Human Nutrition and the Digestive System

Need for food:

- Growth - provide substances for synthesis of cells and tissues.
- Energy - food is broken down to provide energy for chemical reactions and various activities.
- Replacement of damaged tissues - provides substances to replace and repair tissues and cells.

Balanced Diet:

- Contains the correct quantities of all nutrients.
- Enough carbohydrates and fats to meet energy requirements.
- Enough proteins to make new cells for growth and repair.
- Vitamins, minerals, salts, water, and fibre are also important.

Energy Requirements:

- Cheapest energy - carbohydrates.
- Most energy - fats.
- Proteins give the same amount of energy as carbohydrates but are more expensive.
- Total energy should be sufficient to:
    - Maintain internal body processes
    - Maintain body temperature
    - Sustain work and other activities
- 1g of carbs/protein - 16/17 kJ
- 1g of fat - 37 kJ
- Average energy required - 12,000 kJ
- Energy requirements depend on age, gender, occupation, activity.
- Females have lower energy requirements due to lower body mass, different physical demands.
- Energy requirements increase with age until metabolism begins to slow down.
- 2400 kJ used in sleep - basal metabolism.
- Basal metabolism - circulation, breathing, brain function, other essential processes.
- Excess food is stored as glycogen in the liver or fat below the skin.

Protein Requirements:

- Supply amino acids which are needed to build up body structures.
- 0.57g of protein needed for every kg of body weight.

Vegetarian and Vegan diets:

- Relatively less protein in plants.
- Cereals, peas, beans, nuts, should be included in a diet.

Special Needs:

<u>Pregnancy:</u>

- Metabolism adapts to a baby's demands if diet is adequate.
- Calcium, protein, vitamin D, iron, folic acid is required.
- Calcium and vitamin D needed for bone development.
- Protein needed for building tissues.
- Iron is needed for haemoglobin in blood.

<u>Lactation:</u>

- Production of breast milk for feeding babies.
- Proteins, vitamins, and calcium are needed.

<u>Growing children:</u>

- Need less food than adults, but more in proportion to body weight.
- Calcium, iron, vitamin D, vitamin A needed.

Malnutrition:

- Not enough food or too much food of the wrong kind.
- If food isn’t enough tissues are broken down for the energy to stay alive.
- Causes weight loss, muscle wastage, starvation and weakness.
- Extreme slimming diets cause anorexia nervosa.
- Too much fat leads to coronary heart disease.

- Fatty deposits block coronary arteries resulting in blood clots and reduce blood supply to the heart causing angina and heart attacks.
- Lack of minerals causes deficiency diseases
    - Iron - anaemia
    - Vitamin D, calcium - rickets
    - Vitamin C - scurvy

Kwashiorkor:

- Caused by protein deficiency.
- Symptoms - pot belly, change in hair colour, weakness, lethargy, enlarged fatty liver.
- Also caused by infection, plant toxins, digestive failure, psychological problems.
- Cure/prevention - consuming dried skimmed milk as a protein source.
- Eg. of PEM-Protein Energy Malnutrition

Marasmus:

- Caused by protein and energy deficiency.
- Acute form of malnutrition.
- Occurs in infants below age 1.
- Symptoms - reduced fat and muscle, thin skin which hangs in folds, prominent ribs.
- Treatment - revision of energy rich balanced diet.

World Food:

- Green revolution increased food production.
- High yielding varieties of crops used.
- High input of fertilizers and pesticides.
- Since 1984, yields are not rising fast enough for population increase.
- Loss of farmland due to urbanisation and erosion.
- 15% of the world population is undernourished.
- GM seeds are a possible solution. However, there are concerns about safety, gene transfer to plants and animals, allergies, cost, and pesticides.
- Crops suited to the region should be grown.
- Dry areas - millet, and sorghum.
- Cash crops - foreign currency but no food value.
- Surge in palm oil production resulted in deforestation.
- Food crops should be grown instead of cash crops.
- Non sustainable farming practices lead to erosion.
- Over irrigation leads to an increase in soil salinity.
- Conservation of land, water, and energy is essential.
- Vitamin and mineral supplements should be provided to malnourished people.

