

The Human Digestive System

The Chemical Foundation of Digestion :

All organisms, regardless of size or complexity, have some method to obtain the essential nutrients they need for survival. Heterotrophs are organisms that depend on organic molecules manufactured by other living things. Autotrophs are organisms that nourish themselves using inorganic material (examples: water and carbon dioxide).

The **Essential Nutrients** are the basic raw materials organisms need to make their own structures, perform functions, and obtain energy for survival.

There are Six Essential Nutrients :

- 1) carbohydrates
- 2) fats (lipids)
- 3) proteins
- 4) minerals
- 5) vitamins
- 6) water

Your body functions best when these essential nutrients are present in correct proportions. A diet that satisfies this is called a ***balanced diet***.

1. **Carbohydrates :** consist of atoms of carbon, hydrogen, and oxygen (CHO). Carbohydrates are broken down to simple sugars during digestion such as glucose, fructose and galactose. Their main function is to provide a source of energy. The excess carbohydrates are converted to fat and stored. Some food sources would be glucose, rice, bread, pasta, etc.
2. **Fats (lipids) :** are made up of fatty acids and glycerol. Their functions include providing a source of energy, insulating the body from the cold, and protecting organs from injury. They can also be used as a building material for cell membranes and hormones. They are broken down to fatty acids and glycerol by the digestive system. Some food sources would be margarine, butter, meat, cheese, nuts, eggs, etc.
3. **Protein :** They are made up of peptides which consist of strings of amino acids (8 essential amino acids). Their functions include, cell growth and repair, enzymes in your body are all proteins (act in metabolism), and can supply energy. Some food sources would be meat, milk, poultry, fish, eggs, cheese, etc.
4. **Vitamins :** Our bodies require very small amounts in diet. They act as coenzymes, chemicals needed to make enzymes function. Examples would be vitamins: A, B, C, D, E, K. *See table 11-1 page 358.*

5. **Minerals** : They are the inorganic compounds that your body needs in small amounts. Their functions include helping to build bones and cartilage, enabling certain chemical reactions, and helping to maintain acid-base balance within the body. They are readily absorbed into the bloodstream.
6. **Water** : Its major role in the body is to act as a solvent. Most chemical reactions (body metabolism) that occur in the body require water. The main source would be food and liquids. Regardless of an organism's food source, the nutrients that an organism takes in or derives from its food must be in a form that can readily pass through the organism's cell membrane. Many organisms must reduce their food to a form from which nutrients can be absorbed.

Digestive System : It breaks down food masses into small useful substances that can be absorbed into the circulatory system where nutrients are transported to individual cells and are again absorbed.

Digestion - is the process of breaking necessary substances into smaller molecules so that they can be absorbed in the body. *This occurs in the alimentary canal, a continuous tube beginning at the mouth and ending at the anus.*

There are TWO basic types of digestion:

1. **Mechanical Digestion** : It is the initial stage of physically breaking down food into smaller pieces. It occurs mainly in the mouth where teeth chew food and tongue manipulates the food.
2. **Chemical Digestion** : It is the separation of food into molecular components by chemical means. The process begins in the mouth with the secretion of saliva which contains the digestive enzyme *amylase*. The chemically breaking down of food continues through the stomach and is completed in the small intestine.

NOTE : *Mechanical and chemical digestion act together to speed up the digestion process. Mechanical digestion aids chemical digestion by exposing more food particles to digestive enzymes.*

The Major Organs and Glands involved in digestive process:

1. **Salivary Glands** : There are three pairs located in the mouth – parotid glands (largest of the glands), sublingual glands, and submaxillary glands. These glands open up into the mouth cavity by means of ducts (*tubular canals that carry glandular secretions from one part of the body to another*).
2. **Esophagus** : It is a hollow tube leading from the mouth into the stomach. It is lined with

circular and longitudinal muscles that contract alternatively causing waves of movement that pushes food through the canal. It has a hollow interior space called the ***lumen***. The lumen is lined with layers of cells called mucosa that secrete mucus. The ***sphincter muscle***, located at the lower end of the esophagus, is thickened in order to give some control over the flow of food into the stomach.

3. **Stomach** : It is a muscular, j-shaped, sac-like organ which can store approximately 2 litres of food.. The interior is lined with layers of mucosa that secrete mucus, enzymes, hydrochloric acid and water which form gastric juice (pH around 1). The muscles lining the stomach work to physically break food into smaller pieces and mix it with gastric juices to form a thick liquid called ***chyme***. The end of the stomach leading into the small intestine consists of a thick muscular structure referred to as the ***pyloric sphincter***.

4. **Pancreas** : It has two main functions with regards to digestion to regulate homeostasis of blood sugar and produce pancreatic juice. The pancreatic juice can act to neutralize stomach acid; it contains digestive enzymes, and it contains proteases which break down polypeptides into shorter chains. It also secretes ***lipase*** which can break down fats or triglycerides into fatty acids and glycerol. The pancreas also produces amylase similar to that produced by the salivary glands. The pancreatic juice reaches the small intestine through the pancreatic duct.

