Nutrition

Chapter 3: NUTRITION - PHOTOSYNTHESIS • FOOD SUBSTANCES

Learning Objectives: Upon completion of this chapter, students should be able to:

- Define nutrition and its importance.
- Differentiate between photosynthesis and animal nutrition.
- Explain the process of photosynthesis, including raw materials, products, and conditions.
- Describe the different classes of food substances and their dietary roles.
- Discuss the importance of water, mineral salts, vitamins, and roughage in the diet.
- Understand common nutritional deficiencies and their causes.
- Explain the concept of a balanced diet.
- Differentiate between autotrophic and heterotrophic nutrition.

3.1 Introduction to Nutrition

- **Definition:** Nutrition is the process by which living organisms obtain and utilize food substances for growth, energy, repair, and maintenance of life processes.
- **Importance:**
    - **Energy Production:** Food provides the necessary energy for all metabolic activities (e.g., movement, growth, reproduction).
    - **Growth and Development:** Essential for the formation of new cells and tissues, leading to an increase in size and complexity.
    - **Repair and Maintenance:** Replaces worn-out cells and tissues, and maintains the proper functioning of organs and systems.
    - **Disease Prevention:** Adequate nutrition boosts the immune system, protecting the body from infections and diseases.
- **Types of Nutrition:**
    - **Autotrophic Nutrition:** Organisms synthesize their own food from simple inorganic substances (e.g., carbon dioxide, water) using an external energy source (e.g., sunlight).
        - *Examples:* Green plants, algae, some bacteria.
        - *Process:* Primarily photosynthesis, but also chemosynthesis.
    - **Heterotrophic Nutrition:** Organisms obtain food by consuming other organisms or organic matter. They cannot synthesize their own food.
        - *Examples:* Animals, fungi, most bacteria.
        - *Sub-types:* Holozoic (ingestion, digestion, absorption), Saprophytic (feeding on dead organic matter), Parasitic (feeding on living hosts).

3.2 Photosynthesis: The Basis of Life

- **Definition:** Photosynthesis is the process by which green plants, algae, and some bacteria convert light energy into chemical energy in the form of glucose, using carbon dioxide and water as raw materials. Oxygen is released as a by-product.
- **Word Equation:** Carbon Dioxide + Water + Light Energy \xrightarrow{\text{Chlorophyll}} Glucose + Oxygen
- **Chemical Equation (Simplified):** 6CO_2 + 6H_2O \xrightarrow{\text{Light Energy, Chlorophyll}} C_6H_{12}O_6 + 6O_2
- **Location:** Primarily occurs in the chloroplasts of plant cells, specifically within the chlorophyll-containing thylakoids.
- **Raw Materials:**
    - **Carbon Dioxide (CO_2):** Absorbed from the atmosphere through stomata on leaves.
    - **Water (H_2O):** Absorbed from the soil by roots and transported to leaves via xylem vessels.
- **Products:**
    - **Glucose (C_6H_{12}O_6):** A simple sugar, used as an immediate energy source or converted to starch for storage.
    - **Oxygen (O_2):** Released into the atmosphere through stomata; vital for respiration in most living organisms.
- **Conditions Necessary for Photosynthesis:**
    - **Light Energy:** Provides the energy to drive the reaction.
    - **Chlorophyll:** The green pigment that traps light energy.
    - **Suitable Temperature:** Photosynthesis is an enzyme-controlled process, so an optimal temperature range is required.
- **Stages of Photosynthesis (Briefly for secondary level):**
    - **Light-Dependent Reactions:** Occur in the thylakoids; light energy is captured by chlorophyll and converted into chemical energy (ATP and NADPH). Water is split, releasing oxygen.
    - **Light-Independent Reactions (Calvin Cycle):** Occur in the stroma; ATP and NADPH are used to fix carbon dioxide and synthesize glucose.

3.3 Animal Nutrition and Modes of Nutrition

- **Definition:** The process by which animals obtain and process food, including ingestion, digestion, absorption, assimilation, and egestion.
- **Modes of Animal Nutrition:**
    - **Holozoic Nutrition:** Involves the ingestion of solid or liquid organic food, which is then processed internally.
        - *Examples:* Humans, cows, amoeba.
        - *Stages:*
            1. **Ingestion:** Taking food into the body.
            2. **Digestion:** Breaking down complex food molecules into simpler, absorbable forms.
            3. **Absorption:** Uptake of digested food molecules into the bloodstream or lymphatic system.