Western Diets:

- No shortage of food.
- Too much of the wrong kind of food.
- Refined sugar (sucrose):
    - Concentrated source of energy.
    - More than necessary is consumed.
    - Major cause of tooth decay.
    - Causes obesity.
- Fats:
    - Causes plaques in arteries causing coronary heart disease and stroke.
    - Plaques - lipids and cholesterol combined with protein.
    - Animal fat - saturated.
    - Plant oils - unsaturated (better, less likely to cause plaques).
- Fibre:
    - Processed food had inadequate fibre.
    - Leads to constipation.
    - Lack of fibre causes overeating.
    - Fibre protects intestines from cancer or other disorders.

Overweight and Obesity:

- Different degrees of the same disorder.

- Excess food is stored as fat droplets under the skin or in the abdomen.
- Obesity - more likely for high blood pressure, coronary heart disease, diabetes.
- There may be a genetic predisposition.

Carbs:

- Sugar and starch - important carbs.
- Starch - potatoes and bread.
- Sugar - added to food as sucrose.
- Glucose and fructose - obtained from fruits and some vegetables.
- Cheapest, readily available energy.
- Contains carbon, hydrogen, and oxygen.
- Carbs are oxidised forming CO_2 and H_2O
- Excess carbohydrates are converted to glycogen or fat.
- Glycogen - is stored in the liver, muscles.
- Fats - are stored in the abdomen, around kidneys, under skin.
- Cellulose in cell walls are important for fibre.

Fats:

- Fats and oils are collectively known as lipids.
- Animal fats - milk, meat, cheese, egg yolks.
- Plant fats - oils in fruits and seeds.
- Used to form part of the cell membrane and other membrane systems.
- Oxidised into CO_2 and H_2O.
- Can be stored.
- Adipose tissue forms an insulation layer under the skin.

Protein:

- Animal - lean meat, fish, egg, milk.
- Plant - soybeans, pumpkin seeds, nuts.
- Provides chemical substances to build cells and tissues.
- Long amino acid chains.
- Digested into amino acids which are absorbed into the bloodstream.
- Amino acids are used to build proteins for cytoplasms, enzymes, etc.
- Amino acids cannot be stored.
- Liver removes amino (NH_2) groups to form glycogen for energy.
- Contains carbon, hydrogen, oxygen, nitrogen, and sometimes, sulphur or phosphorus.

Vitamins:

- Not digested for energy.
- Not built into body structures.
- Essential in small quantities.
- Needed for chemical reactions in association with enzymes.
- Lack of vitamins causes deficiency diseases.
- Two classes - fat soluble and water soluble.
- Fat soluble vitamins are found in animal fats, vegetable oils.
- Water soluble vitamins are found in green leaves, fruits, and cereals.
- Vitamin C
  - Aka ascorbic acid.
  - Found in citrus, tomatoes, green vegetables.
  - Prevents scurvy in which collagen fibres don’t form properly causing bleeding under skin, at joints, and gums.
- Vitamin D
  - Aka calciferol.
  - Butter, milk, cheese, egg yolk, liver.
  - Prevents rickets.
  - Helps in the absorption of calcium ions and the deposition of calcium in bones.
  - Deficiency can lead to rickets in children and osteomalacia in adults.
  - The body can manufacture vitamin D in sunlight.

Minerals:

- Iron
    - Contained in haemoglobin.
    - When RBCs die, the iron is stored in the liver. However, some iron is lost and needs to be replaced.
    - Iron is lost as bilirubin in the faeces.
    - Iron is found in liver, kidney, eggs, groundnuts, brown rice, spinach.
    - Iron deficiency causes anaemia (weakness, exhaustion, irritability.)
- Calcium
    - Found in bones and teeth, blood plasma.
    - Calcium phosphate makes bones and teeth hard.
    - Helps in the clotting of blood.
    - Needed for muscle contractions and the transmission of nerve impulses.
    - Found in milk, cheese, hard water.
    - Many calcium salts are insoluble in water and hence vitamin D and bile salts are needed for its absorption.

