NUTRITION

Chapter 8

Major Concept

In this Unit you will learn:

- Introduction
- Nutrition in Plants
  - Nutrition and Nutrients in Plant
  - Nutrients and Modes of Nutrition
  - Mineral Nutrition in Plants (Role of Nitrates and Magnesium and effects of their deficiencies)
- Heterotrophic Nutrition
- Nutrition in Man
  - Major Components of Food
  - Effects of Vitamins
  - Effects of Minerals
  - Effects of Water and Dietary fibers
  - Balanced Diet
  - Problems related to Nutrition
  - Protein Energy Malnutrition
  - Mineral Deficiency diseases
- Digestion in Man
  - Ingestion
  - Digestion
  - Absorption
  - Assimilation
  - Egestion
  - Role of liver in digestion
  - Absorption of Food (Structure of Villus)
- Disorders of Gut (Diarrhea and Constipation)

INTRODUCTION

Process by which organisms obtain and use the nutrients required for maintaining life is called nutrition. Essential substances that our body needs in order to grow and stay healthy are known as nutrients. There are two processes by which food is obtained or prepared such as:

- **Autotrophic nutrition** - it is the mode of nutrition in which an organism makes its own food from the simple inorganic materials like carbon dioxide, water and minerals present in the surrounding (with the help of energy). The processes are photosynthesis or either chemosynthesis.
- **Heterotrophic nutrition** - it is the mode of nutrition in which an organism can't make its own organic material but depends on other organisms for its food and use it for growth and energy.

Nutrition is the study of nutrients in food, how the body uses nutrients, and the relationship between diet, health, and diseases.

Figure 8.1 Nutrients

8.1 NUTRITION IN PLANTS

Plants and animals do not obtain food by the same processes. Plants and some bacteria have the green pigment chlorophyll to 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 and heterotrophic.

1. Autotrophic nutrition:

The term 'autotroph' is derived from two Greek words-autos (self) and trophe (nutrition). In autotrophic nutrition, an organism makes its own food from simple raw materials.

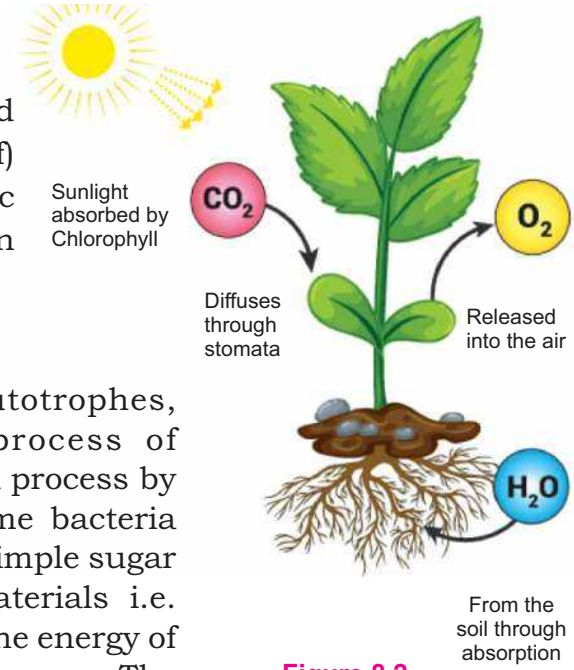


Figure 8.2
A summary of nutrition in green plants

Photosynthesis:

Green plants, which are autotrophes, synthesize food through the process of photosynthesis. Photosynthesis is a process by which green plants, algae and some bacteria having chlorophyll, synthesize the simple sugar (glucose) from the simple raw materials i.e. water and carbon dioxide by using the energy of sunlight. Oxygen is released in this process. The overall equation of photosynthesis is:

$$6CO_2 + 12H_20 \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

2. Heterotrophic nutrition:

The word 'heterotroph' is derived from two Greek words-heteros (other) and trophe (nutrition). Unlike autotrophes, which manufacture their own food, heterotrophic organisms obtain food from other organisms. As heterotrophs depend on other organisms for their food, they are also called consumers. All animals, non-green plants like and 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 simple molecules with the help of biological catalysts, i.e., 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, saprotrophic or holozoic.

(i) Parasitic nutrition:

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. This mode of nutrition is called parasitic nutrition. Different parasites, like Cuscuta (akash-bel), hookworms, tapeworms, leeches, etc., have different modes of feeding, depending upon habit, habitat and modifications.

Cuscuta

Cassytha

Leech

Tapeworm

Figure 8.3 Parasites

(ii) Saprotrophic nutrition:(Gr: Sapros=rotten, Trophic=nutrition)

Saprotrophic organisms, or saprotrophes, derive their food from dead and decaying organic material. This mode of nutrition is called saprotrophic nutrition. They secrete enzymes that are released on food material outside their body. These enzymes break down complex food into simple forms. Common examples of saprotrophes are fungi (moulds, mushrooms, yeasts) and many bacteria.

(iii) Holozoic nutrition: (Gr:Holo=Whole, Zoikos=of animal)

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 out) from the body. This kind of nutrition is found mainly in non-parasitic animals-simple ones like Amoeba and complex ones like human beings.

How organisms obtain nutrition?

Different organisms obtain food in different ways. Nutrition in unicellular organisms like Amoeba, involves ingestion by the cell surface, digestion and egestion.

Amoeba takes in complex organic matter as food. Amoeba first identifies its food then throws out a number of small pseudopodia (projections of cytoplasm, also called false feet). These pseudopodia enclose the food particle and prevent it from escaping. The food enclosed in the cell membrane forms a food vacuole.

The complex food is broken down into simpler molecules with the help of digestive enzymes produced by an organelle called lysosome. The digested food is distributed in the cytoplasm and the undigested food is egested through the cell membrane.

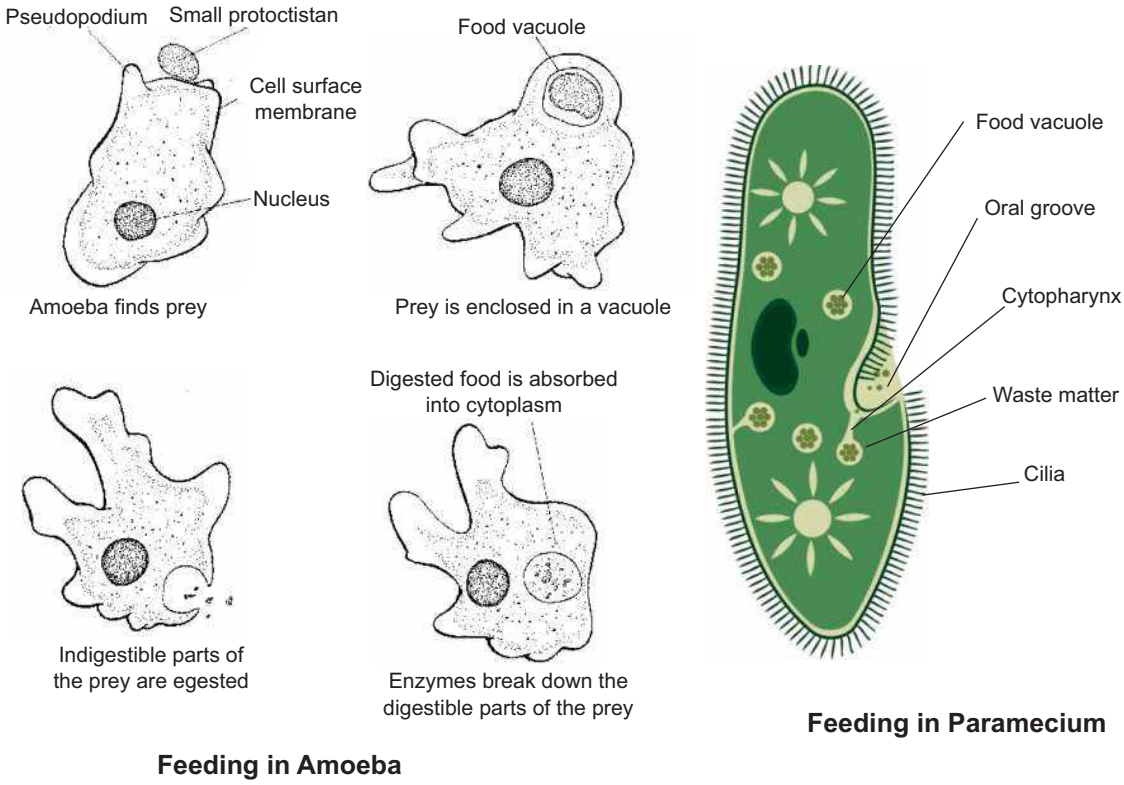


Figure 8.4 Food gathering by Amoeba and Paramecium

In Paramecium, a unicellular organism with a specific shape, food is ingested through a special opening, the cytostome (cell mouth). Food is brought to this opening by the lashing movement of cilia that cover the entire surface of the cell.

