Chapter 7: Human Nutrition

1. The Need for Food

- [cite_start]All living organisms require food for several key purposes[cite: 460]. These include:
    - [cite_start]**For growth:** Food provides the necessary substances to create new cells and tissues[cite: 463].
    - [cite_start]**As a source of energy:** Energy from food is essential for chemical reactions that keep organisms alive[cite: 465]. [cite_start]This energy is used for activities like movement, heartbeat, nerve impulses, and maintaining body temperature in mammals[cite: 467, 468].
    - [cite_start]**For repair and replacement:** Food supplies the substances needed to replace damaged tissues and cells, such as red blood cells and skin[cite: 469, 470].

2. Balanced Diets and Nutrients

- [cite_start]A **balanced diet** is one that contains all the essential nutrients in the correct proportions to maintain good health[cite: 473].
- [cite_start]The main nutrients required for a balanced diet are carbohydrates, fats, proteins, vitamins, minerals, fibre (roughage), and water[cite: 474].
- [cite_start]A balanced diet must provide enough carbohydrates and fats for energy, and enough protein for growth and repair[cite: 475, 476]. [cite_start]It also needs to contain adequate vitamins, mineral ions, and water[cite: 477].

3. Classes of Food and Their Functions

- **Carbohydrates:**
    - [cite_start]Include sugars and starch[cite: 544]. [cite_start]Sources are potatoes, bread, rice, and sugary foods like jam and cakes[cite: 544, 546].
    - [cite_start]They are the cheapest and most readily available source of energy, providing about 16-17 kJ of energy per gram[cite: 508, 515, 551].
    - [cite_start]Excess carbohydrates are stored in the liver and muscles as glycogen, or as fat under the skin and in the abdomen[cite: 552, 553].
    - [cite_start]Cellulose in plant cell walls is a carbohydrate that humans cannot digest but is important as dietary fibre (roughage) to keep the digestive system healthy[cite: 554, 555, 556].
- **Fats:**
    - [cite_start]Found in animal products like meat, milk, and butter, and in plant oils from seeds and fruits[cite: 575, 576].

    - [cite_start]Fats provide the most energy, yielding 37 kJ per gram, which is more than double the energy from the same weight of carbohydrates or proteins[cite: 509, 516, 580, 581].
    - [cite_start]They are used to build cell membranes, serve as a long-term energy store, and a layer of fatty tissue under the skin helps to reduce heat loss[cite: 578, 582, 584].
- **Proteins:**
    - [cite_start]Supply the amino acids needed to build body structures[cite: 586]. [cite_start]Good sources include lean meat, fish, eggs, milk, cheese, soybeans, and nuts[cite: 587, 588].
    - [cite_start]Proteins are essential for building cells, tissues (like skin and muscle), and forming parts of cytoplasm and enzymes[cite: 591, 592].
    - [cite_start]They are chemically different from carbohydrates and fats because they contain nitrogen and sometimes sulfur, in addition to carbon, hydrogen, and oxygen[cite: 598].
    - [cite_start]Proteins can also provide energy, giving about 17 kJ per gram[cite: 515, 597]. [cite_start]Excess amino acids are deaminated in the liver and converted to glycogen for storage or energy[cite: 595, 596].
- **Vitamins:**
    - [cite_start]Organic substances required in small quantities for health[cite: 638, 641].
    - [cite_start]They are not used for energy or built into body structures but are vital for chemical reactions in cells, often working with enzymes[cite: 640, 641, 642].
    - [cite_start]**Vitamin C:** Found in citrus fruits and vegetables[cite: 652]. [cite_start]It is needed for healthy skin and gums[cite: 653]. [cite_start]A deficiency causes **scurvy**, with symptoms including bleeding gums, joint pains, and poor wound healing[cite: 654, 655].
    - [cite_start]**Vitamin D:** Can be made by the body when skin is exposed to sunlight[cite: 659]. [cite_start]It is also found in oily fish, butter, milk, and cheese[cite: 665]. [cite_start]Vitamin D helps in the absorption of calcium and phosphorus from the gut[cite: 667]. [cite_start]A deficiency leads to soft bones, causing **rickets** in children and an increased risk of fractures in adults[cite: 669, 670].
- **Mineral Ions:**
    - [cite_start]Elements other than carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus that the body needs[cite: 675, 676].
    - [cite_start]**Iron:** Part of the haemoglobin molecule in red blood cells, which transports oxygen[cite: 678, 679, 688, 689]. [cite_start]A deficiency can lead to **iron-deficiency anaemia**, causing weakness, tiredness, and irritability[cite: 684, 691].
    - [cite_start]**Calcium:** Forms the mineral calcium phosphate, which makes bones and teeth hard[cite: 693]. [cite_start]It is also essential for blood clotting, muscle contraction, and nerve impulse transmission[cite: 694, 695]. [cite_start]A lack of calcium can lead to soft

bones (rickets, linked to vitamin D deficiency), brittle nails, and muscle cramps[cite: 701, 702, 703].

