ZOOLOGY

UNIT II

PHYSIOLOGY OF DIGESTION

CONTENTS

DR. WKB'S ZOOLOGY STUDY MATERIAL

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FOOD AND ITS COMPONENTS

Food is defined as a composite mixture of various substances which sustain life activities. Foodstuff is defined as anything which can be used as food. The foodstuff of animals is composed of the following six components namely carbohydrates, proteins, lipids, vitamins, minerals and water.

Food has four important functions in the life of animals.

1. It supplies energy which maintains the day to day life activities.
2. Food is essential for the growth and repair of body and its parts.
3. It gives temperature for the body.
4. Certain type of food materials like vitamins regulates the activities of animals.

Carbohydrates

Carbohydrates are the cheapest source of energy in the animal food. Carbohydrates are hydrates of carbon with an empirical formula $C_n(H_2O)n$. Carbohydrate is defined as an organic compound that contains carbonyl group, namely aldehyde or ketone in addition to two or more alcohol groups or that yields such compounds on hydrolysis, For Example, Glucose, Fructose, Sucrose, Lactose, Cellulose, Starch, Glycogen etc.

Physiological Role of Carbohydrates

Carbohydrate has the following functions:

1. It is the main source of energy. Energy is essential for day to day activities.
2. It plays main role in metabolism.
3. It provides roughage. Roughage is the indigestible part of carbohydrate. For Example, Cellulose diet. It gives bulk to the diet and hence it helps to satisfy the appetite.
4. It forms the main source of reserve food, For Example, Glycogen, Starch.
5. When sufficient amount of carbohydrate is provided in the diet, proteins are not utilized for energy purposes. As a result, the entire protein taken in the diet can be utilized for the building of the body tissues. This is known as protein sparing action of carbohydrate.
6. Most of non-essential amino acids are synthesized from the intermediate products of carbohydrate.

Proteins

Proteins are complex organic nitrogenous compounds. Proteins are defined as high molecular weight polymers in which the building blocks are the amino acids. For example, Albumin, Globulin, Haemoglobin etc.

Physiological Role of Proteins

In the animal world, protein has the following functions:

1. Most of the enzymes are protein in nature. The enzymes function as biocatalysts.
2. The hormones secreted by endocrine glands are protein in nature.
3. Haemoglobin transports gases.
4. Immunoglobin of blood plasma acts as antibodies.
5. Proteins are essential for the growth and repair of animals.
6. They supply energy and heat.
7. Some proteins serve as structural materials of various body parts. For Example, Myosin of muscles, Keratin of skin & nail and collagens of connective tissues.
8. Nucleoproteins form important constituent of genes.

LIPIDS

Lipids include fats, oils, waxes etc. They are natural compounds of C, H and O. the term lipid is applied to a group of natural substances characterized by their insolubility in water and their solubility in fat solvents like ether, chloroform, boiling alcohol and benzene. Chemically, lipids are either esters of fatty acid or substances capable of forming such esters.

Physiological Role of Lipids

1. Fats serve as the main source of energy in organisms.

2. It is a storage food in organisms.
3. They are responsible for cell permeability and cell organization.
4. They provide flavour and taste to the diet.
5. They serve as vehicles for the fat soluble vitamins A, D, E and K.
6. Adrenal corticoids and sex hormones are synthesized from fat derivatives.
7. The fat deposition below the skin acts as an insulator against excessive heat loss. For Example, Blubber in whales.
8. Fat supply essential fatty acids like linoleic acid, arachidonic acid etc. deficiency of essential fatty acids leads to follicular hyperkeratosis or phreniderma.
9. Fats provide support for many organs in the body such as heart, kidney and intestine.

VITAMINS

Vitamins are defined as potent organic compounds, occurring in varying and minute proportions in food, which must be available to the organisms from exogenous sources, in order to that physiological processes essential to life may proceed normally. The salient features of vitamins can be summarized below:

1. Vitamins are organic compounds.
2. Plants synthesize vitamins; animals can synthesize a few.
3. Animals obtain vitamins from the food stuffs.
4. Man requires about 15 or lesser vitamins.
5. They are required in very small quantities.
6. They function like hormones.
7. They do not provide any energy for the animals; but they regulate the physiological activities functioning as catalysts.
8. Vitamins are destroyed by high temperature and cooking for longer duration of tie.
9. When vitamins are deficient in the food, they produce a set of diseases called deficiency diseases. These diseases can be cured only with the treatment with particular vitamin which is deficient.

Dr. Funk introduced the term '*Vitamine'* for these organic compounds. The vitamin, which Funk extracted contained an amine and that is found to be essential for 'vital' activities. Hence he coined the name *Vitamine*. But later it was found that amine was not present in all the vitamins discovered. Hence 'e' was deleted and the term Vitamin was used instead of *Vitamine*.

Vitamins are named with the alphabet with the order of their discovery. Thus there are vitamins A, B,C,D,E,K,Q,U etc. The vitamins are classified into two groups according to their solubility. They are fat soluble vitamins and water soluble vitamins. Vitamins A, D, E and K are fat soluble and Vitamins B and C are water soluble.

MINERALS

The body of organisms are constructed by organic components and inorganic elements. The organic components include carbohydrates, protein and fats. These organic compounds themselves are derivatives of inorganic elements or minerals. The functions of minerals are immense in the biological world. Animal tissues contain about 29 elements. These elements are classed into two groups' namely essential elements and non-essential elements.

Essential Elements

The role of certain elements in organisms is known and they are indispensable for normal life activities. These elements are called essential elements. They are divided into two groups according to their actual amounts in the body. They are macroelements and microelements or trace elements.

Macroelements are those which are required to be present in the diet in amounts more than 1mg. they constitute 60-80% of the elements present in the body. There are about 12 macroelements. They are carbon, hydrogen, oxygen, nitrogen, sodium, potassium, calcium, magnesium, iron, phosphorus, sulphur and chlorine.

Microelements or Trace elements are required in very small amounts (in micrograms). The trace elements include copper, zinc, cobalt, manganese, molybednum, iodine and fluorine.

Non-Essential Elements

The role of certain elements in the body is not known. Hence these elements are called non-essential elements. These include bromine, boron, silicon, arsenic, aluminium, lead, vanadium and titanium.

Calcium

Calcium is a major mineral component of man.

Sources

Milk and milk products form the main source of calcium. One litre of cow milk contains about 1200 mg of calcium. One litre of human milk contains about 300 mg of calcium. Other sources are fish, vegetables like radish, beetroot, mustard, greens, curry leaves, drum stick leaves, soya beans and tamarind, fruits like sitaphal, cereals, especially ragi water and chewing betel leaves.

Functions

1. It is essential for the formation and maintenance of bones and teeth.
2. It promotes coagulation of blood.
3. It is essential for muscle contraction.
4. It is an important component of enzymes.
5. It plays an important role in the transmission of impulse from the nerve to the muscle across the neuromuscular junction by helping the secretion of acetylcholine.
6. Calcium is essential for the excitation of nerves
7. Membrane permeability is decreased by calcium and this effect balances the opposite action of sodium and potassium capillary permeability.

Iron

Iron is an important mineral in biology.

Sources

The richest sources are as follows liver, poultry, carrots, apples, kidney, beans, bananas, oranges, heart, wheat, beef, palm gur, fish, peas, cheese, jaggery, egg, spinach and tomatoes. The vegetables cut by knives and cooked in the iron containers are also important sources of iron. Milk is a very poor iron source.

