction** is that occur when an object is not moving i.e. it's friction that prevents motion.

Applications of static friction

- Enables the feet to grip the ground, preventing slipping while running or walking.
- Enables us to grasp and hold objects like a pen while writing
- Allows nails, screws, and bolts to hold materials together securely.
- Keeps objects stationary on conveyor belts until pushed forward.

- (ii) **Dynamic/kinetic friction** is a type of friction that slows down already moving bodies. It is lower than static friction but still opposes motion.

Applications of dynamic friction

- Braking of moving car, when a driver applies brakes, dynamic friction between the brake pads and the wheel slows down the car.
- Writing with Pens and Pencils, dynamic friction helps deposit ink or graphite onto the surface.
- Sanding and Polishing, wearing down rough areas is due to kinetic friction. This process creates smooth surfaces in furniture, jewelry, and automotive parts.
- Rubbing Hands for Warmth, dynamic friction generates heat.
- Walking and Running; kinetic friction between shoes and the ground provides grip. It prevents slipping and aids in maintaining balance.
- Sparks fire when a match stick strikes the match box

Disadvantages of friction

- (i) Causes unnecessary heat
- (ii) Reduces the efficiency of machines
- (iii) Causes things like tires, soles of shoes to wear out
- (iv) Causes parts of machines to break
- (v) Cause irritating noise

Main Methods of Reducing Friction

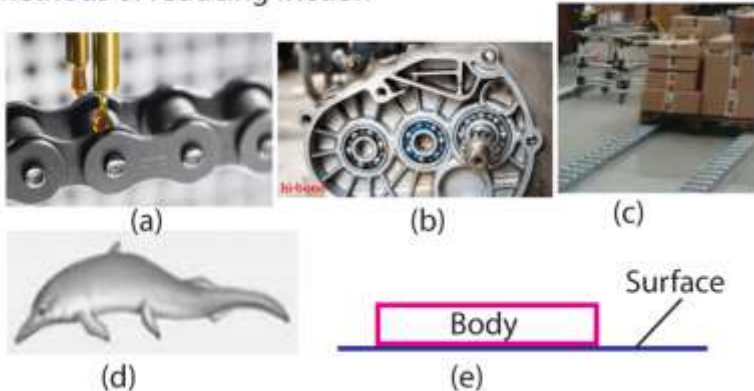
- (i) **Lubrication:** Applying oil, grease, or graphite creates a thin film between surfaces, preventing direct contact and reducing resistance.
Examples: Engine oil in cars, grease on bicycle chains, cooking oil on pans.
- (ii) **Ball Bearings:** Small metal or ceramic balls convert sliding friction into rolling friction, which is much smaller.
Examples: Used in bicycles, fans, skateboards, and car wheels.
- (iii) **Polishing Surfaces:** Smooth surfaces reduce interlocking of irregularities, making sliding easier.
Examples: Polished furniture, sanded wood, smooth tiles.

- (iv) **Streamlining Objects:** Shaping objects to allow air or water to flow smoothly reduces fluid friction (drag).
Examples: Airplanes, cars, boats, swimmers' suits.
- (v) **Using Wheels and Rollers:** Wheels reduce sliding friction by rolling, making movement easier.
Examples: Cars, trolleys, conveyor belts.
- (vi) **Air Cushions:** A thin layer of air reduces contact between surfaces.
Examples: Hovercrafts, some high-speed trains.
- (vii) **Reducing Surface Contact Area:** Smaller contact areas mean less resistance.
Examples: Narrow tires for racing bicycles.

Exercise 9.3

Identify the methods of reducing friction in each figure below.

Methods of reducing friction



Methods that increase friction and their applications

Increasing friction is useful when we need grip, stability, or control. Methods include roughening surfaces, using treads, applying adhesives, increasing weight, and choosing materials with higher friction. These are applied in walking, driving, construction, and sports.

Methods of Increasing Friction

- (i) **Roughening surfaces:** Making surfaces coarse prevents slipping.
Examples: Sanding wood, rough floors in bathrooms.
- (ii) **Treads and grooves:** Patterns on tires or shoes increase grip.
Examples: Car tires, shoe soles, tractor tires.

- (iii) **Adhesives:** Glue or sticky substances increase resistance between surfaces.
Examples: Tape, glue, sticky mats.
- (iv) **Increasing weight/force:** Heavier objects press surfaces together more, increasing friction.
Examples: Adding weight to tires for better traction.
- (v) **Using rough materials:** Materials like rubber or sandpaper naturally have high friction.
Examples: Rubber shoe soles, sandpaper for polishing.