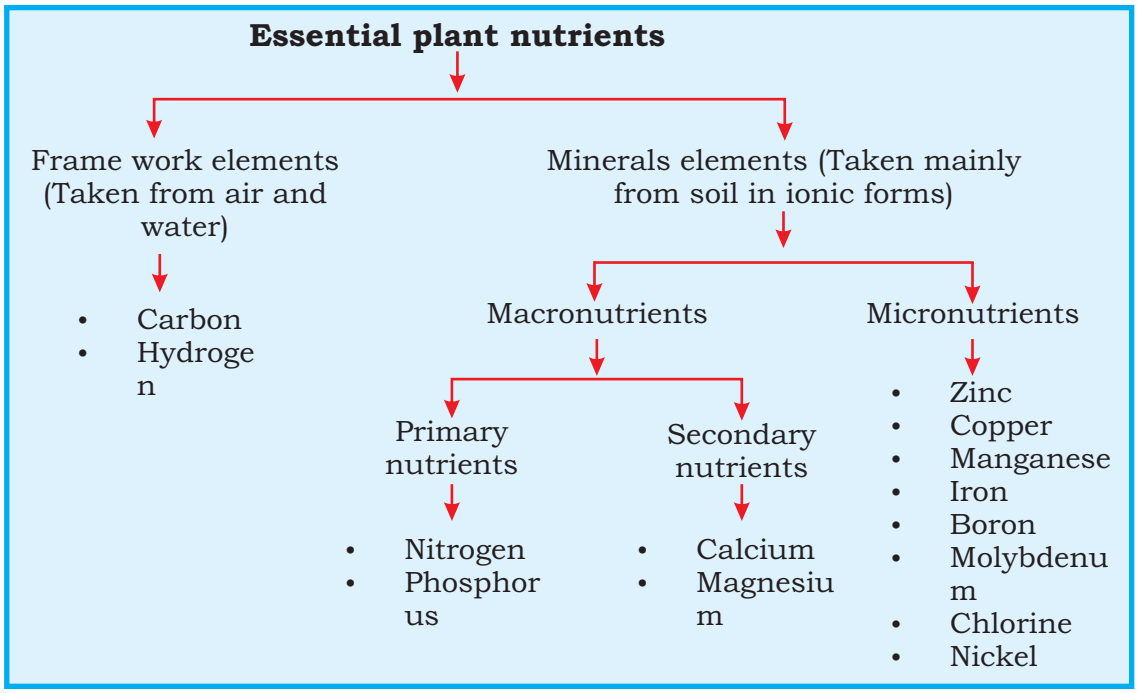
Mineral nutrition in plants:

The process involving the absorption, distribution and utilization of mineral substances by the plants for their growth and development is called mineral nutrition.

Plants have the most efficient mechanism for preparing there food by using many elements essential for plant nutrition. Plants require a steady supply of macronutrients and micronutrients. The difference between the two is quite simple: macronutrients are required in larger quantities than micronutrients.

The names of the two categories don't apply, indicate that one type of nutrient is more important than another; it just means that more macronutrients must be present in the soil than micronutrients. Plants obtain nearly all of the nutrients they need from the soil, although some are synthesized or produced via photosynthesis.

Classification of essential plant nutrients



8.1.1 Role of Nitrogen and Magnesium:

(i) Nitrogen

Nitrogen is essential for plants to synthesize amino acids, which are the building blocks for protein synthesis and also required for the production of chlorophyll, nucleic acids, and enzymes. From all metabolic elements which plants use from soil, nitrogen needs in the largest amounts.

Symptoms of nitrogen deficiency:

Nitrogen-deficient plants exhibit stunted growth, reduced yields and their foliage pale green.

(ii) Magnesium:

Many enzymes in plant cells require magnesium in order to perform properly and is a constituent of the chlorophyll molecule, which is the driving force of photosynthesis.

Symptoms of magnesium deficiency:

Magnesium deficiency is most prevalent on sandy-textured soils, which are subject to leaching, particularly during seasons of excess rainfall. The predominant symptom is **interveinal chlorosis** (dark green veins with yellow areas between the veins). The bottom leaves are always affected first as shown in figure 8.5.

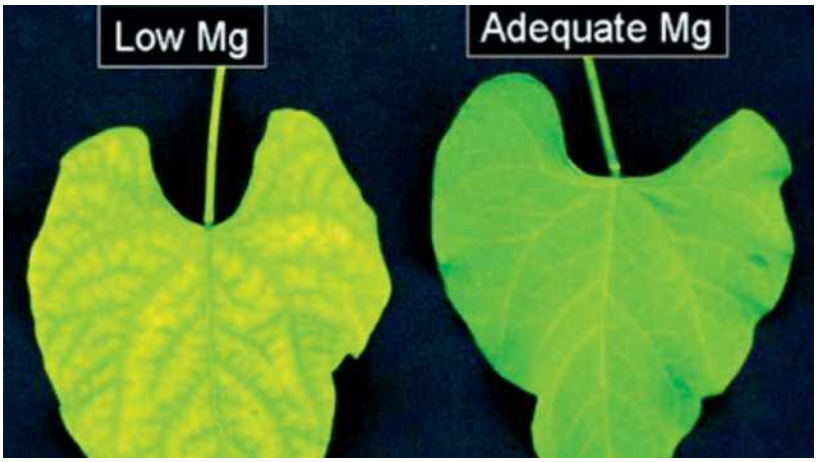


Figure 8.5 Interveinal chlorosis

8.1.2 Importance of fertilizers:

Fertilizers are substances containing chemical elements such as manure or mixture of nitrates that improves the growth of plants. They give nutrition to the crops and produce more fruit, faster growth, more attractive flowers. When added to soil or water, plants can develop tolerance against pests like weeds, insects and diseases. And the use of manure and composts as fertilizers is probably almost as old as agriculture. Modern chemical fertilizers include one or more of the three elements that are most important in plant nutrition: nitrogen, phosphorus, and potassium. Chemicals fertilizers are simply plant nutrients applied to agricultural fields to supplement required elements found naturally in the soil.

8.1.3 Environmental hazards related to chemical fertilizers:

An environmental hazard is a condition, which has the potential to threat natural environment or adversely affect people's health, including pollution and natural disasters.

The farmers apply fertilizer for better growth of their crops, but on the other side these fertilizers pollute water and soil as well.

1. Soil nutrient holding capacity:

The massive quantities of inorganic fertilizers affect the soil nutrient holding capacity.

2. Eutrophication:

The high solubility of fertilizers also degrade ecosystem through eutrophication (means an increase in chemical nutrients typically compounds containing nitrogen or phosphorus in an ecosystem).

3. Emission of greenhouse gas:

Storage and application of some nitrogen fertilizers may cause emission of greenhouse gas, e.g nitrous oxide.

4. Soil acidity:

Ammonia gas (NH_3) may be emitted from applied inorganic fertilizers. This extra ammonia can also increase soil acidity.

5. Pest problems:

Excessive nitrogen fertilizers can lead to pest problem by increasing their reproduction rate.

6. Nutrient balance:

It is recommended that nutrient content of the soil and nutrient requirement of crop should be carefully balanced with application of inorganic fertilizers. It is critical to apply no more than it is needed; any excess in nutrient will definitely develop pollution of any kind.

8.1.4 Components of Human Food:

Holozoic nutrition is the type of heterotrophic nutrition. Heterotrophic organisms have to acquire and take in all the organic substances they need to survive. There are seven major classes of nutrients: carbohydrates, protein, fats, minerals, fiber, vitamins, and water.

1. Carbohydrates:

Carbohydrates are necessary for your body specially glucose, which is primary source of energy. They are generally divided in two categories: simple carbohydrates such as sucrose, which digest quickly and complex carbohydrates such as starch etc, which digest slowly. Sources of simple carbohydrates include fruits, sugars and processed grains, such as white rice or flour. You can find complex carbohydrates in green or starchy vegetables, potatoes, whole grains, beans and lentils. The most common and abundant forms are sugars, fibers, and starches.