4. **Assimilation:** Utilization of absorbed nutrients by cells for energy, growth, and repair.
5. **Egestion:** Elimination of undigested waste materials from the body.

- **Saprophytic Nutrition:** Organisms feed on dead and decaying organic matter. They secrete digestive enzymes externally and absorb the digested nutrients.
  - *Examples:* Fungi, some bacteria.
- **Parasitic Nutrition:** Organisms (parasites) obtain nutrients from a living host organism, often causing harm to the host.
  - *Examples:* Tapeworms, lice, mosquitoes.

3.4 Food Substances: Composition and Roles

Food is composed of various chemical substances, each playing a specific role in the body. These are broadly categorized into Macronutrients (needed in large amounts) and Micronutrients (needed in small amounts).

- **Macronutrients:**
  1. **Carbohydrates:**
     - **Composition:** Carbon, hydrogen, oxygen (CHO).
     - **Types:** Monosaccharides (glucose, fructose), Disaccharides (sucrose, lactose), Polysaccharides (starch, glycogen, cellulose).
     - **Sources:** Bread, rice, pasta, potatoes, fruits, sugar.
     - **Functions:**
       - **Primary energy source:** Readily available energy for cellular activities.
       - **Energy storage:** Stored as glycogen in animals and starch in plants.
       - **Structural component:** Cellulose in plant cell walls.
     - **Deficiency:** Weight loss, fatigue, reduced physical and mental performance.
     - **Excess:** Weight gain (converted to fat), increased risk of type 2 diabetes.
  2. **Proteins:**
     - **Composition:** Carbon, hydrogen, oxygen, nitrogen (CHON), sometimes sulfur. Made up of amino acids.
     - **Sources:** Meat, fish, eggs, dairy products, legumes, nuts.
     - **Functions:**
       - **Growth and repair:** Essential for building and repairing tissues, muscles, organs.
       - **Enzymes and hormones:** Form enzymes (biological catalysts) and many hormones (chemical messengers).
       - **Antibodies:** Part of the immune system, defending against infections.
       - **Transport:** Haemoglobin transports oxygen.
       - **Energy source:** Can be used for energy in extreme cases (when fats and carbs are insufficient).
     - **Deficiency:** Kwashiorkor (swelling, stunted growth), Marasmus (severe wasting), poor wound healing, weak immune system.
     - **Excess:** Can strain kidneys, contribute to dehydration.
  3. **Fats (Lipids):**
     - **Composition:** Carbon, hydrogen, oxygen (CHO) – higher proportion of hydrogen and lower oxygen than carbohydrates. Made of fatty acids and glycerol.

        - **Types:** Saturated (solid at room temp, e.g., butter, animal fat) and Unsaturated (liquid at room temp, e.g., vegetable oils).
        - **Sources:** Oils, butter, nuts, fatty meats, avocados.
        - **Functions:**
            - **Concentrated energy source:** Provide more than twice the energy per gram compared to carbohydrates or proteins.
            - **Energy storage:** Stored as adipose tissue, providing insulation and protection for organs.
            - **Absorption of fat-soluble vitamins:** Essential for the absorption of Vitamins A, D, E, K.
            - **Cell membranes:** Component of cell membranes.
        - **Deficiency:** Dry skin, hair loss, reduced growth, difficulty absorbing fat-soluble vitamins.
        - **Excess:** Obesity, increased risk of heart disease, high cholesterol.
- **Micronutrients:**
    1. **Vitamins:**
        - **Definition:** Organic compounds required in small amounts for various metabolic functions; the body cannot synthesize most of them.
        - **Types:**
            - **Fat-soluble (A, D, E, K):** Stored in body fat; can accumulate to toxic levels.
            - **Water-soluble (B-complex, C):** Not stored in the body; excess is excreted.
        - **Functions (Examples):**
            - **Vitamin A (Retinol):** Good vision, healthy skin, immune function. *Deficiency:* Night blindness.
            - **Vitamin B Complex:** Energy metabolism, nerve function, red blood cell formation. *Deficiency:* Beriberi (B1), Pellagra (B3), anaemia (B12).
            - **Vitamin C (Ascorbic Acid):** Collagen formation, immune function, antioxidant. *Deficiency:* Scurvy.
            - **Vitamin D (Calciferol):** Calcium absorption, bone health. *Deficiency:* Rickets (children), Osteomalacia (adults).
            - **Vitamin E (Tocopherol):** Antioxidant, protects cells.
            - **Vitamin K:** Blood clotting.
        - **Sources:** Fruits, vegetables, dairy, meat, fortified foods.
    2. **Mineral Salts:**
        - **Definition:** Inorganic elements required in small amounts for various body functions.
        - **Examples & Functions:**
            - **Calcium (Ca):** Strong bones and teeth, muscle contraction, blood clotting. *Deficiency:* Osteoporosis, rickets. *Sources:* Dairy, leafy greens.
            - **Phosphorus (P):** Bone and teeth formation, energy transfer (ATP). *Sources:* Meat, dairy, nuts.
            - **Iron (Fe):** Component of haemoglobin (oxygen transport), enzyme function. *Deficiency:* Anaemia. *Sources:* Red meat, beans, spinach.
            - **Iodine (I):** Thyroid hormone production (metabolism). *Deficiency:* Goitre. *Sources:* Iodized salt, seafood.