Fibre

- Found in the cell wall of plants- cellulose
- Cannot be digested
- Adds bulk to colon contents
- Helps faeces retain water
- Prevents constipation, keeps the colon healthy
- Found in fruits, vegetables, etc

Water

- Forms 70% of tissues
- Forms majority of cytoplasm, blood, lymph, tissue fluid
- Acts as a transport medium and as a solvent for digested food and excretory products.
- Digestion requires water to break down insoluble food molecules
- Essential as a reactant and a solvent

DIGESTIVE SYSTEM

- Ingestion - taking in of substances such as food and drink through the mouth.
- Mechanical digestion - breakdown of food into smaller pieces without chemical change.
- Chemical digestion - breakdown of large insoluble molecules into smaller soluble molecules.
- Absorption - movement of food molecules and ions through intestinal wall, into blood.
- Assimilation - movement of digested food molecules into the cell where they are used, becoming a part of the cell.
- Egestion - passing of undigested, unabsorbed food through the anus as faeces.

Alimentary Canal:

- Tube running through the body where food is digested.
- Lining consists of epithelial cells that are worn away by the movement of food and need to be replaced.
- Cells in the lining produce mucus which protects from wear and tear and attack from digestive enzymes.
- Few enzymes are produced in the lining.
- Many blood vessels are present in the walls of the canal, which provides oxygen, removes CO2, absorbs digested food.

Mouth
↓
Oesophagus
↓
Stomach
↓
Small intestine

↓
Large intestine
↓
Anus

Mouth: (buccal cavity)

- Mechanical digestion - chewing aka mastication.
- Types of teeth
    - Incisors - chisel shaped for biting.
    - Canines - slightly pointed with similar function as incisors.
    - Premolars - bicuspid with 1 or 2 roots for tearing and grinding.
    - Molars - 4 or 5 cusps with 2 or 3 roots for chewing and grinding.
- **Tooth structure**
    - Crown - visible above the gum line.
    - Root - embedded in the jaw bone.
    - Enamel - hardest tissue in the body. Outermost layer is made up of calcium salts, produced by tooth forming cells.
    - Dentine - forms the majority of the tooth. Softer than enamel, harder than bone. Contains a series of fine canals. Made of calcium salts deposited on collagen fibres.
    - Pulp cavity - contains tooth producing cells, blood vessels, and nerves. Sensitivity is experienced when the pulp cavity is exposed.
    - Cement - enables root to grip to bony socket in the jaw.

- **Dental Decay:**
    - Bacteria feed on sugar and produce acid, dissolving calcium salts in the enamel.
    - Small holes (cavities) form in the enamel.
    - The dentine is exposed and also dissolved.
    - Acid irritates nerve endings causing toothache.
    - The cavity has to be cleaned and filled otherwise bacteria create abscess requiring tooth extraction.
    - Critical pH - pH below which enamel is attacked.

Salivary Glands:

- 3 glands
    - Parotid (cheek)
    - Submandibular (under jaw)
    - Sublingual (under tongue)
- Saliva contains water, mucus, and salivary amylase.
- Salivary amylase - enzyme, converts starch to maltose.
- Chewing breaks food into pieces that can be swallowed and combines it with saliva forming bolus.
- Functions of saliva
    - moisten/lubricate food
    - Solvent for hydrolysis
    - Formation of bolus
    - Starch digestion

Oesophagus:

- The epiglottis is a flap of cartilage that guides the food into the gullet and ensures it doesn't go into the windpipe.
- Once food reaches the back of the mouth, swallowing becomes a reflex action.
- Peristalsis is a wave of contractions that push the food through the alimentary canal.
- A series of contractions, one below the other take place.
- Peristalsis helps in mechanical digestion as the contractions compress and crush the bolus further.
- 2 types of muscles are involved -

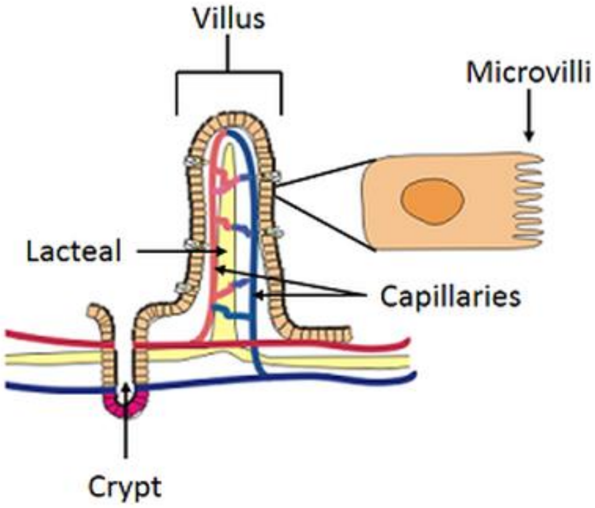
    - Circular - run around the canal.
    - Longitudinal - run along the length of the canal.
- Longitudinal muscles contract ahead of the bolus.
- Circular muscles contract behind the bolus.
- Circular and longitudinal muscles work in opposite ways. One contracts while the other relaxes.

