Biology

DIGESTIVE SYSTEM

Chapter

FOOD AND ITS COMPOSITION

Food provides us the necessary fuel for our daily activities. These foods are broken down by digestive processes, releases energy and transported to supply energy to maintain body growth, all body processes, body temperature and activity. Foods differ markedly in the amount of nutrients they contain. They can be classified on the basis of their composition as:

- Carbohydrates

  They are compounds containing carbon, hydrogen and oxygen and have a general formular $C_x(H_20)_y$. It is the major component of our food as it all energy need by our cells. The main sources are rice, wheat, maize, potato, banana, sugar etc. Carbohydrates are divided into

  Monosaccharides are simple sugars consisting of three or more carbon atoms. Our body digests them quickly and easily e.g. Ribose,glucose, fructose and galactose

  Disaccharides are formed by the union of two monosaccharids. (These takes longer to be digested than Monosaccharides. Found in foods like bread, noodles, rice, vegetables.)

  Maltose (malt sugar) = glucose+ glucose

  Lactose (Milk sugar) = glucose+ galactose

  Sucrose (cane sugar) = glucose+ fructose.

  Polysaccharides are made up of large number of monosaccharids units(300 to over 1000). E.g. starch, cellulose in plants , glycogen, chitin in animals. The nutrional role of carbohydrate is the production of energy. These are main sources of blood glucose and stored in tissues as glycogen in liver and muscles for further use when necessary.

- Lipids (Fats)

  These are a group of fatty substances found in all living organisms and these contain less amount of oxygen than in carbohydrates but yield twice the amount of energy than carbohydrates. Fats are not soluble in water but in alcohol, ether, or organic solvents. Fat is more suitable as stored food, insulates our body from cold, provides cushioning effects for our organs, and helps the fat soluble vitamins to be transported through when they are needed. The important sources are fatty acids and glycerol. Fatty acids can be grouped into saturated fatty acid and unsaturated fatty acids. These are designated as saturated or unsaturated, depending on whether the chemical bonds between the carbon atoms of the fat molecules contain all the hydrogen atoms they are capable of holding (saturated) or have capacity for additional hydrogen atoms (unsaturated). Saturated fats generally are solid at room temperature; unsaturated and polyunsaturated fats are liquids. Unsaturated fats may be converted to saturated fats by adding hydrogen atoms in a process known as hydrogenation. Saturated fatty acids come from animal foods like meat,

milk, cheese, and some oils that come from plants. Unsaturated fatty acids are different - they come from plants and fish. Together, these two substances are grouped and called the fat content in food.

- **Proteins**

Proteins are complex compounds formed from about 20 amino acids which are needed for the synthesis of protoplasm. These amino acids are composed of carbon, hydrogen, oxygen, nitrogen and sometimes sulphur. These are essential for body growth. Some of the amino acids are not produced in the animal body and it must be supplied with food. These are called essential amino acids and the rest are non essential amino acids. The deficiency causes Kwashiorkor in children below 5 years who instead of mother's milk take mainly carbohydrate diet. If the mother's milk is replaced to children below 1 year it causes Marasmus.

- **Vitamins**

These organic substances of various types which cannot be synthesised in sufficient quantities by the body and have to be supplied in its diet. Vitamins can be classified into water soluble vitamins and fat soluble vitamins. Fat soluble vitamins are stored in our body and water soluble do not get stored as much in our body. Instead, they travel through your blood stream. The deficiency of vitamins causes various diseases. A detailed list containing the sources, benefits and deficiency of vitamins are given below:

VITAMIN	FOOD SOURCES	HEALTH BENEFIT	DEFICIENCY
Fat Soluble			
A (Retinol)	Eggs, butter, whole milk, vegetables and liver.	Component of light-sensitive pigments in eye, epithelial tissue maintenance	Night blindness, Xerophthalmia or dry eye, extremely dry skin (Dermatosis)
D (Calciferol)	Fish, egg yolks and the rays of the sun	Calcium absorption, bone formation	Rickets (bone deformities) in children, Osteomalacia in Adult.
E (Tocopherol)	Margarine, seeds, green leafy vegetables	Protects fatty acids and cell membranes from oxidation	Sterility