Storage

Iron is stored in the form of ferritin in the liver, spleen and intestinal mucosa.

Functions

1. In the form of haemoglobin, iron transports oxygen from lungs to tissues and CO_2 from tissues to lungs.
2. The myoglobin, an iron compound stores oxygen in the muscles.
3. Iron is the main component of many enzymes like cytochrome, catalases and peroxidases.
4. Iron is inevitable for the synthesis of haemoglobin and RBC.
5. It plays an active role in metabolic oxidation.

Phosphorus

Phosphorus is present in almost all the foodstuffs.

Sources

Milk, cheese, almonds, beans, butter, nuts, meat and egg.

Functions

1. Energy is stored for immediate use in phosphorus compounds like ATP. ADP etc.
2. They play an important role in metabolism. They take part in phosphorylation reactions.
3. They are important for the construction of bones and teeth.
4. With proteins they form phosphoproteins.
5. They form important components of nucleic acids like RNA, DNA etc.

Magnesium

The important sources are almonds, cereals, beans, green vegetables, potatoes and cheese.

Functions

1. Magnesium ions function as activators of enzymes like phosphorylase,

phosphoglucomutase, Enolase peptidase, alkaline phosphatase, RNA polymerase, polymerase etc.

Sulphur

The main sources of sulphur are the proteins found in the foodstuff.

Functions

1. Organic sulphur compounds are utilized for the synthesis of hormones like insulin and anterior pituitary hormones.
2. It is involved in the formation of proteins like chondroproteins, keratins and heparin, coenzyme A and acyl carrier protein.
3. It is involved in the formation of sulphhydryl groups (S-H) which acts as the active centres of the enzymes and also plays an important role in tissue respiration.
4. It also forms disulphide linkages (S-S) in the protein molecules which are responsible for the maintenance of higher level of structure of the proteins.
5. A high energy sulphur bond similar to that of phosphate plays an important role in metabolism.

Sodium, Potassium and Chlorine

These are widely distributed in the plants and animals. The source of sodium and chloride is common salt. The sources of potassium are coffee, tea, cocoa, dried beans, molasses, green vegetables, milk, fish, chicken, liver, beef, pork, bananas, oranges, pineapples, potatoes etc.

Functions

1. They maintain the osmotic pressure of the body and thereby protect the body from dehydration.
2. The sodium salts and potassium salts with the corresponding weak acids form the chief buffer systems of extracellular and intracellular fluids respectively. These buffer systems play an important role in maintaining pH.
3. They are involved in the transport of CO_2.
4. They are involved in the maintenance of neuro-buffer irritability and excitability.
5. They maintain a proper viscosity of blood.
6. Gastric hydrochloric acid is derived from sodium chloride.

Copper

An adult human contains 100 to 150 mg of copper. The sources of copper are milk, liver, nuts, legumes and leafy vegetables.

Functions

1. It is a component of certain enzymes like cytochrome oxidase, catalase monoamine oxidase, uricase and ascorbic acid oxidase.
2. It helps in the absorption, transport and utilization of iron.
3. It helps in bone formation.
4. It is essential for the formation of myelin sheath in the nerve fibres.
5. It is an important component of haemocyanin, a blue pigment present in gastropods, arthropods and cephalopods.

Iodine

An adult man contains about 20 to 30 mg of iodine. It is an important component of thyroid hormone. The sources of iodine are food and water. The richest sources are common salt, sea fish, cod liver oil etc.

Deficiency of iodine leads to goitre. But all goitres are not due to iodine deficiency. The most practical method to supplement dietary iodine is by iodinization of salt. The addition of potassium iodide to common salt (1:10000) is now as established prophylaxis of goitre.

Fluorine

It is found in the bones, teeth and hard tissues. It is never found free in nature. The main sources of fluoride are drinking water, sea fish, cheese, tea etc.

Fluoride is often called a two edged sword because high and low doses cause ill effects. High dose leads to dental and skeletal fluorosis. Low dose causes dental caries. Dental fluorosis is characterized by mottling and corroding of teeth and skeletal fluorosis by sclerosis of the bones of the spine, pelvis and limbs, calcification of ligaments and ossification of tendinous insertions of muscles.

In optimum amounts, fluorine is beneficial to teeth and reduces the incidence of dental caries.

Cobalt

In human body, liver contains maximum cobalt and it is the storage organ for cobalt. The diet contains sufficient amount of cobalt. It is essential component of vitamin B_{12} (cyanocobalamine) which is required to maintain normal bone marrow function for producing erythrocytes.

Zinc

Zinc is found in the blood (RBC), hair, bone. Liver, muscles, pancreas, gastrointestinal tract and spleen. The main sources are sea foods like oysters and liver, wheat, germ, yeast and lettuce.

It is an important component of several enzymes like carbonic anhydrase, carboxyl peptidase, uricase, kidney phosphatase etc.

Manganese

Manganese activates a number of enzymes such as arginase, phosphoglucomutase, choline esterase and mitochondrial respiratory enzyme systems. In human beings, it functions in the formation of haemoglobin.

Molybednum

It is found in the bones, liver and kidney. It is essential component of certain metalloflavoprotein enzymes such as xanthine oxidase, aldehyde oxidase, nitrate reductase and hydrogenase.

WATER

A water molecule is constructed from covalent bonding of two atoms of hydrogen and one atom of oxygen. Water may exist in any of the three following forms: Above 100^{o}C, it occurs in the form of water vapour or steam, below 0^{o}C it occurs as ice and between 0^{o}C and 1000^{o}C it occurs in the form of liquid.

Unique Properties of Water

1. Water is a solvent. No other known liquid is able to dissolve in itself so many and such diverse substances as water. Water serves to carry O_2 add CO_2. Water forms the only general solvent for inorganic salts. It also acts as a substratum and the medium in and against which the vital activities of living organisms are carried.
2. The heat capacity of water is remarkable. Water has the ability to withhold large amounts of heat even when there is a small temperature fluctuation.
3. Water has relatively high freezing point. Maximum density of water is reached at 4^{o}C.
4. Water has a highest surface tension when compared with other liquids.
5. Viscosity of water is higher than that of alcohol and chloroform.
6. Water has the highest heat conducive capacity among liquids.
7. The salinity of water varies from freshwater to marine water.
8. Water exists in two forms namely hard water and soft water. Hardness of the water is caused by the presence of soluble salts of calcium and magnesium. It is an important inorganic component of body. The water content of human body is 60 to 79% of adult weight. The water content is lesser in women and higher in men. The amount decreases with increase in age.

According to the location of water in the body it is divided into two types namely intracellular fluid and extracellular fluid.

1. **Intracellular Fluid**: The water present inside the cells, i.e. in the protoplasm is called intracellular fluid. It constitutes 50% of the body weight. It occurs in two forms namely free water and bound water. Free water constitutes 95% of the water content

of the cell. The bound water occurs in chemical combination with proteins and other constituents of cytoplasm.

2. **Extracellular Fluid**: The water present outside the cell is called extracellular water. It constitutes 20% of the body weight. It is divided into two categories namely plasma water present in the blood vessels constitutes 5% of body weight and interstitial fluid that is present outside the blood vessels. It constitutes 15% of body weight.

Water Intake

Animals obtain their water from the following sources:

1. **Diet**: The diet is the main source of water. Its water content is 70 to 90% of the weight of the diet.
2. **Metabolic Water**: Water is an important by-product of metabolism. This water is also utilized by the body. Generally 10 to 16 ml of water are produced per 100 calories of energy produced. The amount of water produced varies with the different types of food.