Figure 8.6 The food rich in carbohydrates

2. Proteins:

Proteins consist of units called amino acids, attach together in complex formations. Proteins are complex molecules, the body takes longer to break them down. As a result, they are much slower and long lasting source of energy than carbohydrates.

Proteins

Figure 8.7 The food rich in proteins

There are 20 amino acids. The body synthesizes some of them from components within the body, but it cannot synthesize 9 of the amino acids called essential amino acids. They must be consumed in the diet.

The body needs protein to maintain and replace tissues and their function. Protein is not usually used for energy. However, if the body is not getting enough calories from other nutrients or from the fat stored in the body, protein is used for energy.

The energy obtained from carbohydrates, proteins, and fats is measured in units called calories.

3. Fats:

Fats are complex molecules composed of fatty acids and glycerol. The body needs fats for growth and energy. It also uses them to synthesize hormones and other substances needed for the body's activities.

Figure 8.8 The food rich in fats

Fats are the slowest source of energy but the most energy-efficient form of food. The body deposits excess fat in the abdomen (omental fat) and under the skin (sub cutaneous fat) to use when it needs more energy. The body may also deposit excess fat in blood vessels and within organs, where it can block blood flow and damage organs, often causing serious disorders.

Some typical sources of saturated fats include:

- Fatty cuts of beef and lamb.
- Poultry skin.
- High fat dairy foods (whole milk, butter, cheese, sour cream, ice cream)
- Tropical oils (coconut oil, palm oil, cocoa butter)

Function of each food type in Human body

Carbohydrates	(i) Sugar →	**For energy**
	(ii) Starch →	**For energy**
	(iii) Fibre →	**Prevents constipation**
Protein →		**For growth and repair of cells**
Fat →		**For energy and insulation**
Vitamins	(i) Vitamin C →	For healthy skin/gums
	(ii) Vitamin D →	For strong bones
Minerals	(i) Calcium →	For strong bones
	(ii) Iron →	To make red blood cells
Water →		To dissolve and transport substances

4. Vitamins

A vitamin is an organic molecule (or related set of molecules), an essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism. They are for maintaining normal health and development. Lack of vitamins can cause several diseases. They are divided into two types:

(i) Fat-soluble Vitamins: Vitamin which can soluble in organic solvent are called Fat-soluble vitamins (A, D, E and K) are less excreted from the body as compared to water-soluble vitamins.

(ii) Water soluble Vitamins: Vitamin which are soluble in H_2O. These are vitamins B and C. Cooking or heating destroys the water soluble vitamins more readily than the fat-soluble vitamins.

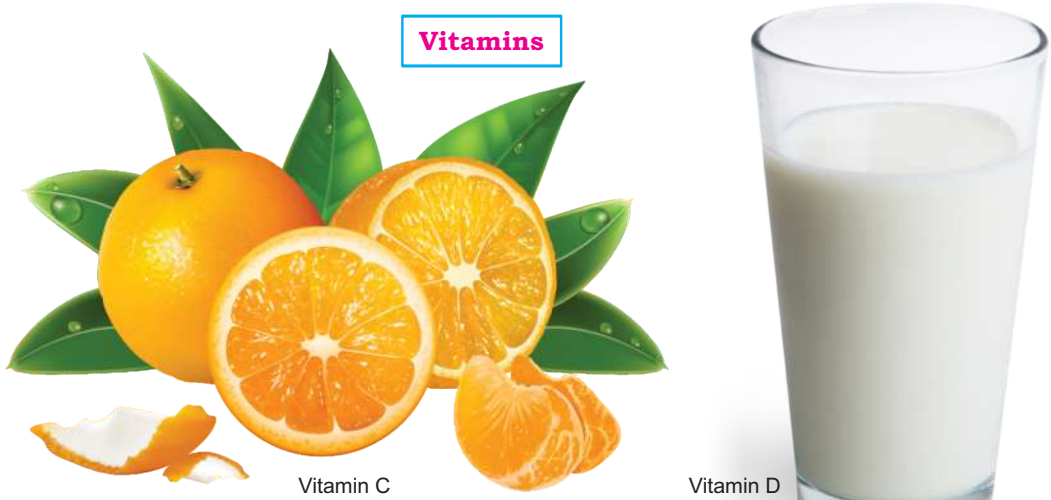


Figure 8.9 The food rich in Vitamins

Functions, chemical names and deficiencies of important vitamins

Vitamin generic name	Deficiency diseases
Vitamin K	Bleeding disorder
Vitamin D	Rickets and osteomalacia
Vitamin C	Scurvey
Vitamin B	Beriberi
Vitamin A	Night blindness, eye-infection, rough skin, respiratory infections

5. Minerals:

A class of naturally occurring solid inorganic substances with a characteristic crystalline form. Minerals are vital for proper human health.

Essential minerals include calcium, iron, zinc, iodine and chromium. Deficiencies can result in serious health conditions such as brittle bones and poor blood oxygenation. Minerals are found in a variety of foods including dairy and meat products.

Metabolic function of Calcium:

Calcium metabolism refers to the movements and regulation of calcium ions (Ca^{+2}) in and out of various body compartments. Good calcium nutrition, along with low salt and high potassium intake, prevents from hypertension and kidney stones.

- **Sources of calcium include:**
  - Milk, cheese and other dairy foods
  - Soya beans
  - Bread
  - Green leafy vegetables
  - Nuts
  - Fish

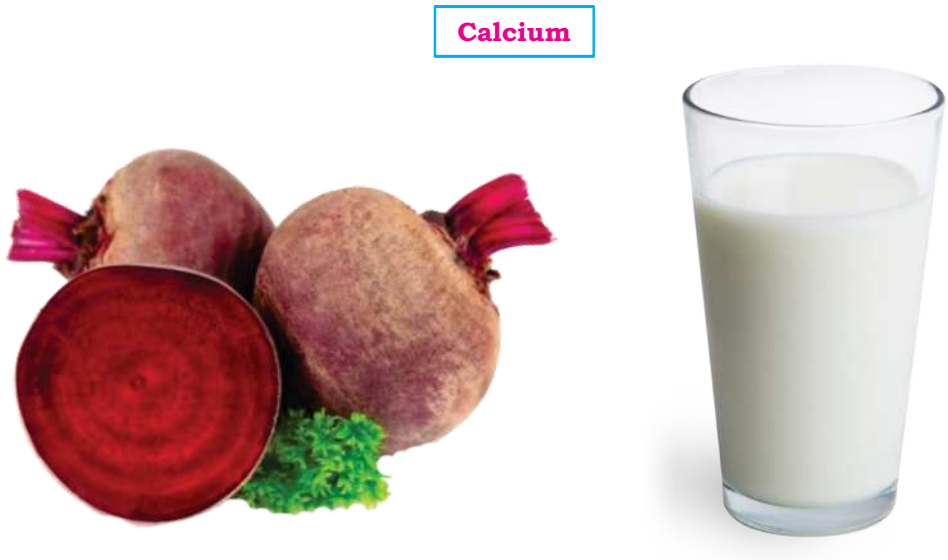


Figure 8.10 The food rich in Calcium

Deficiency symptoms of calcium:

- Fainting
- Heart failure
- Numbness and tingling sensations around the mouth or in the fingers and toes
- Difficulty swallowing
- Voice changes due to spasm of the larynx
- Chest pains
- Wheezing
- Muscle cramps, particularly in the back and legs; may progress to muscle spasm (tetany)

Metabolic function of iron:

Iron plays a major role in oxygen transport and storage. It is a component of haemoglobin in red blood cells and myoglobin in muscle cells.

Some of the best plant and animal sources of iron:

- Beans and lentils
- Tofu
- Dark green leafy vegetables such as spinach

Deficiency symptoms of iron:

- Extreme fatigue
- Pale skin
- Chest pain, fast heart beat or shortness of breath
- Brittle nails
- Weakness
- Headache, dizziness
- Inflamation or soreness of tongue
- Poor appetite in infants

6. Metabolic function of Water and Dietary fibres:

Water is the medium for various enzymatic and chemical reactions in the body. It moves nutrients, hormones, antibodies and oxygen through the blood stream and lymphatic system. Water maintains the body temperature through evaporation as in sweating. Severe dehydration causes cardio-vascular problems.

Water

Figure 8.11 The Water

Generally speaking, dietary fiber is the edible part of plants, or similar carbohydrates, that can't be digested and absorbed in the small intestine. Fibre plays very important role to prevent from constipation. Soluble fibre helps in lowering the blood cholesterol and blood sugar level.

To get the proper nutrition from your diet, you should consume the majority of your daily calories in: fresh fruits and fresh vegetables.