K	Green leafy vegetables	Blood clotting	Uncontrolled bleeding
Water Soluble			
B1 (Thiamine)	Organ meats, pork, grains, legumes	Carbohydrate metabolism, nerve and heart function	Beriberi (weakened heart, edema, nerve and muscle degeneration
B2 (Riboflavin)	Milk products, liver, eggs, grains, legumes	Energy metabolism	Aniboflavinosis-Eye irritation, inflammation and breakdown of skin cells
B3 (Niacin or Nicotinic Acid)	Liver, lean meats, grains, legumes	Oxidation-reduction reactions in cellular respiration	Pellegra (skin and gastrointestinal disorders, nerve inflammation, mental disorders)
B5 (Pantothenic Acid)	Milk products, liver, eggs, grains, legumes	Energy metabolism	Fatigue, loss of coordination
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B6 (Pyridoxine)	Whole-grain cereals, vegetables, meats	Amino acid metabolism	Convulsions, irritability, kidney stones
B12 (Cobalamin)	Red meats, eggs, dairy products	Nucleic acid production	Pernicious anemia, neurological disorders

Biotin	Meats, vegetables, legumes	Fat synthesis and amino acid metabolism	Depression, fatigue, nausea
C (Ascorbic Acid)	Citrus fruits, green leafy vegetables, tomatoes	Collagen formation in teeth, bone, and connective tissue of blood vessels; may help in resisting infection	Scurvy (breakdown of skin, blood vessels, and teeth
Folic Acid	Whole-wheat foods, green vegetables, legumes	Nucleic acid metabolism	Anaemia, diarrhoea

❒ Minerals

Mineral salts are needed in very small quantities but very essential for the functioning of the body. Blood contains 0.9 per cent salt, most of which is sodium chloride, very essential for maintaining osmotic pressure.

Anaemia is caused due to iron deficiency and characterised by deficiency of haemoglobin in red blood cells.

Hypokalemia is caused by loss of potassium and characterised by kidney damage, rise in hear beat, paralysis of muscles.

Hyponatremia is due to the increased loss of sodium which leads to dehydration, low blood pressure and loss of body weight.

Simple Goitre is caused by deficiency of iodine which regulates the secretion of the thyroxine from the thyroid gland. It causes the increased production of thyroid stimulating hormone which brings about the enlargement of gland.

MINERAL	FOOD SOURCES	HEALTH BENEFIT	DEFICIENCY
Major			
Calcium	Milk, cheese, dried legumes, vegetables	Bone and teeth formation, blood clotting, and nerve transmission	Rickets, osteoporosis, convulsions
Chlorine	Foods containing salt; some vegetables and fruits	Fluid regulation between cells or cell layers	Acid-base imbalance in body fluids (very rare)
Magnesium	Whole grains; green, leafy vegetables	Enzyme activation, protein synthesis	Growth failure, behaviour problems, spasms
Phosphorus	Milk, cheese, yogurt, fish, poultry, meats,	Bone and teeth formation, acid-base balance	Weakness, loss of calcium
Potassium	Bananas, leafy vegetables, potatoes, cantaloupe, milk, meats	Acid-base balance and fluid balance maintenance, nerve transmission	Muscle cramps, mental confusion, loss of appetite, irregular cardiac rhythm - hypokalamia

Sulphur	Fish, poultry, meats	Acid-base balance maintenance and liver function	Disorders unlikely if body gets small amounts needed
Sodium	Table salt	Acid-base balance and body water balance maintenance, nerve function	Hyponatremia-Muscle cramps, reduced appetite, mental apathy
Chromium	Legumes, cereals, organ meats, fats, vegetable oils, meats, whole grains	Glucose metabolism	Adult onset diabetes
Copper	Meats, drinking	Red blood cell	Anaemia, impairs
	water	formation	bone and nervous tissue development
Fluorine	Drinking water, tea, seafood	Bone structure maintenance, decay-resistant teeth	Osteoporosis; tooth decay
Iodine	Salt-water fish, shellfish, dairy products, vegetables, iodized salt	Component of thyroid hormone	Enlarged thyroid (goitre)
Iron	Lean meats, eggs, whole grains, green leafy vegetables, legumes	Haemoglobin formation in blood; energy metabolism	Anaemia
Selenium	Seafood, meat, grains	Prevents breakdown of fats and other body chemicals	Anaemia
Zinc	Lean meat, whole-grain breads and cereals, dried beans, seafood	Component of many enzymes included in digestion, cell repair, sexual reproduction	Growth failure, small sex glands, delayed wound healing

❐ Enzymes

Enzymes are biological catalysts. These are the secretions of digestive gland with ducts. These are composed of amino acids(proteins); it t generally accelerate biochemical reaction by reducing the energy requirement, however certain substances called inhibitors slow down the rate of enzymatic reaction. These are specific in their action and on a particular substrate only. Each enzyme has its own pH and temperature at which it works. It show maximum activity at body temperature known as optimal temperature. Some enzymes are formed in an inactive form called the precursors or zymogens and are later activated by a number of agents, including co-enzymes or co factors.