Comparison Table

Method	How It Works	Everyday Example
Roughening surfaces	Creates irregularities that resist sliding	Rough bathroom tiles
Treads/grooves	Channels grip into surfaces	Car tires
Adhesives	Sticky layer bonds surfaces	Glue, tape
Increasing weight	More force presses surfaces together	Tractor tires
Rough materials	Naturally high resistance	Rubber soles

Applications in Everyday Life

- (i) **Walking safely:** Shoe soles with treads prevent slipping.
- (ii) **Driving:** Car tires with grooves grip the road. Tarmacking increases friction
- (iii) **Construction:** Rough surfaces help bricks and cement stick together.
- (iv) **Sports:** Athletes use shoes with spikes or rubber soles for grip.
- (v) **Household safety:** Rough tiles in bathrooms prevent accidents.

Key Insight

While friction often wastes energy, **increasing friction is essential for safety, stability, and control.** Without it, walking, driving, building, and even writing with a pen would be impossible.

Gravitational Force

Gravitation force is the force that pulls objects toward the Earth, like how a dropped apple falls to the ground.

Mass of an object is the quantity of matter a body contains. It is constant across the globe.

Acceleration due to gravity, often denoted as **g**, is the rate at which objects accelerate toward the ground due to Earth's gravitational pull. On Earth, this acceleration is approximately **9.81 m/s²**—meaning that an object's velocity increases by **9.81 meters per second** every second it falls.

Weight is the force exerted on an object due to gravity. It's calculated using the formula:

Weight = Mass (kg) × Acceleration due to gravity(g)

Exercise 9.4

Taking acceleration due to gravity = 10ms^{-2} . Calculate the weight the following masses

- (a) 10kg [100N]
- (b) 5g [0.05N]
- (c) 6mg [0.00006N]

Why gravity less on the moon than on earth

Gravity is weaker on the Moon than on Earth because the Moon has less mass and a smaller radius compared to the those of the earth. This means objects weigh less and fall more slowly on the Moon.

Why the earth revolves around the sun

Earth revolves around the Sun because the Sun's immense gravity pulls it inward while Earth's forward motion (inertia) keeps it moving sideways, creating a stable orbit. This balance of gravitational attraction and inertia results in Earth's continuous "free-fall" around the Sun, repeating every 365 days.

Importance of force of gravity to life on earth

Gravity is essential for life on Earth because it holds the atmosphere, keeps water and living things anchored, controls tides, and maintains Earth's orbit around the Sun. Without gravity, life as we know it would not exist.

Importance of Gravity to Life

- (i) **Keeps us anchored:** Prevents humans, animals, and objects from floating away into space.
- (ii) **Maintains atmosphere:** Holds air around Earth, allowing breathing, weather, and climate.
- (iii) **Controls water bodies:** Keeps oceans, lakes, and rivers on Earth's surface.
- (iv) **Causes tides:** The Moon's gravity pulls ocean water, creating tides that influence marine life and coastal ecosystems.
- (v) **Supports plant growth:** Guides roots downward and stems upward, ensuring proper growth.
- (vi) **Enables Earth's orbit:** Keeps Earth revolving around the Sun, which causes seasons and regulates climate.
- (vii) **Allows rainfall:** Pulls raindrops down from clouds, sustaining agriculture and ecosystems.
- (viii) **Facilitates construction:** Provides stability for buildings, bridges, and roads.

Summary Table

Role of Gravity	Effect on Life	Example
Anchoring	Keeps living things grounded	Walking, sitting
Atmosphere	Holds air for breathing	Oxygen supply
Water control	Keeps oceans and rivers in place	Hydrological cycle
Tides	Influences marine ecosystems	Fishing, navigation
Plant growth	Guides roots and stems	Agriculture
Orbit	Causes seasons	Summer, winter
Rainfall	Brings water to Earth	Farming
Construction	Provides stability	Buildings, bridges

Key Insight

Gravity is the **invisible force that makes Earth habitable**. It ensures we breathe, eat, grow food, build homes, and experience seasons. Without gravity, Earth would lose its atmosphere, water, and orbit — making life impossible.

Exercise 9.5

Explain the importance of gravity to life on Earth.

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