***Table**: The amount of metabolic water produced.*

Carbohydrate	0.56 ml per 1 gm
Protein	0.34 ml per 1 gm
Fat	1.07 ml per 1 gm

DIGESTION

Digestion is defined as a process that involves physical and chemical breakdown of insoluble complex food materials into soluble simple food materials. During digestion, carbohydrates are converted into glucose, Proteins are converted into amino acids and Lipids are converted into fatty acids and glycerol.

Digestion involves two processes namely physical or mechanical and chemical.

Mechanical Digestion includes the breakdown of large food molecules into smaller molecules.

Chemical Digestion includes the breakdown of complex food molecules into small molecules in the presence of the digestive enzyme.

Intracellular Digestion

The digestion occurring inside the cell is called intracellular digestion. Intracellular digestion is correlated with sluggish habits or microphagous feeding i.e., feeding small food particles. For Example, Protozoans, Sponges, Coelentrates, Turbellarians etc.

The food materials enter the body by pinocytosis or phagocytosis. Pinosomes or phagosomes enclosing food materials are formed. They fuse with lysosomes and the food materials are digested. In freshwater mussel, a certain amount of food is taken into the cells of the hepatopancreas and are digested inside the cells.

Extracellular Digestion

Digestion taking place outside the cell is called extracellular digestion. The digestion taking place inside the stomach is an extracellular digestion. It is also called intercellular digestion as it occurs in between the cells in the lumen of stomach. Extracellular digestion is the advanced type of digestion. The evolutionary trend has been towards the replacement of intracellular digestion by extracellular digestion. The animals possessing an alimentary canal exhibit extracellular digestion. Digestion occurs within the lumen of alimentary canal.

MECHANICAL DIGESTION OF FOOD

The food taken in the mouth passes through the alimentary tract. As it passes down, it is treated mechanically and chemically. Mechanical process of digestion refers to all the physical treatments given to the food when it is inside the alimentary tract. This process splits the larger particles into smaller particles. The mechanical process of digestion is brought about by the movement of alimentary canal. It includes mastication, deglutition, gastric motility, motility of small intestine, motility of large intestine and defaecation.

Mastication

Mastication or chewing is the rhythmic movements of the jaws, tongue and lips. It serves to breakdown the food particles into smaller masses. The breakdown of food into smaller particles is brought about by the action of teeth through the movements of the lower jaw. The jaw moves vertically, side to side and anteroposteriorly. This helps in cutting and made crushing the food. The smaller particles are collected and made into a spherical ball called bolus. The bolus is pushed backwards for swallowing.

Deglutition (Swallowing)

After mastication, the food is swallowed into the stomach. This process is called *deglutition*. It is divided into three stages namely oral phase, pharyngeal phase and oesophageal phase.

1. **Oral Phase**: The first stage of deglutition consists of passage of food through the oral cavity into the pharynx. This stage of swallowing is initiated voluntarily. The mouth and nasal passage are closed; respiration is inhibited reflexively; hyoid is slightly elevated; finally the back portion of the tongue is elevated and retracted against the hard palate; this action of the tongue, pushes the bolus into the pharynx.
2. **Pharyngeal Phase**: In the second phase, the food is propelled through the pharynx into the oesophagus. It is caused by reflex action; the contact of the food with the structures of pharynx initiates the reflex. Respiration and speech are interrupted.
3. **Oesophageal Phase**: Whenever there is swallowing effort, a peristaltic wave appears in the upper part of the oesophagus. This peristaltic wave is called primary oesophageal peristalsis. The wave moves down the bolus.

   When the wave reaches the cardiac sphincter (located at the junction of the oesophagus and cardiac stomach), it relaxes and allows the bolus to enter the cardiac stomach.

   If the oesophagus is not emptied completely by the primary wave, an additional wave appears in the oesophagus. This is called the secondary oesophageal peristalsis. They continue until the oesophagus is empty.

Gastric Motility

The movement of the stomach is called *gastric motility*. It is of two types namely hunger contraction and digestive peristalsis.

1. **Hunger Contraction**: The contractions exhibited by the empty stomach is called hunger contraction. It is in the form of peristaltic waves. They travel the entire length of the stomach. Hunger contractions are inhibited as long as the stomach contains food.
2. **Digestive Peristalsis**: As soon as food is taken, the hunger contraction stops and are replaced by digestive peristalsis. It occurs when the stomach contains food.

   It is characterized by the constancy of its rhythm. It occurs at a frequency of 3 per minute. Each wave begins as a circular constriction of the stomach. It travels towards pylorus until it finally ends with a contraction of the pyloric sphincter.

Motility of Small Intestine

The intestinal movement is due to the rhythmicity of the circular muscles of the intestinal wall. It is characterized by alternate contractions and relaxations. The intestinal motility is of two types namely segmenting contractions and intestinal peristalsis.

Segmental Contractions

It is a kind of rhythmic contraction in which a section of the intestine is divided into short segments by rings of contractions occurring at regular intervals. When the contracted areas relax, the relaxed areas contract, dividing each segment into halves. The two halves of adjacent segments now join together to form a new segments.

Ludwing (1861) named these as pendulum movements. These contractions occur at a rate of 11 per minute in the duodenum and 8 to 9 per minute in the ileum. The rhythmic contractions are myogenic. These contractions agitate the intestinal contents. Such agitation brings about the following functions:

1. It breaks the food materials into smaller particles.
2. It mixes the food with the intestinal secretions.
3. It constantly changes the layers of fluid in contact with the intestinal mucosa; this facilitates absorption.
4. These contractions also bring about changes in pressure; this also helps in absorption.

Intestinal Peristalsis

The contractions which travel in an aboral direction in the intestinal wall are called intestinal peristalsis. These movements are in the form of waves. Intestinal peristalsis is superimposed upon the rhythmic segmenting contractions in such a way that the two are present simultaneously. The peristaltic waves appear in the small intestine at irregular intervals and travel for varying distances; some travel only a few inches; others a few feet.

The intestinal peristalsis tends to sweep the contents forward or towards the distal end of the intestine.

Motility of Intestinal Villi: They exhibit two types of movements. They are lashing movements and rhythmical shortening and lengthening. These movements accelerate the flow of blood and lymph and that they increase absorption.

Motility of Large Intestine (Colon)

There are two types of motility in the colon. They are the movements concerned with mixing and absorption and the movements concerned with propulsion.

Mixing and Absorbing Movements

These movements help to mix and absorb the contents of colon. These are of three kinds namely kneading movements, antiperistaltic waves and mass peristalsis.

1. **Kneading Movements**: These movements resemble the segmenting contractions of small intestine but these occur at a slower rate. The rate of these movements is two per minute.
2. **Antiperistaltic Waves**: These movements appear when the colon becomes distended. They appear at a frequency of 5 to 7 per minute.
3. **Mass Peristalsis**: The contraction of large intestine after a meal is called mass peristalsis.

Propulsive Movements

These movements propel the contents of colon towards the anus. These are of two types namely colonic peristalsis and mass movements.

1. **Peristalsis of Colon**: It is similar to intestinal peristalsis. It consists of a contraction wave preceded by relaxation. It appears in association with the act of defaecation.
2. **Mass Movements**: These movements are simultaneous contractions of large segments of the colon. They occur at infrequent intervals. Usually they occur after a meal or on any occasion when the stomach is being filled with food. These movements serve to empty the contents of the proximal colon rapidly into the more distal portions. Frequently such movements are followed by a desire to defecate.