NUTRITION

Plants and animals do not obtain food by the same processes. Plants and some bacteria have the green pigment chlorophyll to help synthesize food, while animals, fungi and other bacteria depend on other organisms for food. Based on this, there are two main modes of nutrition: autotrophic (Plant Nutrition) and heterotrophic

Heterotrophic nutrition

The word 'heterotroph' is derived from two Greek words—heteros (other) and trophe (nutrition). Unlike autotrophs, which manufacture their own food, heterotrophic organisms obtain food from other organisms. As heterotrophs depend on other organisms for their food, they are called consumers. All animals and non-green plants like fungi come under this category.

Consumers which consume herbs and other plants are called herbivores, and those which consume animals are called carnivores. After taking complex organic materials as food, heterotrophs break them into simpler molecules with the help of biological catalysts, or enzymes, and utilize them for their own metabolism.

Depending upon the mode of living and the mode of intake of food, heterotrophs may be parasitic, saprophytic or holozoic.

Parasitic

Parasitic organisms, or parasites, live on or inside other living organisms, called hosts, and obtain their food from them. The host does not get any benefit from the parasite. Different parasites, like Cuscuta (akash-bel), Cassytha (amar-bel), hookworms, tapeworms, leeches, etc., have different modes of feeding, depending upon habit, habitat and modifications.

Saprophytic

Saprophytic organisms, or saprophytes, derive their food from dead organisms. They secrete enzymes that are released on food material outside their body. These enzymes break down complex food into simple forms. Common examples of saprophytes are fungi (moulds, mushrooms, yeasts) and many bacteria.

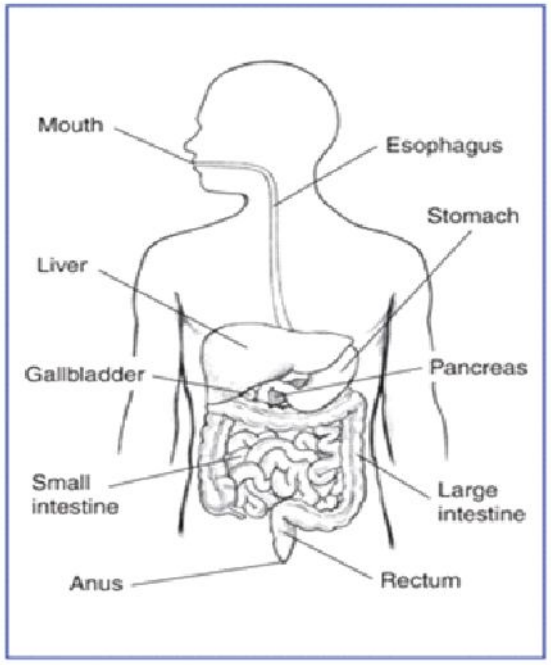
Holozoic

In holozoic nutrition complex organic substances are ingested (taken in) without their being degraded or decomposed. After intake, such food is digested by enzymes produced within the organism. Digested food is absorbed into the body and the undigested product is egested (expelled) from the body. This kind of nutrition is found mainly in non-parasitic animals—simple ones like Amoeba and complex ones like human beings.

DIGESTION IN HUMANS

The digestive system is a group of organs working together to convert food into energy and basic nutrients to feed the entire body. Food passes through a long tube inside the

body known as the alimentary canal or the gastrointestinal tract (GI tract). The alimentary canal is made up of the oral cavity, pharynx, oesophagus, stomach, small intestines, and large intestines. In addition to the alimentary canal, there are several important accessory organs that help your body to digest food but do not have food pass through them. Accessory organs of the digestive system include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.



Physiology

To achieve the goal of providing energy and nutrients to the body, six primary processes of the digestive system include:

- Ingestion of food

  The first function of the digestive system is ingestion, or the intake of food. The mouth is responsible for this function, as it is the orifice through which all food enters the body. The mouth and stomach are also responsible for the storage of food as it is waiting to be digested. This storage capacity allows the body to eat only a few times each day and to ingest more food than it can process at one time.