Stomach:

- The pyloric sphincter controls the flow of bolus into the duodenum.
- The stomach stores food, turns it into a liquid called chyme and releases it into the small intestine.
- The peristaltic action of the muscles in the stomach churn and squeeze the food, breaking it down further.
- Stomach contains HCl - maintains pH for pepsin, kills foreign particles.
- Gastric juice is secreted by glands in the walls of the stomach.
- Rennin is present in children to break down milk proteins.

Small Intestine:

- It is alkaline, because of hydrogen carbonate in bile.
- Enzymes lipase, pancreatic amylase, trypsin are present in pancreatic juice and break down nutrients.
- Carbohydrates - glucose.
- Protein - peptides.
- Lipids - fatty acids and glycerol.
- Trypsin is produced in inactive form - activated in duodenum.
- Almost all absorption in ileum:
    - Long
    - Has increased surface area - villi, microvilli
    - Thin epithelial lining.
    - Dense network of blood capillaries.
- Nutrients move into the villi through active transport.
- Water moves in through osmosis.
- The nutrients are absorbed into the capillary network in the villi.
- The capillaries join to form veins which join to form the hepatic portal vein.
- The hepatic portal vein carries absorbed food to the liver.
- These absorbed products may be stored/ altered in the liver.



- Fatty acids and glycerol are absorbed into the lymphatic system through the lacteal.
- Fat soluble vitamins enter the cell in fat droplets.
- Cell division occurs in the crypts to replace worn epithelial cells.

Liver:

Functions:

- Bile Production:
    - Yellow-green colour caused by pigments bilirubin and biliverdin.
    - Stored in gall bladder.
    - No enzymes.

  - Alkaline due to sodium hydrogen carbonate.
  - Bile salts emulsify fats allowing lipase to digest it.
- Regulation of blood sugars.
- Detoxification.
- Storage of iron:
  - Haemoglobin is broken down in the liver to produce bile pigments.
  - Iron is stored in the liver.
- Manufacture of plasma proteins
- Storage of vitamins
- Deamination - removal of nitrogen containing part of amino acids to form urea, followed by release of energy . Nitrogen is needed for metabolic activities and growth.

Large Intestine:

- Mixture of water, undigested matter, cellulose, fibre, mucus, dead cells.
- Bacteria in the colon digest part of fibre to form fatty acids.
- Fatty acid, bile salts, and water are absorbed.
- Waste (semi-solid) - faeces.
- Passed into rectum, expelled through anus (ejection or defecation)

Cholera:

- Causative organism - vibrio cholerae (bacteria)
- Water borne disease.
- Multiply in the small intestine, invade epithelial cells.
- Release toxins, chloride ions making solution hypertonic.
- Water is drawn into the small intestine from surrounding cells.
- Causes acute diarrhoea and dehydration which can lead to kidney failure.
- Cure -
  - rehydration, restoration of salts - ORS
  - Use of antibiotic, eg. tetracycline
- Prevention -
  - Purify water
  - Good sanitation
  - Proper sewage treatment

Assimilation:

- Cells absorb and use glucose, fats, amino acids.

  Glucose:
  - Oxidised to carbon dioxide and water.
  - Provides energy for chemical processes such as building up of proteins, muscle contraction, electrical changes in nerves.

  Fats:
  - Built into cell membranes and other cell structures.
  - Oxidised into carbon dioxide and water for energy.

  Amino Acids:
  - Built up into proteins with aid of enzymes.
  - Amino acids not used to build up proteins are converted into glycogen in the liver
  - Proteins - blood, enzymes, membranes and other cell structures.

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