        - **Sodium (Na), Potassium (K), Chloride (Cl):** Fluid balance, nerve impulses, muscle function. *Sources:* Salt, fruits, vegetables.
        - **Zinc (Zn):** Immune function, wound healing, growth. *Sources:* Meat, nuts, legumes.
    - **Sources:** Varied diet, often specific foods for specific minerals.
3. **Water (H_2O):**
    - **Composition:** Hydrogen, oxygen.
    - **Sources:** Drinking water, beverages, fruits, vegetables.
    - **Functions:**
        - **Solvent:** Dissolves and transports nutrients, waste products, hormones.
        - **Medium for reactions:** Most biochemical reactions occur in an aqueous environment.
        - **Temperature regulation:** Evaporation of sweat cools the body.
        - **Lubrication:** Component of synovial fluid in joints, saliva.
        - **Forms structures:** Essential for maintaining cell turgidity.
    - **Deficiency:** Dehydration, fatigue, impaired organ function, potentially fatal.
4. **Roughage (Dietary Fibre):**
    - **Definition:** Indigestible plant material (e.g., cellulose) that adds bulk to food.
    - **Sources:** Whole grains, fruits (skins), vegetables, legumes.
    - **Functions:**
        - **Prevents constipation:** Adds bulk to faeces, facilitating bowel movements.
        - **Promotes gut health:** Feeds beneficial gut bacteria.
        - **Helps regulate blood sugar and cholesterol levels:** Slows sugar absorption.
    - **Deficiency:** Constipation, increased risk of bowel disorders.

3.5 Balanced Diet

- **Definition:** A diet that provides all the essential nutrients (carbohydrates, proteins, fats, vitamins, mineral salts, water, roughage) in the correct proportions and adequate amounts to meet an individual's specific needs for growth, energy, repair, & health maintenance.
- **Factors Affecting a Balanced Diet:**
    - **Age:** Growing children and adolescents need more energy and protein.
    - **Gender:** Males generally have higher energy requirements than females.
    - **Activity Level/Occupation:** Physically active individuals or those in demanding jobs require more energy.
    - **Health Status:** Pregnant/lactating women, ill individuals, or those recovering from surgery have specific nutritional needs.
    - **Climate:** Cold climates may require more energy-rich foods for heat production.
    - **Body Size:** Larger individuals generally require more food.
- **Importance of a Balanced Diet:**
    - Ensures optimal growth and development.
    - Provides sufficient energy for daily activities.
    - Maintains a healthy immune system.
    - Prevents deficiency diseases.
    - Promotes overall well-being and reduces the risk of chronic diseases.

3.6 Nutritional Disorders (Brief Overview)

- **Malnutrition:** A condition resulting from a diet that lacks the right balance of nutrients, either too much (overnutrition) or too little (undernutrition).
- **Under-nutrition:**
    - **Protein-Energy Malnutrition (PEM):**
        - **Kwashiorkor:** Primarily protein deficiency, often with adequate calorie intake. Symptoms: oedema (swelling), stunted growth, skin lesions, apathy.
        - **Marasmus:** Severe deficiency of both protein and calories. Symptoms: severe wasting, extreme thinness, stunted growth.
    - **Vitamin Deficiencies:** Scurvy (Vit C), Rickets (Vit D), Night blindness (Vit A), Beriberi (Vit B1), Pellagra (Vit B3).
    - **Mineral Deficiencies:** Anaemia (Iron), Goitre (Iodine).
- **Over-nutrition:**
    - **Obesity:** Excessive accumulation of body fat, usually due to consistent intake of more calories than expended. Leads to increased risk of heart disease, diabetes, joint problems.