8.2 A BALANCED DIET IS RELATED TO AGE, SEX AND ACTIVITY

Different factors affect the nutritional requirement during the periods of body growth & development. Energy requirements change through life and depend on many factors, such as: Age; Sex and Level of activity.

The key stages in life include:

Childhood; the energy requirements of children increase rapidly because they grow quickly and become more active. Young children do not have large stomachs to cope with big meals. Therefore, to achieve the relatively high energy intake for their age, foods should be eaten as part of small and frequent meals.

Adolescence; is a period of rapid growth and development and is when puberty occurs. The demand for energy and most nutrients are relatively high. Boys need more protein and energy than girls for growth.

Children should be encouraged to remain a healthy weight with respect to their height.

Figure 8.12 Balance Diet

Adulthood; a good supply of protein, calcium, iron, vitamin A and D, as part of a healthy, balanced diet, are important. Calcium is needed for healthy tooth development, and together with vitamin D, can help develop strong bones.

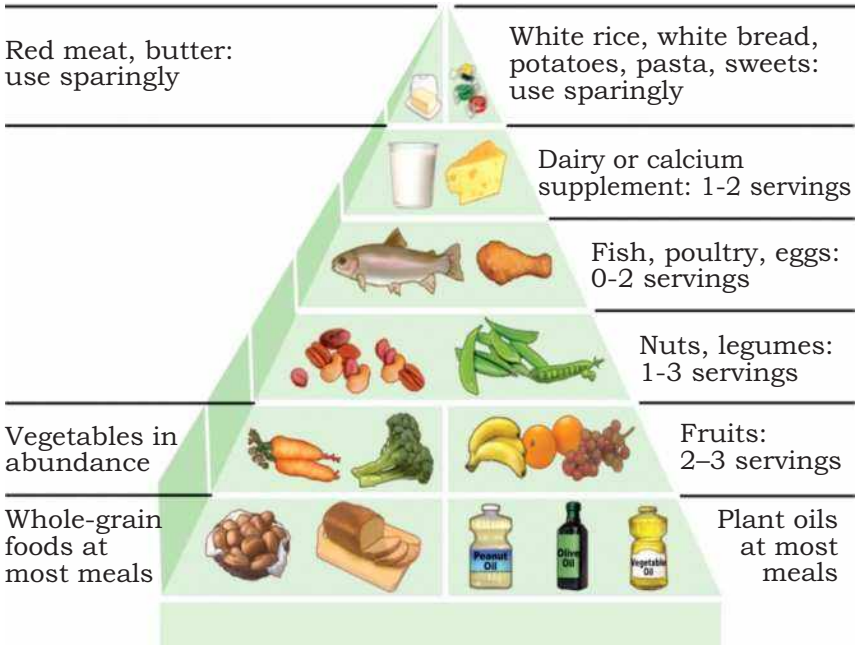


Figure 8.13 Healthy Eating Pyramid

Men are more active than women so they need more energy than women of same age group. Muscular tissues are more in men, their body size is larger, and therefore, boys of growing age need more body building nutrients (Proteins, Calcium) as compared to girls of same age.

8.2.1 Problems related to nutrition (Malnutrition):

Problems related to nutrition are grouped as malnutrition. The malnutrition is a condition that occurs when a body does not get enough nutrients. Malnutrition results from a poor diet or a lack of food. It happens when the intake of nutrients or energy is too high, too low, or poorly balanced. Consuming less than 2100 calories a day, one is considered to be under-nourished and suffering from hunger.

According to the World Health Organization (WHO), malnutrition is the gravest single threat to global public health. Globally, it contributes to 45 percent of deaths of children aged less than 5 years.

There are two types of malnutrition:

Chronic malnutrition: characterized by delayed growth in the children.

Acute malnutrition: Characterized by insufficient weight in relation to the child's height (emaciation). Acute malnutrition can be moderate or severe according to the child's weight.

Under-nourishment and malnutrition have serious consequences for the health of the younger children. Worldwide, three nutrient deficiencies are of particular concern:

- Vitamin A deficiency is the world's most common cause of preventable child blindness and vision impairment.
- Iron deficiency is associated with decreased cognitive abilities and resistance to disease.
- Iodine deficiency is the major preventable cause of mental retardation worldwide.

Malnutrition is one of the most prevalent public health problems in Pakistan. It is one of the major underlying factors for high infant and under 5 mortality rate in Pakistan. Poverty, lack of education, poor environmental hygiene and food fads are some of the reasons for its high prevalence in Pakistan.

8.2.2 Protein deficiency disorders:

Protein energy malnutrition (PEM) refers to inadequate availability or absorption of energy and proteins in the body. It is the leading cause of death in children in developing countries. PEM may lead to diseases such as;

(a) Kwashiorkor:

Kwashiorkor is a severe form of malnutrition, caused by a deficiency in dietary protein. The extreme lack of protein causes an osmotic imbalance in the gastro-intestinal system causing swelling of the gut diagnosed as an edema or retention of water as shown in figure 8.14.

(b) Marasmus:

Marasmus is a form of severe malnutrition characterized by energy deficiency. It can occur in anyone with severe malnutrition but usually occurs in children. A child with marasmus looks emaciated. Body weight is reduced to less than 62% of the normal (expected) body weight for the age as shown in figure 8.14.

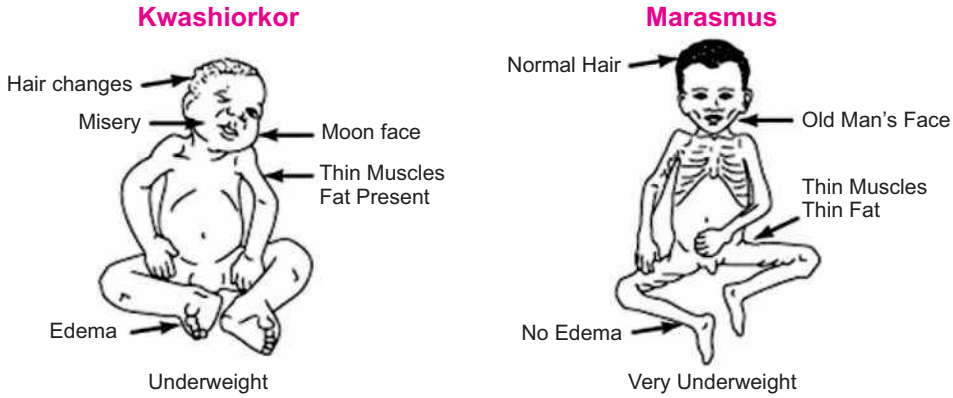


Figure 8.14 Characteristics of kwashiorkor and marasmus

8.2.3 Mineral deficiency disease:

Diseases resulting from deficiency of a mineral are relatively rare among humans some are given below;

1. Goiter:

Goiter is a condition in which thyroid gland becomes enlarged and it results in swelling in neck. Goiter is caused by an insufficient amount of "Iodine" in diet. Iodine is used by thyroid gland to produce hormones that control the body's normal functioning and growth.

2. Anemia (most common of all mineral deficiency diseases):

The term anemia literally means "a lack of blood". The condition is caused when number of red blood cells reduced to a level lower than normal. Haemoglobin molecule contains four atom of iron. If body fails to receive sufficient amount of iron, an adequate number of haemoglobin will not be formed. So, there are not enough functioning red blood cells. A person becomes weak and there is shortage of oxygen supply to body's cells.

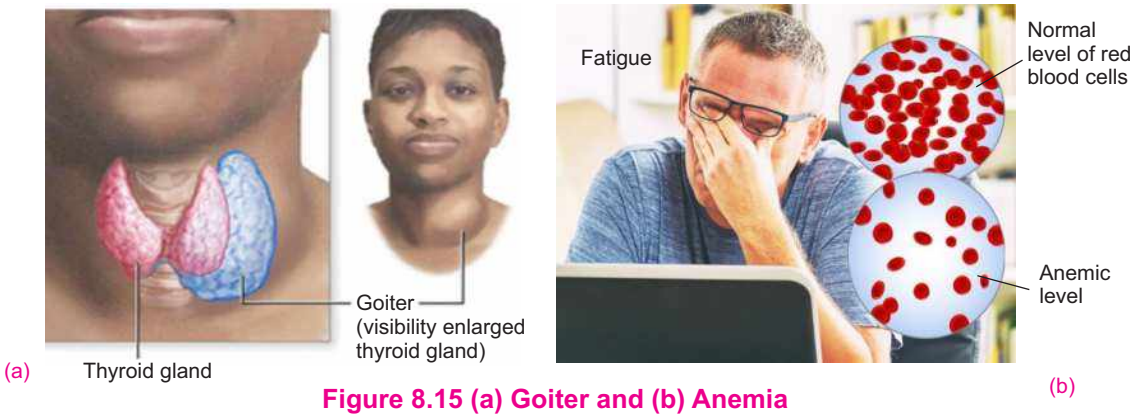


Figure 8.15 (a) Goiter and (b) Anemia

3. Over intake of nutrients:

It is a form of malnutrition in which more nutrients are taken than the amount required for normal growth, development and metabolism. The effects of over-intake of nutrients are usually intensified when there is reduction in daily physical activity (decline in energy expenditure). High intake of carbohydrates and fats leads to obesity, diabetes and cardiovascular problems. Similarly, high dose of vitamin A causes loss of appetite and liver problems. Excess dose of vitamin D can lead to deposition of calcium in various tissues.