- **Secretion** of fluids and digestive enzymes

- In the course of a day, the digestive system secretes around 7 liters of fluids. These fluids include saliva, mucus, hydrochloric acid, enzymes, and bile. Saliva moistens dry food and contains salivary amylase, a digestive enzyme that begins the digestion of carbohydrates. Mucus serves as a protective barrier and lubricant inside of the GI tract. Hydrochloric acid helps to digest food chemically and protects the body by killing bacteria present in our food. Enzymes are like tiny biochemical machines that disassemble large macromolecules like proteins, carbohydrates, and lipids into their smaller components. Finally, bile is used to emulsify large masses of lipids into tiny globules for easy digestion.

- **Mixing and movement** of food and wastes through the body

  The digestive system uses 3 main processes to move and mix food:

  Swallowing

  It is the process of using smooth and skeletal muscles in the mouth, tongue, and pharynx to push food out of the mouth, through the pharynx, and into the oesophagus.

  Peristalsis

  It is a muscular wave that travels the length of the Gastro-Intestinal (GI) tract, moving partially digested food a short distance down the tract. It takes many waves of peristalsis for food to

travel from the oesophagus, through the stomach and intestines, and reach the end of the GI tract.

Segmentation

It occurs only in the small intestine as short segments of intestine contract like hands squeezing a toothpaste tube. Segmentation helps to increase the absorption of nutrients by mixing food and increasing its contact with the walls of the intestine.

- **Digestion** of food into smaller pieces

It is the process of turning large pieces of food into its component chemicals. Mechanical digestion is the physical breakdown of large pieces of food into smaller pieces. This mode of digestion begins with the chewing of food by the teeth and is continued through the muscular mixing of food by the stomach and intestines. Bile produced by the liver is also used to mechanically break fats into smaller globules. While food is being mechanically digested it is also being chemically digested as larger and more complex molecules are being broken down into smaller molecules that are easier to absorb. Chemical digestion begins in the mouth with salivary amylase in saliva splitting complex carbohydrates into simple carbohydrates. The enzymes and acid in the stomach continue chemical digestion, but the bulk of chemical digestion takes place in the small intestine thanks to the action of the pancreas. The pancreas secretes an incredibly strong digestive cocktail known as pancreatic juice, which is capable of digesting lipids, carbohydrates, proteins and nucleic acids. By the time food has left the duodenum, it has been reduced to its chemical building blocks—fatty acids, amino acids, monosaccharides, and nucleotides.

- **Absorption of nutrients**

Once food has been reduced to its building blocks, it is ready for the body to absorb. Absorption begins in the stomach with simple molecules like water and alcohol being absorbed directly into the bloodstream. Most absorption takes place in the walls of the small intestine, which are densely folded to maximize the surface area in contact with digested food. Small blood and lymphatic vessels in the intestinal wall pick up the molecules and carry them to the rest of the body. The large intestine is also involved in the absorption of water and vitamins B and K before faeces leave the body.

- **Excretion of wastes**

The final function of the digestive system is the excretion of waste in a process known as defecation. Defecation removes indigestible substances from the body so that they do not accumulate inside the gut. The timing of defecation is controlled voluntarily by the conscious part of the brain, but must be accomplished on a regular basis to prevent a backup of indigestible materials.

ANATOMY

Mouth

Food begins its journey through the digestive system in the mouth, also known as the oral cavity. Inside the mouth are many accessory organs that aid in the digestion of food—the tongue, teeth, and salivary glands. Teeth chop food into small pieces, which are moistened

by saliva before the tongue and other muscles push the food into the pharynx.

Teeth

The teeth are 32 small, hard organs found along the anterior and lateral edges of the mouth. Each tooth is made of a bone-like substance called dentin and covered in a layer of enamel—the hardest substance in the body. Teeth are living organs and contain blood vessels and nerves under the dentin in a soft region known as the pulp. The teeth are designed for cutting and grinding food into smaller pieces.

Tongue

The tongue is located on the inferior portion of the mouth just posterior and medial to the teeth. It is a small organ made up of several pairs of muscles covered in a thin, bumpy, skin-like layer. The outside of the tongue contains many rough papillae for gripping food as it is moved by the tongue's muscles. The taste buds on the surface of the tongue detect taste molecules in food and connect to nerves in the tongue to send taste information to the brain. The tongue also helps to push food toward the posterior part of the mouth for swallowing.