5. **Liver** : *The liver has many functions but only those related to digestion will be discussed here.* If glucose is absorbed into the blood from a meal, liver cells collect and convert glucose into glycogen, a polysaccharide. The glycogen is stored in the liver until it is needed by the body. The liver also produces bile, which contains no enzymes but emulsifies fat (breaks it down into tiny droplets). This allows ***lipase*** to digest lipids faster since the droplets have more surface area.

6. **Gall Bladder** : It is not involved in enzyme production but serves as a storage warehouse for bile produced in the liver. Bile contains a number of chemicals including cholesterol and bile salts which are important in the digestion of fats.

7. **Small Intestine** : It is the most important organ of the digestive tract. It is approximately 6 metres long. It is the site of most chemical digestion and absorption of food molecules into the blood. It can be subdivided into three parts:
(I) **Duodenum** is the first region of the small intestine. The pancreatic and bile ducts lead into here making it a site where chemical digestion occurs. It contains circular folds that greatly increase surface area allowing for more food to be absorbed. These folds are finger-like projections called ***villi*** (microvilli) that serve to increase the absorptive surface of the intestinal tract. The duodenum contains the enzyme peptidase which breaks polypeptides into individual amino acids and other enzymes which break disaccharides into monosaccharides.

(II) *Jejunum* is the next part. It contains many folds and intestinal glands in order to breakdown any remaining protein or carbohydrates.

(III) *Ileum* is the last part. It contains few and very small villi. Their main function is to absorb nutrients through processes such as diffusion and active transport. It also pushes remaining undigested material through to the large intestine.

8. **Large Intestine :** It is divided into different structures: *caecum, colon, rectum and anal canal*. It is much shorter than the small intestine although the diameter is much larger(which is the basis for its name). It can be separated from the small intestine by a valve. The *caecum* is a sac-like structure at one end of the small intestine where the *appendix* is found. The *colon* is the main portion of the small intestine where water and dissolved minerals are absorbed from undigested food. The *colon* also contains *intestinal bacteria* that helps to breakdown undigested material to provide more nutrients and can produce *vitamins B-12 and K*. The mass of indigestible material that remains is known as *feces*. The *feces* passes through the *rectum* and *anal canal* and out the body through the *anus*. The *anus* contains rings of muscular muscle called the anal *sphincter* that allow the body to control timing of elimination to some extent.

The Pathway of food through the Human Digestive System :

1. The *mouth* contains teeth along the upper and lower jaws. The teeth can vary in structure and number depending on the species; (examples would be *incisors, canine, premolars and molars*). The mouth contains the tongue that is composed of skeletal muscle and changes shape when it contracts. A mucus membrane attaches the tongue to the floor of the mouth. The tongue is covered with tiny pimple-like structures called *papillae* that hold most of the taste buds. The *uvula* hangs from the middle edge of the soft palate in the mouth and helps prevent food from entering the pharynx when we swallow. The mouth contains salivary glands that secrete saliva.
2. The *esophagus* is the connecting tube from the mouth to the stomach. It is lined with muscles that work to move the food along. It also contains mucin, a lubricant, secreted by glands located within the esophagus.
3. The *esophageal sphincter* is a thick, circular muscle ring at the lower end of the esophagus before the entrance to the stomach. It provides some involuntary control over the flow of food into or out of the stomach.
4. The *stomach* is a muscular, j-shaped, sac-like structure. It contains a third muscular layer not present in the esophagus (*the oblique layer*) that works to break down food physically and mix it with gastric juices.
5. The *pyloric sphincter* is a thickened, circular muscle structure which forms a valve at the juncture between the stomach and the duodenum. It can contract and relax to control the flow of food leaving the stomach.
6. The *small intestine* is divided into three sections: duodenum, jejunum, and the ileum. It is lined with microvilli and villi that aid in the absorption of nutrients.

7. The *large intestine* is divided into separate sections; caecum, colon, rectum and anal canal. The feces passes out through the body at the end of the anal canal referred to as the anus.

Movement of food through the Digestive System :

- water acts as a lubricant which helps food pass through the digestive system.
- ***Peristalsis*** - a series of wavelike contractions and relaxations of longitudinal and circular muscles that move food. To move the food, circular muscles over the food mass relax, longitudinal muscles in front of the food mass relax and circular muscles immediately behind the food mass contract.
- ***rhythmical segmentation*** - can also aid in the movement of food through the digestive system. The food is held in approximately the same location of the intestine in ***rhythmical segmentation*** and rhythmical contraction of circular muscles squeeze it back and forth.

Chemical Digestion and Enzymes :

Digestion - is the chemical breakdown of food by hydrolysis.

Hydrolysis- is a reaction where covalent bonds between subunit molecules in a macromolecule are broken down by the addition of a water molecule. A water molecule is added at the point where a link in the complex molecule is broken.