8.2.4 The Effects of Malnutrition

Malnutrition hurts people both mentally and physically. The more malnourished a person is; the more nutrients the person is missing, the more likely person will experience health issues. Some of them are given below:

1. Starvation:

It is a severe deficiency in caloric energy intake. It is the most extreme form of malnutrition. In humans, prolonged starvation can cause permanent organ damage and eventually, death.

2. Heart diseases:

The term "heart disease" is often used interchangeably with the term "cardiovascular disease." Cardiovascular disease generally refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke. Heart problems occur in those people who take unbalanced diet. Fatty foods increase blood cholesterol level. It obstructs the blood vessels leading to heart diseases.

3. Constipation:

People do not schedule their meals. This irregularity cause many health problems like constipation. It can be well defined, a condition in which there is difficulty in emptying the bowels, usually associated with hardened faeces.

4. Obesity:

It is a medical condition in which excess body fat has accumulated to the extent that it may have a negative effect on health. Obesity is most commonly caused by a combination of excessive food intake, lack of physical activity, and genetic susceptibility. Obesity is known as mother-disease and may lead to heart problems, hypertension, diabetes etc.

8.2.5 Social problems related to malnutrition:

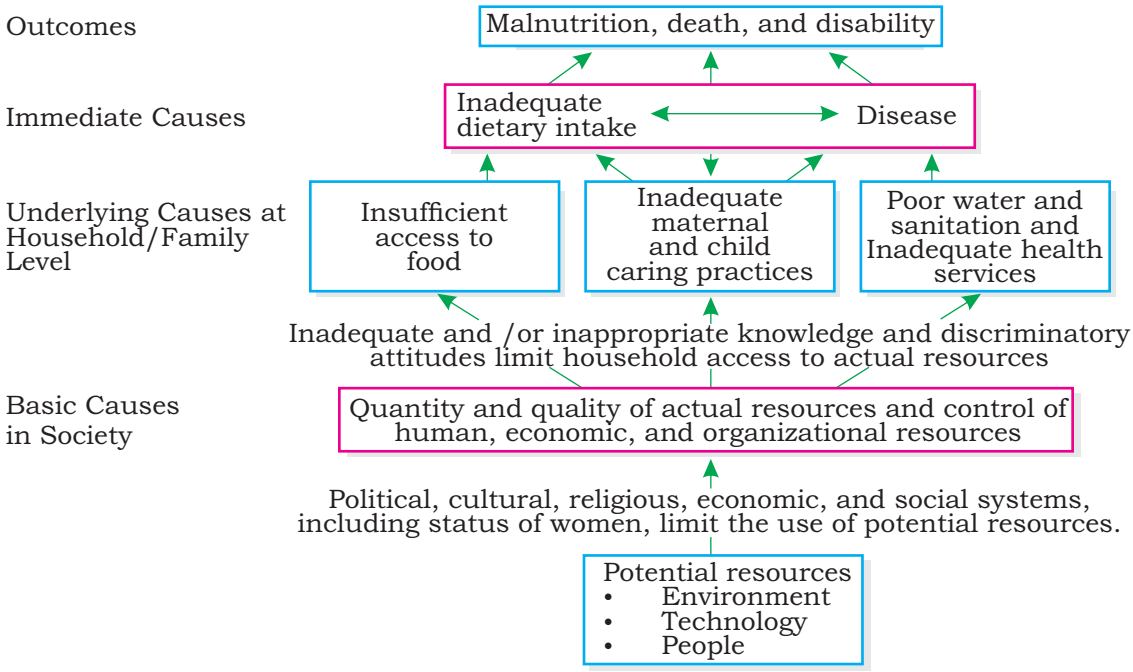
Chronic malnutrition disables and even kills its victims. The World Health Organization (WHO) believed that malnutrition is a causative factor in nearly half of the 10.4 million deaths among children under age five in developing countries. An adequate amount of food or dietary energy supply is necessary to enjoy a healthful and productive life. Malnutrition is not a simple problem with a simple solution. It results from the complex interplay of social and biomedical factors.

1. Food insecurity:

Food insufficiency refers to insufficient food supplies to meet minimum daily diet requirement.

Several countries in Africa and parts of other developing countries do not produce enough food to keep up with the food needs and increased population. Not only do they not produce sufficient food supplies to meet their own needs, but they are economically unable to purchase available food from the exporting countries, which has led to food insecurity in poor countries; as a result, millions are hungry and malnourished. Besides these problems drought (lack of water) and flood (over flow of water) play terrible role in decreasing crop yields.

Graphic representation of the role of society regarding malnutrition



Despite the profound effects of malnutrition problems on human and social developments, the world has shown only limited public alarm.

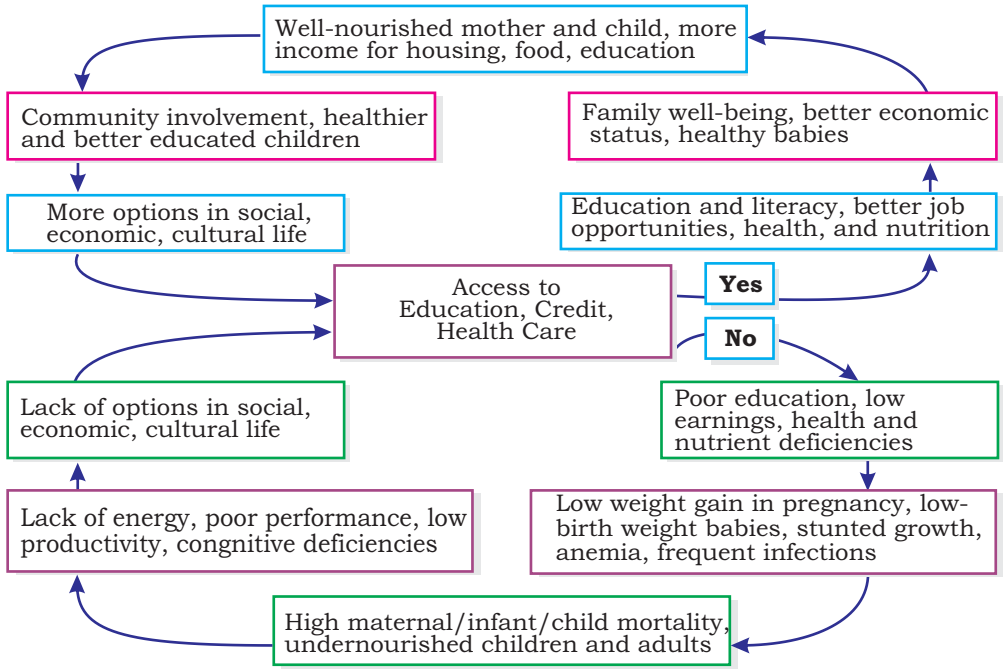
2. Poverty:

For various reasons people in developing countries are increasingly unable to produce enough food to meet their own needs. To meet the ongoing demand for food, food-deficit countries (those unable to produce sufficient food to meet their needs) must import additional food and make it available to people. Even if there is an abundance of food, some people may not have access to it, because more and more, access to food in developing countries is determined by household income.

3. Inequality

Because of a cultural preference for men over women in many developing countries, many women risk malnutrition throughout their lives. The risk for malnutrition in girls begins at an early age. Although nutritional needs are the same for boys and girls in the first 10 years of life, boys often get more food than girls do.

Graphic representation: how to overcome social and economic problems related to malnutrition?