Salivary Glands

Surrounding the mouth are 3 sets of salivary glands. The salivary glands are accessory organs that produce a watery secretion known as saliva. Saliva helps to moisten food and begins the digestion of carbohydrates. The body also uses saliva to lubricate food as it passes through the mouth, pharynx, and oesophagus.

Pharynx

The pharynx, or throat, is a funnel-shaped tube connected to the posterior end of the mouth. The pharynx is responsible for the passing of masses of chewed food from the mouth to the oesophagus. The pharynx also plays an important role in the respiratory system, as air from the nasal cavity passes through the pharynx on its way to the larynx and eventually the lungs. Because the pharynx serves two different functions, it contains a flap of tissue known as the epiglottis that acts as a switch to route food to the oesophagus and air to the larynx.

Oesophagus

The oesophagus is a muscular tube connecting the pharynx to the stomach that is part of the upper gastrointestinal tract. It carries swallowed masses of chewed food along its length. At the inferior end of the oesophagus is a muscular ring called the lower oesophageal sphincter or cardiac sphincter. The function of this sphincter is to close of the end of the oesophagus and trap food in the stomach.

Stomach

The stomach is a muscular sac that is located on the left side of the abdominal cavity, just inferior to the diaphragm. In an average person, the stomach is about the size of their two fists placed next to each other. This major organ acts as a storage tank for food so that the body has time to digest large meals properly. The stomach also contains hydrochloric acid and digestive enzymes that continue the digestion of food that began in the mouth.

Small Intestine

The small intestine is a long, thin tube about 1 inch in diameter and about 10 feet long that is part of the lower gastrointestinal tract. It is located just inferior to the stomach and takes up most of the space in the abdominal cavity. The entire small intestine is coiled like a hose and the inside surface is full of many ridges and folds. These folds are used to maximize

the digestion of food and absorption of nutrients. By the time food leaves the small intestine, around 90% of all nutrients have been extracted from the food that entered it.

Liver and Gallbladder

The liver is a roughly triangular accessory organ of the digestive system located to the right of the stomach, just inferior to the diaphragm and superior to the small intestine. The liver weighs about 3 pounds and is the second largest organ in the body. The liver has many different functions in the body, but the main function of the liver in digestion is the production of bile and its secretion into the small intestine. The gallbladder is a small, pear-shaped organ located just posterior to the liver. The gallbladder is used to store and recycle excess bile from the small intestine so that it can be reused for the digestion of subsequent meals.

Pancreas

The pancreas is a large gland located just inferior and posterior to the stomach. It is about 6 inches long and shaped like short, lumpy snake with its "head" connected to the duodenum and its "tail" pointing to the left wall of the abdominal cavity. The pancreas has both an exocrine and an endocrine secretion. The exocrine secretion is made up of a number of enzymes that are discharged into the intestine to aid in digestion. The endocrine secretion, insulin, is important in the metabolism of sugar in the body. Insulin is produced in small groups of especially modified glandular cells in the pancreas; these cell groups are known as the islets of Langerhans.

Large Intestine

The large intestine is a long, thick tube about 2 ½ inches in diameter and about 5 feet long. It is located just inferior to the stomach and wraps around the superior and lateral border of the small intestine. The large intestine absorbs water and contains many symbiotic bacteria that aid in the breaking down of wastes to extract some small amounts of nutrients. Faeces in the large intestine exit the body through the anal canal.

Rectum

The rectum (Latin for "straight") is an 8-inch chamber that connects the colon to the anus. It is the rectum's job to receive stool from the colon, to let the person know that there is stool to be evacuated, and to hold the stool until evacuation happens. When anything (gas or stool) comes into the rectum, sensors send a message to the brain. The brain then decides if the rectal contents can be released or not. If they can, the sphincters relax and the rectum contracts, disposing its contents. If the contents cannot be disposed, the sphincter contracts and the rectum accommodates so that the sensation temporarily goes away.

Anus

The anus is the last part of the digestive tract. It is a 2-inch long canal consisting of the pelvic floor muscles and the two anal sphincters (internal and external). The lining of the upper anus is specialized to detect rectal contents. It lets you know whether the contents are liquid, gas, or solid. The anus is surrounded by sphincter muscles that are important in allowing control of stool. The pelvic floor muscle creates an angle between the rectum and the anus that stops stool from coming out when it is not supposed to. The internal sphincter is always tight, except when stool enters the rectum. It keeps us continent when we are asleep or otherwise unaware of the presence of stool. When we get an urge to go to the bathroom, we rely on our external sphincter to hold the stool until reaching a toilet, where it then relaxes to release the contents.