Defaecation

Defaecation is the expulsion of faeces. The mass movements drive the faecal masses into the colon. Generally, the rectum remains empty. The faecal matter is stored in the sigmoid and pelvic colon and not in the rectum.

When the mass movements drive the faeces into the rectum, the desire for defaecation occurs. The desire for defaecation is caused by an increase in rectal intraluminal pressure of water. The usual stimulus is taking food, a glass of warm water, a cup of coffee or smoking. The desire to defecate is induced by straining efforts which may raise the abdominal pressure and force faeces into the rectum.

Faeces

The faeces is the digestive waste. It has a characteristic yellow colour. This is due to bile pigments. The bad odour is due to indole, skatole, hydrogen sulphide and other odoriferous substances. The quantity of faeces is controlled by the diet. If the diet is rich in vegetables the quantity is greater. An adult produces 75 to 170 gms of faeces daily. About 25% to 35% of faeces is made up of solids; the remainder is water. It has a bitter taste. It has the pH of 7.0 to 7.5. The components of faeces are as follows:

1. It contains inorganic substances like calcium phosphate, calcium oxalate, iron phosphate etc.
2. It contains organic substances like cellulose, protein and fats.
3. Unabsorbed intestinal secretions like cellulose, protein and fats.
4. Enzymes like amylase, trypsin, nucleases, maltase, sucrase, lipase and lysozyme.

CHEMICAL DIGESTION OF FOOD

Chemical process of digestion refers to the treatment of food materials with enzymes. The chemical process of digestion can be conveniently studied by the digestion occurring in the different regions of the alimentary canal. Based on this, it is grouped into three types namely:

1. Buccal Digestion or Salivary Digestion
2. Gastric Digestion
3. Intestinal Digestion

BUCCAL DIGESTION OR SALIVARY DIGESTION

Digestion of the food occurring inside the buccal cavity is called buccal digestion. As salivary enzymes play the major role here, it is also called salivary digestion. In the mouth, food is masticated. During mastication, the food is crushed into smaller particles. As it is crushed, it mixes with secretions of salivary glands.

SALIVARY GLANDS

The salivary glands are present in the buccal cavity. Vertebrates contain four pairs of salivary glands but man contains three pairs. They are parotid, submandibular and sublingual.

1. **Parotid Glands**: These glands are located just below and in front of the ears. They open into the mouth through duct of stensen.
2. **Submandibular Glands**: These glands are present in the angles of the lower jaw. They open into the mouth by Wharton's duct.
3. **Sublingual Glands**: These glands are located below the tongue. They open into the mouth through several ducts.

The salivary glands are racemose and made up of many sac like alveoli, which form small lobules. Ducts arise from each alveoli. They unite to form large ducts which open into the main duct.

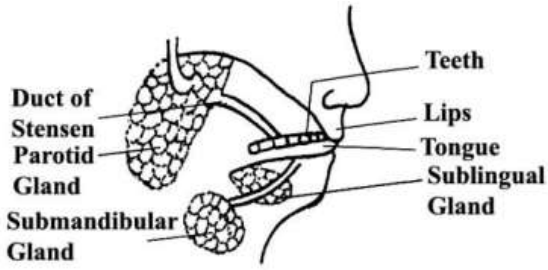

Fig.: Salivary Gland in Man

SALIVA

The secretion of salivary gland is called saliva. It is colorless, slightly cloudy due to the presence of cells and mucin. A man secretes about 1 to 1.5 litre of saliva per day. Saliva is slightly acidic with a pH of 6.02 to 7.05. Water content is 99.5%. Solid content is 0.5%. Cellular components of saliva are yeast, bacteria, protozoa, leucocytes etc. Inorganic salts include NaCl, KCl, $CaCO_3$, calcium phosphate, sodium phosphate and potassium thiocyanate. Enzymes include ptyalin (amylase), lipase, carbonic anhydrase and a bacteriolytic enzyme lysozyme are present in saliva. Organic substances like urea, amino acids, cholesterol and vitamins are also present in saliva. Gases like O_2, N_2 and CO_2 are also present in the saliva.

Functions of Saliva

1. It keeps the mouth moist and helps in speech.
2. It moistens the food and helps mastication and deglutition.
3. It lubricates the mouth cavity and avoids thirsty.
4. It cools down the hot substances.
5. It dilutes the irritant and prevents injury to the mucous membrane.
6. It is essential for the appreciation of taste.
7. Saliva washes down the food debris and there by bacteria do not grow.
8. Saliva excretes toxic metals, thiocyanate, viruses of rabies and mumps, urea etc.
9. The biocarbonates, phosphates and mucin present in the saliva acts as buffer.
10. Saliva is an important digestive agent. It contains two digestive enzymes namely ptyalin (amylase) and maltase.

Ptyalin

It is a salivary enzyme. It acts on starch. First of all it is converted into soluble starch. Then soluble starch is converted into erythrodextrin which in turn is split into achrodextrin. Finally achrodextrin is converted into maltose.

Maltase

It is a salivary enzyme. It acts on maltose and splits it into two glucose molecules.

Control of Salivary Secretion

The secretion of saliva is under the reflex action. The physiological stimulus is the presence of food in the mouth. The food induces the mucous membrane of the mouth which in turn stimulates the salivary centre of brain.

GASTRIC DIGESTION

Digestion in the stomach is called gastric digestion. After swallowing, the food reaches the stomach. Here the food is treated mechanically by gastric movements, as well as, chemically. The chemical changes are due to gastric juices. Gastric juices are the secretion of gastric glands.

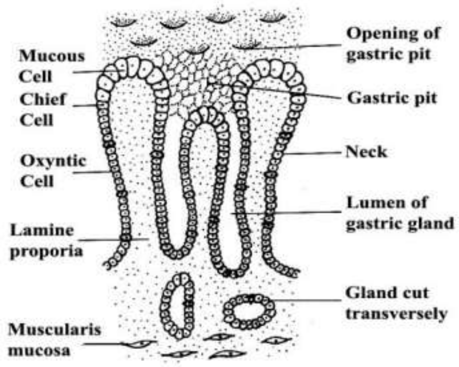

Fig.: Gastric Gland

GASTRIC GLANDS

The glands present inside the stomach are called gastric glands. They secrete gastric juices. There are about 35,000,000 gastric glands in man. The glands are located below the surface of epithelium. These are simple tubular glands arranged as parallel tubes opening on the surface. The main tubular portion of the gland is called body. The inner end extends into the muscular mucosa where it terminates in a blind bulbous end called fundus of the gland. The narrow portion is the neck.

Gastric glands are formed of four types of cells. They are:

1. Mucous neck cells secreting mucous.
2. Chief cells or zymogenic cells or peptic cells secreting pepsin, rennin and gelatinase.
3. Oxyntic or parietal cells secreting hydrochloric acid (HCl).
4. Argentaffin cells are concerned with the secretion of vasoconstrictor serotonin.

GASTRIC JUICE

Gastric juice is the secretion of stomach. It is a transparent yellow fluid. A healthy man secretes 2000 to 3000 ml of gastric juice in 24 hours. But a fasting man secretes only 1000 ml. the gastric juice consists of 99.02% water and 0.98% solid. The specific gravity is low and it varies from 1.001 to 1.01. It is highly acidic in nature. It has a pH of 0.9 to 1.5. It contains plenty of hydrochloric acid in free and combined form. The main enzymes present in the gastric juice are pepsin, renin, lipase, pepsinogen, reninogen etc.