4. Risk of infection:

The normal human body has the capacity to resist foreign organisms or toxins through the immune system, but the immune system ceases to function properly when the body is malnourished. When the immune system (the general process of body) is compromised by malnutrition, the skin's ability to resist the invasion of organisms, the acid secretion produced by the stomach to resist foreign agents, or the production of chemical compounds in the blood that destroy toxins can be affected adversely.

8.3 THE DIGESTIVE SYSTEM OF HUMAN

Digestion is important for breaking down food into nutrients, which the body uses for energy, growth, and cell repair. Food and drinks must be changed into smaller molecules of nutrients before the blood absorbs them and carries them to cells throughout the body.

Digestion is the process in which large and non-diffusible molecules of food are converted into smaller and diffusible molecules that can cross the membranes.

After absorption of the digestible material, indigestible material expelled out of the body through the process of egestion.

Alimentary canal of human:

The digestive system is made up of the alimentary canal and the other abdominal organs that play a part in digestion, such as the liver and pancreas. The alimentary canal (also called the digestive tract) is the long tube of organs - including the esophagus, stomach, and intestines - that runs from the mouth to the anus. An adult's digestive tract is about 30 feet (about 9 meters) long.

The digestion consists of following steps:

Ingestion: Intake of food.

Propulsion: Peristalsis-alternate waves of muscular contraction and relaxation in the primary digestive organs. The end result is to squeeze food from one part of the system to the next.

Mechanical Digestion: Physical preparation of food for digestion.
Segmentation: Mixing of food in the intestines with digestive juices.
Chemical Digestion: Carbohydrates, Fat, and Proteins are broken down by enzymes.
Absorption: Transfer of the digested portion of food into the blood from the digestive canal.
Egestion (Defecation): Removal/elimination of the waste products from the body.

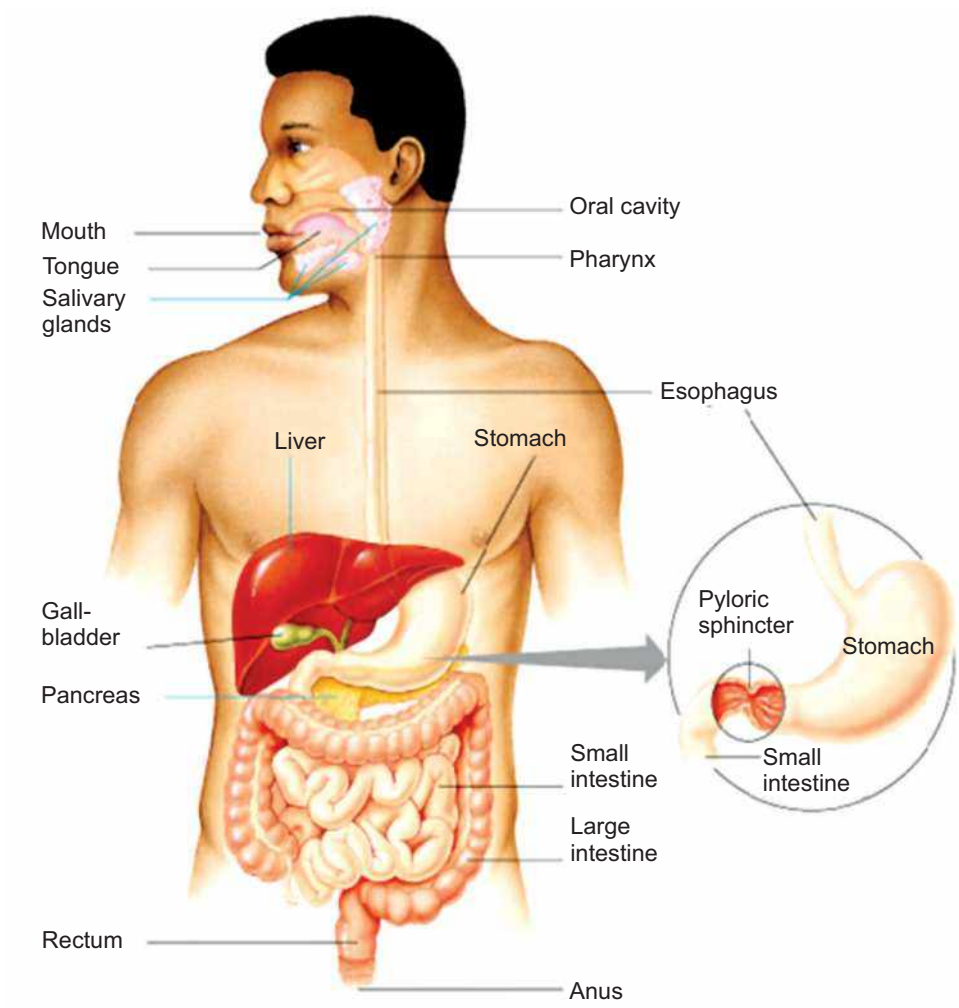


Figure 8.16 The human alimentary canal

Functions of oral cavity

Digestion begins in the oral cavity, well before food reaches the stomach. When we see, smell, taste, or even imagine a tasty snack, our three pairs of salivary glands, which are located under the tongue and near the lower jaw, begin producing saliva. This flow of saliva is co-ordinated with a brain reflex that triggered when we sense food or think about eating. In response to this sensory stimulation, the brain sends impulses through the nerves that control the salivary glands, telling them to prepare for a meal. Oral cavity is the space behind mouth in-between upper and lower jaw and has many important functions:

Food Selection: When food enters the oral cavity it is tasted and felt. Here food is selected or rejected due to the taste, hard object or dirt. Smell and vision also help in selection.

Grinding of food: The second function of oral cavity is the grinding of food by teeth. It is known as chewing or mastication. It is useful because oesophagus can pass only small pieces through it as well as enzymes cannot act on large pieces of food.

Lubrication of food: The third function of the oral cavity is lubrication of food by mixing saliva secreted by saliva. It has two main functions. (i) Adds water and mucus to the food. (ii) Partial digestion of starch by saliva which contains an enzyme salivary amylase.

Chemical digestion: Saliva contains an enzyme salivary amylase which helps in the digestion of starch partially. Than the pieces of food are rolled up by the tongue into small, slippery, spherical mass called bolus.

Swallowing of the bolus: Swallowing is accomplished by muscle movements by the tongue and mouth, food moves into the throat, or pharynx.

Functions of Pharynx and Oesophagus

The pharynx, a passageway for food and air, is about 5 inches (12.7 centimeters) long. A flexible flap of tissue called the epiglottis reflexively closes over the windpipe when we swallow to prevent choking. From the throat, bolus travels down a muscular tube in the chest called the esophagus.

Waves of rhythmic movements of muscle contractions and relaxation called peristalsis force down food through the oesophagus to the stomach. A person normally isn't aware of the movements of the esophagus, stomach, and intestine that take place as food passes through the digestive tract.

At the end of the oesophagus, a muscular ring called a sphincter allows food to enter the stomach and then squeezes shut to keep food or fluid from flowing back up into the oesophagus.

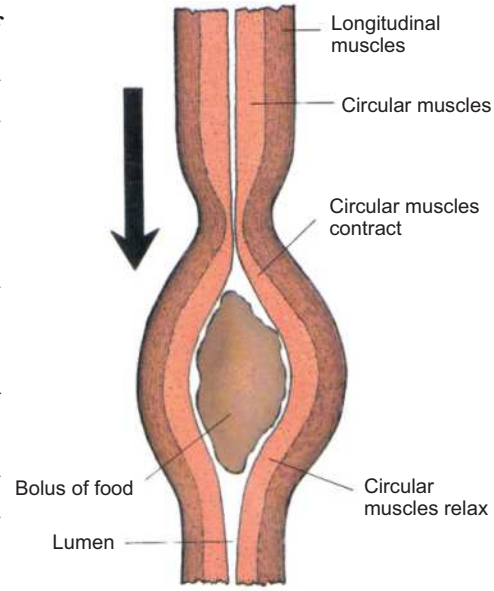


Figure 8.17 Peristalsis

Functions of stomach:

Stomach is j-shaped thick walled, expandable bag, located in the left of abdomen just beneath the diaphragm. The stomach has three regions: **cardiac**, just after the oesophagus, **fundus**, the largest part of stomach and **pyloric**, part located at the other end of stomach and opens into small intestine

The stomach muscles churn and mix the food with acids and enzymes, breaking it into much smaller, digestible pieces. An acidic environment is needed for the digestion that takes place in the stomach. Glands in the stomach lining produce about 3 quarts (2.8 liters) of these digestive juices each day. When food enters into the stomach the gastric juice is secreted by gastric glands found in the stomach wall. It is composed of mucous, hydrochloric acid and protein digesting enzyme pepsinogen. Hydrochloric acid converts the inactive enzyme pepsinogen into active form called pepsin. HCI also kills micro-organisms present in food. Stomach is protected against the action of acid by mucus.