Enzymes - are chemicals produced by cells that speed up reaction rates..

- There are three types of digestive enzymes involved in digestion:
(1) Carbohydrases ; eg. Salivary Amylase and Pancreatic Amylase
(2) Lipases eg. Lipase (from the pancreas)
(3) Proteinases eg. Pepsin (from the stomach) .

The job of a digestive enzyme is to break large molecules which are too big to be absorbed into the bloodstream into molecules small enough to be absorbed.

See Table 11.2 page 365 in the Textbook for examples of foods, enzymes that act on them and their end-products . Know salivary amylase, Pancreatic amylase, Pepsin, Lipase.

Digestive Disorders :

Problems with the digestive system can range from minor inconveniences to a major impediment to a normal life.

Minor Disorders :

1. ***Ulcers :*** The stomach has a very high acidity because it kills most bacteria present in food. The thick mucus layer on the wall of the stomach protects it from acid. Sometimes acid can penetrate the mucus layer and causes the stomach wall to begin to erode resulting in a slow healing sore called an ***ulcer***. Most ulcers are caused by acid resistant bacterium which attach to the stomach wall preventing mucus secretion and directly exposing the stomach wall to stomach acid. Other factors that can cause ulcers include: alcohol consumption, smoking, caffeine, and stress. Ulcer treatments can include medication that reduce stomach acid production or strengthen mucus layer, antibiotics, and making life adjustments. For severe cases, surgery to block nerve impulses or to remove a part of the stomach may be options.

2. ***Gallstones :*** ***Gallstones*** are small, hard masses that form in the gall bladder. The gall bladder stores excess bile produced by the liver. Occasionally, cholesterol in bile can precipitate out and form crystals which can grow in size and become gallstones. Factors leading to the formation of gallstones can include obesity, excessive alcohol use, and heredity. Treatments include medications or lithotripsy (ultrasound shockwaves that disintegrate the stones so they can be passed in the urine). There is a high rate of recurrence of gallstones.

3. ***Inflammatory Bowel Disease :*** These diseases cause inflammation in the intestines.

There are several types:

(I) ***Crohn s Disease*** is a disease of the lower part of the small intestine (ileum), but can affect any part of the digestive tract from the mouth to the anus. *Ileitis* is inflammation of the ileum resulting in pain and making the intestines empty frequently, resulting in diarrhea. Fever and rectal bleeding can occur as well as loss of weight and decreased appetite. The cause is unknown but it is a chronic disease and affects men and women equally. Research has shown the body produces an immune response to a part of the digestive tract misreading it as a foreign substance. Treatments include aspirin like drugs to reduce pain, corticosteroids to reduce inflammation, antibiotics, and immune modifiers to try and minimize the body s immune response. Surgery to remove the diseased portion of the bowel is an option but the disease often recurs years after surgery.

(II) ***Colitis*** is inflammation and ulceration of the lining of the colon. Crohn s disease affects the entire thickness of the colon, colitis only affects the innermost lining. Symptoms include loose, bloody stool, crampy abdominal pain, skin lesions, joint pain and in children, failure to grow normally. Treatments include removing the entire bowel and rectum, and an external opening called an ileostomy is created for waste.

Why is good nutrition so important? It provides the energy our body need to carry out many

metabolic activities such as nerve transmission, muscle contraction, and cell repair and replacement . It also provides the essential raw materials that our bodies need as building blocks but are unable to manufacture for themselves.

Herbal Supplements : Although many people take herbal supplements such as *Echinacea* which is thought to bolster your immune system and prevent infections and colds, there is few scientific studies that actually confirm the claims of these herbs.

Eating Disorders : In today s society, a great deal of value is placed on physical appearances. This places pressure on many individuals to maintain a particular weight or level of fitness. In some cases, individuals may become obsessed with their bodies and deprive themselves of basic nutrients their bodies require in order to stay thin. This can lead to eating disorders.

Examples :

(I) **Anorexia Nervosa** : An eating disorder characterized by a fear of gaining weight and results in the person going on a restrictive diet. It is characterized by a body mass of less than 85% of their normal mass and a distorted image of themself (fat). The symptoms of starvation be present could be low blood pressure, irregular heartbeat, and constipation. Severe cases can lead to drying of skin, trouble in functioning of internal organs, and death. Treatment could involve hospitalization and psychological therapy.

(II) **Bulimia Nervosa** : An eating disorder characterized by episodes of binge eating followed by purging accomplished through the use of laxatives or vomiting. It may be associated with both obesity and anorexia. A person tends to be on a restrictive diet but they lose control at some point and eat large quantities of forbidden food which they later purge from their body. It can result in a change in blood composition, which can damage the heart and kidneys and could lead to death. The ongoing vomiting damages the esophagus and pharynx, and acid from the stomach can damage teeth. Treatment could include psychological therapy and anti-depressants.