In neonates and children (Infants), the gastric juice contains low levels of pepsin, renin and free hydrochloric acid. The pH of HCl is 2.6 to 3.0. The volume of residium is 2 to 5 ml. The pH and residium will reach adult level in 15 to 20 years of age. In about 4% of children, hydrochloric acid is completely absent. The absence of HCl is called achlorhydria. The percentage of achlorhydria gradually increases and there are about 30% achlorhydria at the age of 60.

Pepsin

It is a proteolytic enzyme produced by the peptic or chief cells of gastric gland. It is secreted in an inactive form called pepsinogen. It is converted into active pepsin by HCl. It acts with the help of HCl and coverts proteins into peptones.

Rennin or Rennet or Chymosin

It is secreted by the chief cells of gastric gland. It is secreted in an inactive form called prorenin. It is converted into active rennin by HCl. It acts on the protein casein of milk and converts it into paracasein. Paracasein combines with calcium to form calcium paracaseinate. It separates out as curd and is acted upon by pepsin. This process is called curdling of milk.

Gastric Lipase

It is probably secreted by chief cells of fundic glands. It splits natural fats (simple lipids) into one molecule of glycerol and three molecules of fatty acids.

Hydrochloric acid

It provides an acid medium for the action of enzymes in the stomach. It activates pepsinogen and prorenin. It has some bactericidal effect on harmful bacteria.

INTESTINAL DIGESTION

As far as digestion is concerned, small intestine, especially duodenum, is significant, because it receives pancreatic juice from pancreas, bile from liver and intestinal juice from intestinal glands. Because of these, major events of digestion occur in the small intestine.

PANCREAS

Pancreas is a combination of exocrine and endocrine glands. The exocrine component of pancreas is a tubular gland. It is highly branched and the terminal portions of the gland are known as acini or alveoli.

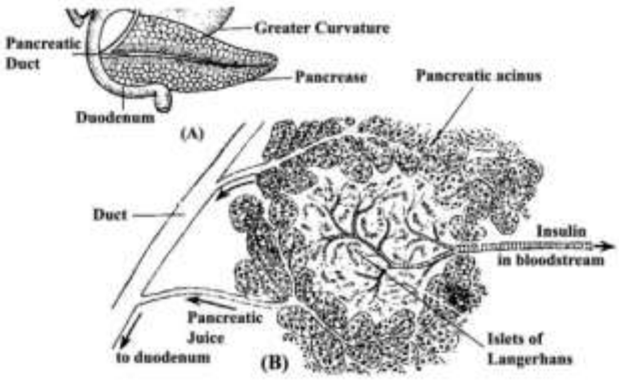

Fig.: (A) Pancreas (B) Microscopic section of pancreas showing Islets of Langerhans surrounded by alveoli

The alveoli are the secretory units. The main duct of pancreas is called duct of Wirsung. It receives several ducts from the lobules. It opens into the duodenum along with the bile duct. Between the acini, there are groups of cells called islets of Langerhans. This is the endocrine component of pancreas.

PANCREATIC JUICE

It is secreted by the acini cells of pancreas. It is colorless and odorless alkaline fluid. It has low viscosity. It is isotonic with blood. The daily secretion is about one litre. It contains large amount of bicarbonate. The sodium bicarbonate present in the juice neutralizes the acidity of the chyme (food). The important enzymes present in the pancreatic juice are trypsin, chymotrypsin, carboxypeptidase, pancreopeptidase or elastase, amylopsin or amylase, steapsin or lipase, sucrase, maltase, lactase and nuclease.

Trypsin

It is secreted in an inactive form called trypsinogen. It is activated by enteropeptidase (enterokinase old name). It is an endopeptidase. It acts on all proteins. It readily digests the denatured or partially digested proteins into some amino acids.

Chymotrypsin

It is secreted in an inactive form called chymotrypsinogen. It is activated by trypsin. It is an endopeptidase. It has a milk curdling effect. It acts on all proteins. The end products are small polypeptides and free amino acids.

Carboxypeptidase

It is secreted in an inactive procarboxypeptidase. It is activated by trypsin. It is an exopeptidase and attacks the peptide linkage of terminal amino acid possessing a free COOH group. It splits certain peptides into amino acids.

Pancreopeptidase or Elastase

It hydrolyses elastin.

Amylopsin or Amylase

Its action is like that of salivary amylase. It digests cooked starch more actively than raw starch. It requires chloride ions for normal activity. The end products of amylopsin action are maltose and small amount of glucose.

Steapsin or Lipase

It is a fat splitting enzyme. Its activity is increased in the presence of a number of substances like Ca, soaps, bile acids, certain amino acids and peptides. It is a glyceride hydrolysing enzyme. The end products of hydrolysis by this enzyme consists of diglycerides, monoglycerides and fatty acids.

Sucrase

It splits sucrose into glucose and fructose.

Maltase

It splits maltose into two molecules of glucose.

Lactase

It splits lactose into glucose and galactose.

Nuclease

There are two types of nucleases namely ribonuclease or RNAase and deoxyribonuclease or DNAase. They act on the polynucleotide chains of RNA and DNA leading to the formation of nucleotides of different lengths.

Control of Pancreatic Secretion

The secretion of pancreatic juice is under the control of nerves and hormones. Vagus nerve is the secretomotor nerve of pancreas. Stimulation of the vagus leads to the secretion of pancreatic juice.

Two hormones are responsible for pancreatic secretion namely secretin and pancreozymin. The stimulus is given by the entry of food into the duodenum. When the mucous of duodenum comes in contact with the food, it secretes the hormone secretin. It is carried by the blood to the pancreas where it stimulates the pancreas to secrete pancreatic juice. Pancreozymin controls the enzyme producing function of the pancreas.

LIVER

Liver is a digestive gland. It is the largest gland in the human body. Liver secretes bile. The liver of man contains two lobes. It is formed of hepatic cells. Numerous capillaries are present between these cells. Capillaries are called bile capillaries. Each capillary starts as a blind tubule. They join together repeatedly to form bigger vessels. In each lobe they are joined together to form a hepatic duct. The two hepatic duct of the two lobes unite together to form the common bile duct or ductus choledochus. It opens into the duodenum along with pancreatic duct through the ampulla of Vater. The upper end of the bile duct gives out a branch called cystic duct. It ends in a oval sac called gall bladder. It is a reservoir for the bile secreted by the liver.

Functions of Liver

1. Liver is the largest chemical factory of the body.
2. It synthesizes glycogen from glucose.
3. It stores glycogen.
4. It secretes bile.
5. It synthesizes urea.
6. It modifies wastes and toxic substances suitable for excretion through bile or urine.
7. It helps in the absorption of fats.
8. It produces RBC in the foetal life.
9. It destroys the dead RBCs.
10. It stores haematin.
11. It removes bilirubin from the blood.
12. It manufactures plasma proteins.
13. It produces prothrombin and fibrinogen.