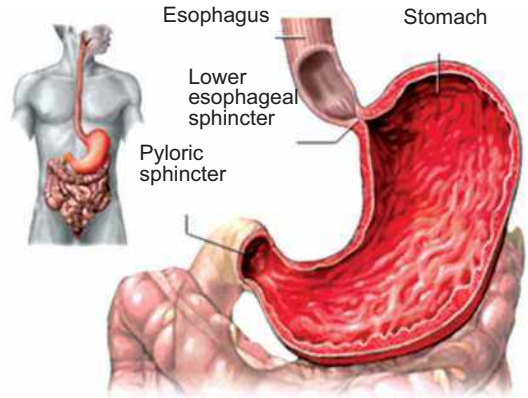


Figure 8.18 Stomach

Stomach has two sphincters (opening which are guarded by muscles). The cardiac sphincter is between stomach and oesophagus. Pyloric sphincter is between stomach and small intestine.

Pepsin partially digests the protein portion of the food into polypeptides and shorter peptide chains. In stomach food is further broken apart through a process called churning. The walls of stomach contract and relax and these movements help in mixing of the gastric juice and food. The churning action also produces heat which helps to melt the lipid contents of the food. By the time food is ready to leave the stomach, it has been processed into a thick paste like liquid called chyme. The pylorus keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Chyme is then squirted down into the small intestine, where digestion of food continues.

Functions of small intestine:

The small intestine is made up of three parts:

- The duodenum, about 25 cm (10 inches) long, C-shaped first part.
- The jejunum, the coiled mid section.
- The ileum, the final section that leads into the large intestine.

The duodenum receives chyme from the stomach and it is a part of alimentary canal where most of the digestive process occurs. Ducts that empty into the duodenum deliver pancreatic juice and bile from the pancreas and liver, respectively.

Bile salts have detergent action on particles of dietary fat which causes fat globules to break down or be emulsified into minute, microscopic droplets.

Pancreatic juice is a liquid secreted by the pancreas, which contains a variety of enzymes, including protease like trypsinogen, pancreatic lipase and amylase, which digest protein, lipids and carbohydrates respectively.

Intestinal juices produced from the small intestine contain enzymes and pancreatic juice break down all four groups of molecules found in food (polysaccharides, proteins, fats, and nucleic acids) into their component molecules.

The inner wall of the small intestine is covered with millions of microscopic, finger-like projections called villi (singular, villus). Each villus is connected and richly supplied with blood capillaries and lymphatic vessels, i.e lacteal. The walls of villus are made up of only one layer of cells, in thickness. The villi are the vehicles through which nutrients can be absorbed into the body. They increase the surface area over which absorption and digestion occur. These specialized cells help absorbed materials cross the intestinal lining into the bloodstream. The bloodstream carries simple sugars, amino acids and nucleosides to the liver via hepatic portal vein for storage or further chemical changes. From liver, the required food molecules go towards the heart via the hepatic vein. The lymphatic system, a network of vessels that carry white blood cells and a fluid called lymph throughout the body, absorbs glycerol, fatty acids and vitamins.

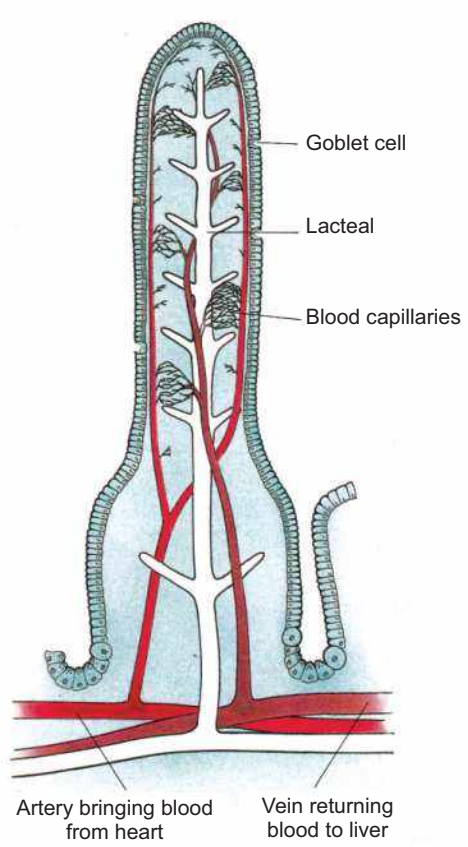


Figure 8.19 Longitudinal section through a villus

Macromolecules Summary

Polymers	Monomers	Roles
Complex Carbohydrates (i.e. starch)	Glucose and other simple sugars	Broken apart to get energy to make ATP.
Proteins	Amino acids	Used to make our own enzymes and other body proteins.
Lipids (Fats, waxes, oils, and steroids)	Fatty acid chains, glycerine (except steroids)	Used for cellular energy and energy storage; used to make cell membranes, steroid hormones.

Large intestine and its functions:

From the small intestine, food that has not been digested (and some water) travels to the large intestine through a muscular ring, that prevents food from returning to the small intestine. By the time food reaches the large intestine, the work of absorbing nutrients is nearly finished. The large intestine's main function is to remove water from the undigested matter and form solid waste that can be egested.

The large intestine is made up of three parts:

- The **caecum** is a pouch at the beginning of the large intestine that joins the small intestine to the large intestine. This transition area expands in diameter, allowing food to travel from the small intestine to the large. The appendix, a small, hollow, finger-like pouch, hangs at the end of the cecum. It no longer appears to be useful to the digestive process.

There's a lot of energy in cellulose, but most animals are simply unable to digest it because they don't have the necessary enzymes.

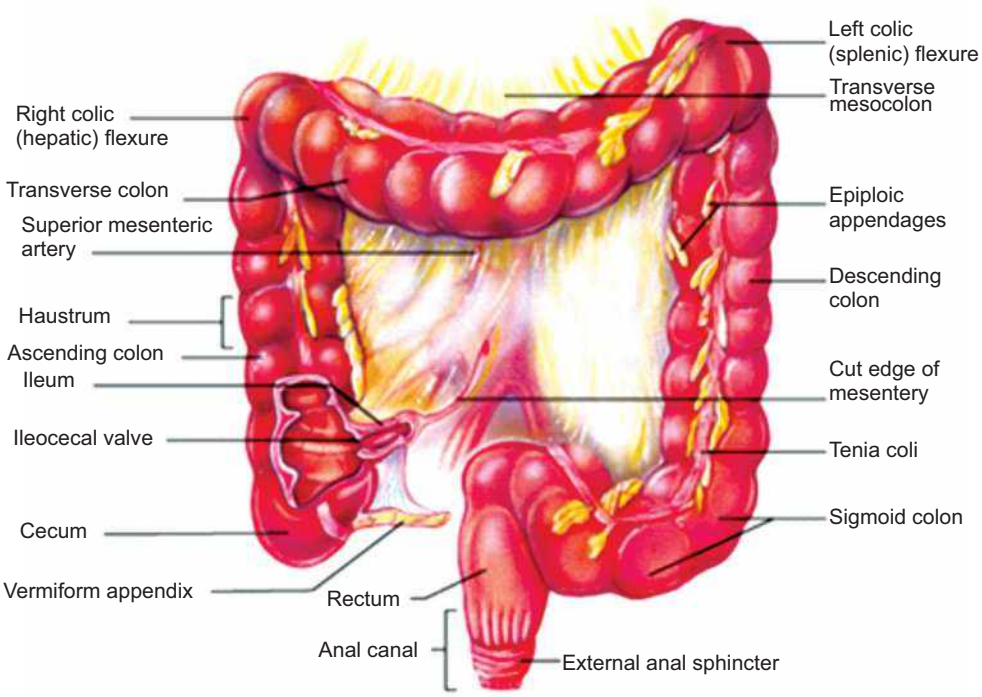


Figure 8.20 Large intestine

- The **colon** extends from the caecum up the right side of the abdomen, across the upper abdomen, and then down the left side of the abdomen, finally connecting to the rectum. The colon has three parts: the ascending colon and transverse colon, which absorb fluids and salts, and the descending colon, which holds the resulting waste (faeces). Faeces mainly consist of undigested material, large number of bacteria, sloughed off gastrointestinal cells, bile pigments and water. Bacteria in the colon help to digest the remaining food products.
- The rectum is where faeces are stored until they leave the digestive system through the anus as a bowel movement.