- **Dietary Fibre (Roughage):**
  - [cite_start]The indigestible cellulose from plant cell walls[cite: 708].
  - [cite_start]It increases the bulk of food in the colon, helps retain water, and softens faeces, which aids in preventing constipation and keeps the colon healthy[cite: 711, 712, 713].
  [cite_start]Good sources include vegetables, fruit, and wholemeal bread[cite: 715].
- **Water:**
  - [cite_start]Makes up about 70% of most tissues and is a vital component of cytoplasm and body fluids like blood[cite: 717, 718].
  - [cite_start]It acts as a solvent and transport medium for digested food, salts, vitamins, and waste products[cite: 719, 720].
  - [cite_start]Water is also a reactant and solvent in many chemical reactions, including digestion[cite: 721, 722].
  - [cite_start]It is lost through evaporation, sweating, urination, and breathing, and must be replaced through diet[cite: 723].

4. The Alimentary Canal and Digestion

- [cite_start]The alimentary canal is the tube through which food passes, where it is digested, and its soluble products are absorbed[cite: 786, 787].
- The five main processes are:
  - [cite_start]**Ingestion:** Taking food and drink into the body through the mouth[cite: 941, 982].
  - [cite_start]**Digestion:** The breakdown of large, insoluble food molecules into small, soluble molecules[cite: 942, 945, 946]. This is done by a combination of physical and chemical digestion.
  - [cite_start]**Absorption:** The movement of nutrients from the intestines into the blood[cite: 943].
  - [cite_start]**Assimilation:** The uptake and use of nutrients by body cells[cite: 944, 1029].
  - [cite_start]**Egestion:** The passing out of undigested or unabsorbed food as faeces[cite: 945, 1050].
- **Physical Digestion:**
  - [cite_start]Involves breaking down food into smaller pieces without changing the food molecules chemically[cite: 829].
  - [cite_start]Occurs mainly in the mouth, where teeth chew food[cite: 830].
  - [cite_start]The muscular walls of the stomach also churn and squeeze food, mixing it with gastric juice to increase its surface area for enzymes to work on[cite: 895, 896, 897].

    - [cite_start]**Bile salts** emulsify fats, breaking them into small droplets with a large surface area, which is a form of physical digestion[cite: 919, 920].
- **Chemical Digestion:**
    - [cite_start]The process by which large, insoluble molecules are broken down into small, soluble molecules using digestive enzymes[cite: 945, 1310].
    - [cite_start]**Mouth:** Salivary amylase begins the digestion of starch, breaking it down into a smaller sugar called maltose[cite: 989, 1075].
    - [cite_start]**Stomach:** Glands in the stomach lining produce gastric juice containing a protease enzyme, pepsin[cite: 998]. [cite_start]Pepsin breaks down proteins into peptides and works best in the acidic conditions created by hydrochloric acid[cite: 999, 1000, 1001, 1084, 1085]. [cite_start]The acid also kills harmful bacteria[cite: 1001].
    - [cite_start]**Small Intestine (Duodenum):** Pancreatic juice and bile are released here[cite: 1004].
        - [cite_start]Pancreatic juice contains several enzymes: protease (trypsin) for proteins, pancreatic amylase for starch, and lipase for fats[cite: 1006, 1007].
        - [cite_start]Bile contains sodium hydrogencarbonate, which neutralizes the acidic food mixture from the stomach to create an alkaline environment suitable for the pancreatic enzymes[cite: 1017, 1018, 1094, 1095].
- **Absorption and Assimilation:**
    - [cite_start]Most nutrient absorption occurs in the ileum, the second part of the small intestine[cite: 1024, 1119].
    - [cite_start]The ileum is well-suited for absorption because it has a large surface area due to its length, circular folds, and thousands of tiny, finger-like projections called **villi**[cite: 1123, 1124]. [cite_start]The cells on the surface of the villi also have **microvilli**, which further increase the surface area[cite: 1126].
    - [cite_start]Glucose and amino acids are absorbed into the blood capillaries within the villi[cite: 1128, 1318].
    - [cite_start]Fatty acids and glycerol are absorbed into the lacteals, which are part of the lymphatic system[cite: 1134, 1135, 1318].
    - [cite_start]Assimilation is the process where cells take up and use these absorbed nutrients for energy, growth, and repair[cite: 944, 1028, 1029].
- **Egestion:**
    - [cite_start]The large intestine absorbs most of the remaining water from the undigested material[cite: 1047, 1316]. [cite_start]The semi-solid waste, called faeces, is stored in the rectum and then passed out of the body through the anus in a process called egestion[cite: 1048, 1050].
    - [cite_start]Egestion should not be confused with excretion, as faeces are not a product of metabolism[cite: 1051, 1052].