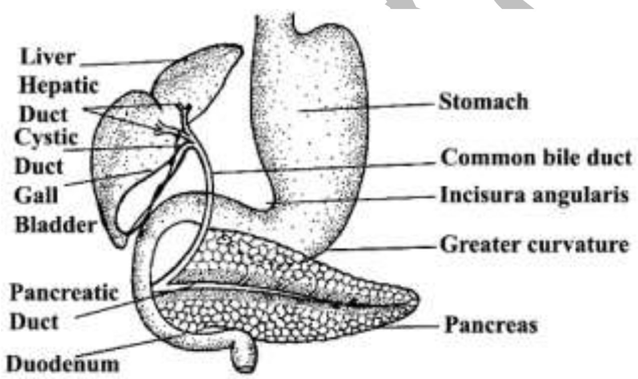

Fig.: Stomach, Liver and Pancreas

GALL BLADDER

Gall bladder is a digestive gland. It is located on the upper surface of liver. It is 8 to 10 cm in length and has a volume of 60 ml. it is pear shaped. It consists of three regions namely a fundus, a body and a neck. It is covered by three coats namely an outer serous peritoneal coat, a middle muscular tissue and an inner mucous membrane. A duct called cystic duct arises from the gall bladder. It opens into the hepatic duct. The two ducts form a common duct called common bile duct which opens into the duodenum along with the pancreatic duct.

Functions

1. The gall bladder functions as a store house of bile.
2. It concentrates the bile by absorbing water from the bile.
3. When food is not eaten, the bile passes into the gall bladder from the liver and the sphincter of oddi remains closed.
4. When food is eaten, the gall bladder contracts, the sphincter of oddi opens and the bile passes through the cystic duct into the duodenum.

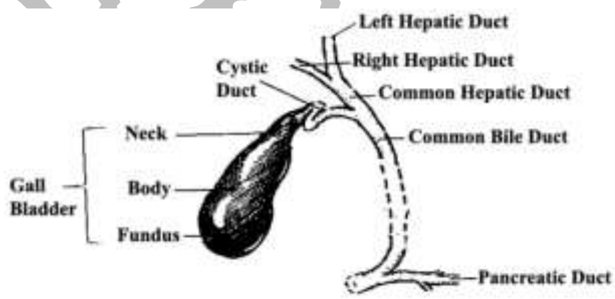

Fig.: Gall Bladder and Bile Duct

BILE

Bile is a product of secretion and excretion of liver. It is produced by the parenchymal cells of the liver. It is stored in the gall bladder. Bile is formed continuously in the liver, but its flow into the duodenum from the gall bladder is intermittent.

It is a clear, golden yellow or greenish fluid. It is slightly viscous. It has a bitter taste and alkaline in nature. Daily secretion is from 500 ml to 1 litre. The bile in the gall bladder is concentrated by the reabsorption of water, bicarbonates, chlorides and sodium. Hence the bile from the liver and that from the gall bladder are slightly different. It contains inorganic salts like sodium bicarbonates, chlorides, carbonates and phosphates of Na and Ca.

Bile Salts

Bile salts are sodium and potassium salts of glycholic acid and taurocholic acid. They are sodium and potassium salts of glycocholates and taurocholates. They are alkaline in nature. They control the pH of bile. The bile salts have the following functions:

1. They emulsify the fat and thereby increase the surface area of the substrate exposed to pancreatic juice.
2. They activate the enzymes cholesterol esterase and pancreatic lipase.
3. They facilitate the absorption of fat soluble vitamins like A, D, E and K.
4. The fatty acids salts have low solubility. Hence they cannot be absorbed. But bile salts react with them to form readily soluble substances. This help absorption of fatty acids salts. Once absorbed, the bile salts get separated from the fatty acids and are returned to the liver to be used.
5. They promote the secretory power of liver cells.
6. With bile, they create an optimum medium for the action of steapsin.
7. They activate the inactive lipase.
8. They keep cholesterol in solution. When the bile acid-cholesterol ratio falls, cholesterol is precipitated and forms gall stones in the liver and gall bladder.
9. They increase intestinal motility.

Bile Pigments

They are coloured substances giving the characteristic colour to the bile. These are metabolic waste products of the degradation of haem. There are two types of colour pigments namely bilirubin and biliverdin. Bilirubin is golden yellow in colour and is present in the bile of liver. Biliverdin is greenish in colour and is found in the bile of gall bladder. Bilirubin is converted into biliverdin by oxidation.

Cholesterol

It is an excretory waste produced by the liver. It is synthesized from acetic acid. Daily production is 1 or 2 gms. It is kept in solution by bile salts. Hence any reduction in bile salt concentration precipitates cholesterol and produces gall stones in the gall bladder or liver.

Lecithin

It is present in small amount in the bile and has no significant function.

Alkaline Phosphatase

The only enzyme present in the bile is alkaline phosphatase. It has no digestive function. In case of obstructive jaundice, the concentration of this substance increases in the blood. This is an indication for the diagnosis of this disease.

Function of Bile

1. It is very essential for life. Life cannot be maintained without it. When its secretion is arrested, it produces abnormalities of bone, anemia, lack of nutrition and finally death.
2. It is essential for the complete digestion of fat.
3. Certain waste products are excreted through bile. They are metals like Ca, Zn, Hg etc., toxins, bacteria, bile pigments, cholesterol, lecithin etc.
4. It stimulates peristalsis of intestine and hence produces laxative action.
5. It acts as a buffer and lubricant.
6. It emulsifies fat.
7. It activates lipase enzymes.

Control of Bile Secretion

Bile secretion is controlled by a number of factors. They are as follows:

1. Stimulation of vagus nerve.
2. Bile salts increase the secretion of bile.
3. The intestinal mucosa secretes a hormone namely cholecystokinin when it comes in contact with food. It cause gall bladder to deliver bile.

INTESTINAL JUICE OR SUCCUS ENTERICUS

The intestinal juice is secreted by the two different types of glands found in the small intestine. These glands are duodenal glands of glands of Brunner and Intestinal glands or crypts of Lieberkuhn.

1. **Glands of Brunner**: These are found in the submucosa of duodenum. They have an alkaline secretion containing mucin and a weak proteolytic enzyme.
2. **Crypts of Lieberkuhn**: It is present throughout the small intestine. It secretes mucous and large number of enzymes.

Composition of Intestinal Juice

1. It is a slightly straw coloured fluid.
2. It is an alkaline fluid having the pH of about 8.3.
3. Daily secretion is about 1 to 2 litres.
4. Water content is 98.5 and solids 1.5%.
5. The juice contains mucin and epithelial cells.
6. Inorganic salts of Na, Ca, Mg with that of chloride, bicarbonate and phosphate. Bicarbonate concentration is very high.
7. The following enzymes are present in the intestinal juice namely enteropeptidase, erepsin, arginase, amylase, sucrase, maltase, isomaltase, lactase, lipase, alkaline phiosphatase, cholesterol esterase, lecithinase etc.

Erepsin

It is a mixture of enzymes including dipeptidases and aminopeptidases. It acts best in an alkaline medium. It cannot act on native proteins. It acts only upon lower peptides and converts them completely into amino acids. The various peptidases act serially one after another upon the smaller fragments or the peptide molecule, till they are completely broken down into amino acids.

i. **Amino peptidase**: It is an exopeptidases and it hydrolyzes small peptides involving an amino acid with free amino group.
ii. **Dipeptidase**: this enzyme splits dipeptides into free amino acids.
iii. **Tripeptidase**: This enzyme acts on tripeptides and release amino acids.

Enteropeptidase

It converts inactive trypsinogen into active trypsin.

Carbohydrases

The carbohydrases namely maltase, lactase and sucrase act on maltose, lactose and sucrose respectively.

Nucleolytic Enzymes

These enzymes acts on nucleic acids.

i. **Polynucleotidases**: It act on polynucleotides and convert them into mononucleotides. These are exonucleases and attack the molecule on the ends of the chain and thus remove various mononucleotides one by one.
ii. **Phosphatases**: These enzymes split mononucleotides into nucleosides and phosphates.

Phospholipase

It acts on phospholipids like lecithins and it converts them into their components of glycerol, fatty acids, phosphoric acid and choline (in acse of lecithins) or ethanolamie or serine (in the case of cephalins).

Digestion in the Large Intestine

Practically there is no digestion in the large intestine because it has no digestive gland. It secretes large amount of mucous. It lubricates food and facilitates easy passage of food.

ABSORPTION

Absorption is a process by which the end products of digestion are transported from the lumen of alimentary canal to the blood stream through the intestinal wall.

Absorption is the process by which nutrients pass from the alimentary canal into the blood and lymph through its mucous membrane. About 90% of nutrients are absorbed in small intestine while the rest 10% absorption occurs in stomach and large intestine.

Absorption of only certain drugs occurs in buccal cavity and very little absorption takes place in the stomach like of alcohol, some water and salts, certain drugs like aspirin etc. Practically, all absorption takes place through the small intestine. Small intestine is adapted to ensure effective absorption:

- It has great length of about 6 metres and is much coiled. The great length keeps the digested food for a longer time in the intestine to help complete absorption.
- Permanent circular folds on the mucosa and called *plicae circulares*.
- Intestinal mucosa raised into four millions of finger like projections, villi. The human intestine contains as many as 50,00,000 villi. They increase the absorptive surface of intestine.
- Each intestinal cell has numerous, electron microscopic evagination, microvilli (3000 per cell).

Each villus is with a lymph capillary called lacteal in the centre which is surrounded by a network of blood capillaries. The molecules of water, minerals, hexose sugars, amino acids and products of nucleic acids are absorbed by blood capillaries of the villi, while the fatty acids and glycerol molecules are absorbed into the lacteals.

Absorption across the plasma membrane of intestinal cells depends upon two types of processes namely passive absorption and active absorption.

Passive Absorption

In this, the nutrients are absorbed along the concentration gradient (higher concentration inside the lumen of intestine while lower concentration inside the intestinal cells). It depends upon the physical processes like *simple diffusion* (e.g., of small and water soluble molecules like some of electrolytes like Cl^-, monosugars like glucose, fatty acids, cholesterol), osmosis (e.g., of water & alcohol) and facilitated diffusion (movement of hydrophilic lipid in soluble molecules like fructose, mannose along concentration gradient with the help of some carrier ions like Na^+). It does not depend upon the energy so is a slow process. It continues till the concentration becomes equal on both sides of cell membrane so the substances cannot absorbed completely. Water, some water soluble substances and fructose are absorbed by passive absorption.

Active Absorption

In this, the nutrients are absorbed through the intestinal mucosa against concentration gradient. This is a rapid process as it depends upon the energy provided by the ATP. Active absorption occurs by two processes:

1. **Active Transport**: It is that active absorption which involves the carrier molecules called permeases or translocases which are generally proteinous in nature. Glucose, galactose, amino acids, Na^+ etc. are absorbed by active transport.
2. **Endocytosis**: It is also an active process by which large sized liquid or solid nutrients are taken in some vesicles through the plasma membrane.

ABSORPTION OF CARBOHYDRATES

Absorption of carbohydrate is the intake of monosaccharides from the lumen of the intestine into the blood. They enter the portal system of blood. Absorption of carbohydrate mainly occurs in the intestine. The maximum rate of glucose absorption is 120g/hour. Carbohydrates are absorbed in the form of glucose, galactose, fructose, mannose and pentoses. Glucose and galactose are absorbed much more rapidly than fructose, mannose and pentoses. Glucose and galactose are absorbed by active transport. Fructose is absorbed by facilitated transport.

Monosaccharides are present in the lumen of intestine. They are transported through the plasma membrane of intestinal cells into the cytoplasm. From the cytoplasm, they diffuse into the venous blood of portal system.

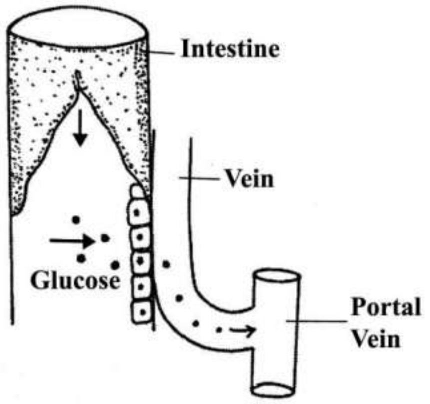

Fig.: Absorption of carbohydrate

The plasma membrane of intestinal cell has carrier protein called SGLT (Sodium dependent glucose transporters). The carrier protein has two binding sites, one for glucose and another for NA^+. It binds with sodium (Na^+) and glucose. Then the carrier protein moves towards the cytoplasm of the cell which brings both Na^+ and glucose facing the cytoplasm. Here both glucose and Na^+ are released. Glucose moves along the cytoplasm and diffuses into the blood. The Na^+ is transported back into the lumen of gut through sodium-potassium pump.

Na^+ is transported into the cell along the concentration gradient. Glucose move against the concentration gradient. The simultaneous transport of Na^+ and glucose is called co-transport. Since Na^+ and glucose are transported simultaneously in the same direction, it is also called symports.

SGLT also transports galactose. Fructose is also transported by the carrier protein GLUT (glucose transporters). The carrier for fructose is independent of Na^+. The transport of fructose is slower.

The carbohydrate absorption is controlled by the following factors:

1. Complete digestion of carbohydrates.
2. Presence of phosphoric acid and phosphokinase.
3. Adrenal cortex
4. Anterior pituitary
5. Insulin and
6. B complex vitamins like thiamine, pantothenic acid and pyridoxine.

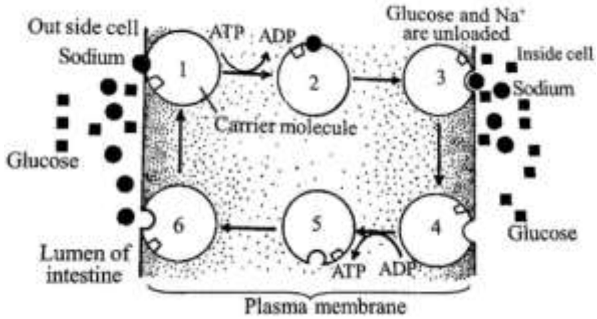

Fig.: Co-transport of glucose and sodium

ABSORPTION OF PROTEINS

Absorption of proteins is the intake of amino acids from the lumen of intestine into the blood. They are transported in to the portal system of blood. Absorption of proteins occur mainly in intestine, most of the protein absorption occurs in the jejunum and some absorption also occur in the ileum.

Amino acids are transported from the lumen of intestine into the cytoplasm of intestinal cells through the plasma membrane. From the cytoplasm they diffuse into the venous blood of portal system.

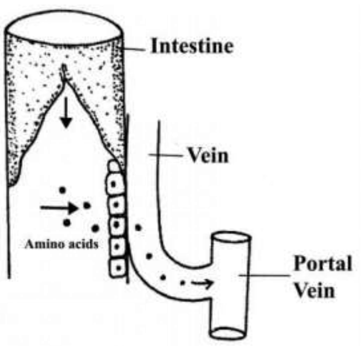

Fig.: Absorption of Protein

They are transported by active transport. Active transport is carried out by carrier proteins present in the plasma membrane of intestinal cells. The carrier protein has two binding sites one for amino acid and another for Na^+. It binds with amino acid and Na^+. Then the carrier protein moves towards the cytoplasm of the cell which brings both Na^+ and amino acid facing the cytoplasm. Here both amino acid and Na^+ are released.

Amino acid moves along the cytoplasm and diffuses into the blood. Na^+ is transported back into the lumen of gut by sodium potassium pump. The simultaneous transport of amino acids and Na^+ is called co-transport or symports.

The transport of amino acid is against concentration gradient and the transport of Na^+ is along the concentration gradient. The L form of amino acids are rapidly and actively transported. The D forms are transported very slowly and passively. About 7 carrier systems are observed for the transport of proteins. Of these 5 transport systems need Na^+ for co-transport and two are not cotransported with Na^+.

There are separate transport systems for neutral amino acids, more non-polar amino acids, less non-polar amino acids, basic amino acids and for proline and hydroxyproline. Some tri and dipeptides are actively transported into the intestinal cells and they are hydrolysed within the cells into amino acids. The amino acids diffuse into the blood. Some small peptides also enter the blood.

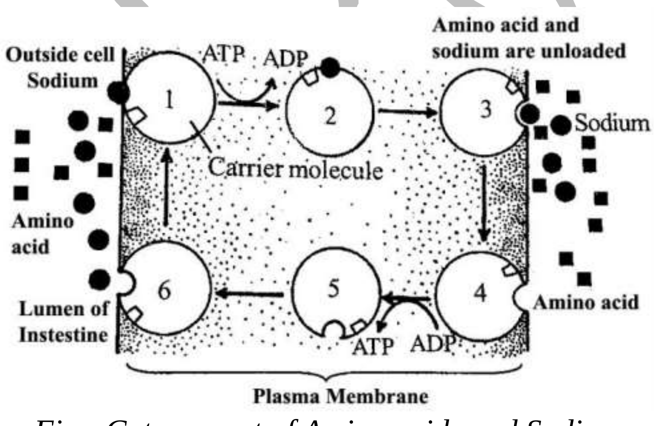

Fig.: Cotransport of Amino acids and Sodium

ABSORPTION OF FATS

Absorption of lipids is the intake of fatty acids and glycerol from the lumen of intestine into the blood. Absorption of lipids mainly occurs in the intestine. The fat is digested into fatty acids, glycerol, triglycerides, diglycerides, monoglycerides, phospholipids, cholesterol, cholesterol esters etc. lipids are transported through two routes namely venous blood and lacteals.

Free fatty acids with 12 or less carbon atoms are absorbed into the portal blood. Fatty acids with 14 or more carbon atoms are absorbed through the lacteals and passed into the thoracic duct. The products of fat digestion are absorbed by the intestinal cells from the lumen of intestine. The intestinal cells (endoplasmic reticulum) resynthesize triglycerides from the absorbed products of fat digestion. The triglycerides pass into the blood from the intestinal cells.

Lipid absorption is facilitated by bile salts of bile. The bile salts perform a ferrying function in transporting lipids from the lumen of intestine to the surface of intestinal cells. The bile salts function as the carrier of lipids.

Bile salts have a polar hydrophilic portion and a non-polar hydrophobic portion. Thus they have affinity for both water and lipids. Bile salts, in the presence of lecithin, interact with fatty acids and monoglycerides to form minute complexes called micelles. They are water soluble.

The micelles make the lipid soluble and transport them to the brush border of the intestinal cells. On contact with the cell surface, the bile salts separate from the lipid portion. The lipid portion passively diffuses through the plasma membrane and enter the cytoplasm.

The separated bile salts move into the lumen and transport more fatty acids and monoglycerides to the brush border. The micelles move down along the concentration gradient to the mucosal surface. Free cholesterol, formed from cholesterol esters by the action of esterases, enters the cell and are re-esterified. The lipids reach the venous blood through two routes namely through the portal blood and through the lacteals. Most of the short chain fatty acids having 12 or less carbon atoms and glycerol of the mucosal cells diffuse into the portal blood. Long chain fatty acids having more than 12 carbon atoms of the mucosal cells are resynthesized into triglycerides. This synthesis occurs in the smooth endoplasmic reticulum.

The resynthesized triglycerides and the absorbed phospholipids, cholesterol, cholesterol esters, free fatty acids with more than 12 carbon atoms and fat soluble vitamins are all combined with protein in the cisternae of endoplasmic reticulum to form large lipoprotein particles called chylomicrons. They enter the lacteals of the villus to be transported via the lymph to the thoracic duct and finally reach the venous blood. The chylomicrons do not enter the portal blood directly.

ROLE OF GIT HORMONES IN THE SECRETION AND CONTROL OF ENZYMES OF GIT

The digestive tract produces various hormones that affect almost every aspect of digestive function and some of them also affect the activities of other systems. These hormones are peptides produced by the enteroendocrine cells in the epithelium of the digestive tract. The main actions of the major gastrointestinal hormones or gut hormones are:

Gastrin

It is secreted by G-cells (flask shaped cells) from the antrum of stomach. Its target organ is stomach. It stimulates gastric glands to secrete and release the gastric juice. It also stimulates gastric mobility.

Enterogastrone or Gastric Inhibitory Peptide (GIP)

It is secreted by duodenum and target organ is stomach. It inhibits gastric secretion and motility (slows gastric contraction).

Secretin

It is secreted by S-cells of duodenum & jejunum and target organ is pancreas, liver and stomach. It stimulates bicarbonate secretion in the pancreatic juice, increases secretion of bile and decreases gastric secretion and motility. Secretin secretion is enhanced by amino acids, bile acid, fats, increased duodenal acidity and it is inhibited by somatostatin.

Cholecystokinin-Pancreozymin (CCK-PZ)

It is secreted by I-cells of small intestine and target organ is gall bladder, pancreas. It stimulates contraction of the gall bladder to release bile. It also stimulates pancreas to secrete and release digestive enzymes in the pancreatic juice.

Duocrinin

It is secreted by duodenum and target organ is duodenum. It stimulates the Brunner’s gland to release mucus and enzymes into the intestinal juice.

Enterocrinin

It is peptide hormone made of 27 amino acids. It is secreted by small intestine and target organ is small intestine. It stimulates the crypts of Lieberkuhn to release enzymes into the intestinal juice.

Vasoactive Intestinal Peptide (VIP)

It is secreted by small intestine and target organ is small intestine and stomach. It dilates peripheral blood vessels of gut and inhibits gastric acid secretion.

Villikinin

It is secreted by small intestine and target organ is small intestine. It accelerates the movements of villi.

Somatostatin (SS)

It is secreted by Delta cells of islets of Langerhans of pancreas, Argentaffin cells of gastric and intestinal glands. The target organs are pancreas, gastrointestinal tract. It inhibits the secretion of glucagon by alpha cells and insulin by beta cells. It also inhibits absorption of nutrients from the gastrointestinal tract. It suppresses the release of hormones from the digestive tract.

Pancreatic Polypeptide (PP)

It is secreted by pancreatic polypeptide cells and target organ is pancreas. It inhibits the release of pancreatic juice from the pancreas.

Motilin

It is 22 amino acids polypeptide secreted by enterochromaffin cells and Mo cells in the stomach, small intestine and colon. It produces contraction of smooth muscle in the stomach and intestines in injection. It is major regulator of the migrating motor complexes (MMCs) that control gastrointestinal motility between meals.

Any Error in this document is silent testimony of the fact that it was a human effort"

"Dr. WKB"

Dr. Wahied Khawar Balwan's Zoology Study Material
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