Liver and its functions:

The liver produces bile, which helps the body to digest and absorb fat. Bile is stored in the gallbladder until it is needed. Bile travels through special channel (bile duct) directly into the small intestine.

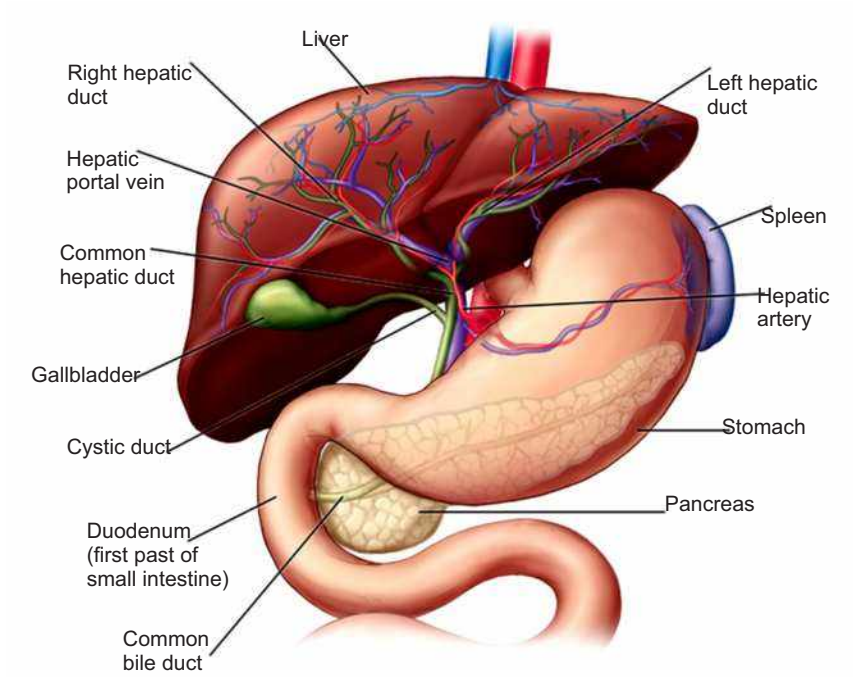


Figure 8.21 The human liver

It also makes a substance that neutralizes stomach acid. The liver also plays a major role in the handling and processing of nutrients, which are carried to the liver in the blood from the small intestine.

The liver is a metabolically active organ responsible for many vital life functions.

8.4 DISORDERS OF GUT

1. Diarrhea:

It is a condition in which the sufferer has frequent watery, loose bowel movements due to fast peristaltic movement. This condition may be accompanied by painful abdominal cramps, nausea, fever and generalized weakness. It occurs when required water is not absorbed in blood from colon. The main cause of diarrhea includes lack of adequate safe water, virus and bacteria. In malnourished individuals, diarrhoea leads to severe dehydration and can be life threatening. To control diarrhea consume adequate amounts of water to replace loss, preferably mixed with essential salts and some amount of nutrients.

2. Constipation:

Constipation is a condition, where a person experiences hard faeces that are difficult to eliminate. The main causes of constipation are hardening of faeces due to excessive absorption of water through colon, insufficient intake of dietary fibre, dehydration, use of medicine (e.g. those containing iron, calcium and aluminum) and tumors in rectum or anus. The treatment of constipation are change in diet and exercise habits, use of laxative (e.g. paraffin) may be in some cases. To prevent Constipation is easier than treatment.

3. Ulcer (peptic ulcer):

It is a sore in gut lining and can be different organs such as; ulcer of stomach is called “gastric ulcer”, Ulcer of duodenum is called “duodenal ulcer”, ulcer of oesophagus is called “esophageal ulcer” and breakdown of tissues by acidic gastric juice. It can be due to the long term use of anti-inflammatory medicine (e.g. aspirin), smoking, drinking coffee, colas and eating spicy food. Few of the signs are as under; abdominal burning after

meals, abdominal pain, rush of saliva after an episode of regurgitation, nausea and loss of appetite and weight. Ulcer can be treated with medicine, containing (alkaline composition) and avoiding spicy food.

Summary

- Process by which organism obtain and use the nutrients required for maintaining life is called nutrition.
- Autotrophic nutrition and heterotrophic nutrition
- Autotrophic nutrition found in plants and some bacteria specially photosynthesis.
- Heterotrophic nutrition found in animal and fungi which gets nutrients from other sources.
- Heterotrophic which use plant as food called herbivorous and those which consume animals. and their products called carnivorous. Both are collectively called consumers.
- The basis of mode living and the mode of intake of food heterotrophes may be parasitic, saprotrophic and holozoic.
- Nutrition in unicellular organisms, like amoeba involve igestion by cell surface.
- Process involving the absorption, distribution and utilization of mineral substances by plant called mineral nutrition.
- The mineral nutrients are macronutrient i.e require in large quantity, micronutrient i.e require in small quantity.
- Fertilizers are substances containing chemical elements such as manure or mixture of nitrates that improve growth of plants.
- Naturally occurring materials which are not chemically modified called inorganic fertilizer.
- Chemical substances which are more complex and takes time to be broken down into useable form called organic fertilizer.

- So many environmental hazard are also related to chemical fertilizers
- There are seven major classes of nutrients, Carbohydrates, proteins, fats, minerals, fibers, vitamins and water.
- Balanced diet is related to age, six and activity of human.
- Problems related to nutrition are grouped as malnutrition.
- Kwashiorkor is a severe difficulty in dietary protein.
- Marasmus characterized by energy deficiency sum of mineral difficulty diseases are Goiter, anemia.
- Effects of malnutrition are starvation, heart diseases, constipation, obesity.
- Digestion is the break down of complex food into simple absorbable nutrients.

Review Questions

1. Encircle the correct answer:

(i) Select the mismatched

(a) Protein → Amino acid (b) Carbohydrate → Glucose

(c) Fats → Starch (d) Nucleic acid → Nucleotide

(ii) Deficiency of vitamin-k cause

(a) Rickets (b) Anemia

(c) Scurvy (d) Beriberi

(iii) Period of rapid growth and development called

(a) Childhood (b) Adult hood

(c) Adolescence (d) Both "a" and "b"

(iv) Deficiency of dietary protein, causes an imbalance in the gastro-intestinal system

(a) Marasmus (b) Edema

(c) Diarrhea (d) Kwashiorkor

(v) An animal that migrates great distances would obtain the greatest benefit from storing its energy as

(a) Fats (b) Carbohydrates

(c) Protein (d) Minerals.

(vi) Which of the following vitamins is correctly associated with its use?

(a) Vitamin K → Production of white blood cells

(b) Vitamin C → Curing rickets

(c) Vitamin E → Protection of skin from cancer

(d) Vitamin A → Incorporated into the visual pigment of the eye

(vii) Which of the following statements describes pepsin?

(a) It is manufactured by the pancreas.

b) It helps stabilize fat-water emulsions.

(c) It splits maltose into monosaccharides.

(d) It begins the hydrolysis of proteins in the stomach.

(viii) Which of the following is true of bile salts?

(a) They are enzymes

(b) They are manufactured by the pancreas

(c) They emulsify fats in the duodenum

(d) They increase the efficiency of pepsin action.

(ix) In human digestive system trachea and oesophagus both connect to the

(a) Large intestine (b) Stomach

(c) Pharynx (d) Rectum

(x) All are sources of calcium except

(a) Red meat (b) Green leafy vegetables

(c) Broccoli (d) Nuts

2. Fill in the blanks:

(i) Sea food is an excellent source of protein because it's usually low in_____.

(ii) Iron deficiency is associated with decreased cognitive abilities and resistance to_____.

(iii) Wave of rhythmic movements of muscle contraction and relaxation called_____.

(iv) Liquid secreted by the pancreas, which contains a variety of _____.

(v) Living organisms which derive their food from dead and decaying organic materials called_____.

(vi) Nutrients that are needed in the highest concentration called_____.

(vii) Fertilizers are substances containing chemical elements such as manure or mixture of _____.

(viii) High solubility of fertilizers also degrades ecosystem through_____.

(ix) Carbohydrates which digested quickly are called _____.

(x) Each gram fat supplies the body with about_____.

3. Define the following terms

(i)	Vitamins	(ii)	Malnutrition	(iii)	Goiter
(iv)	Anemia	(v)	Constipation	(vi)	Obesity
(vii)	Starvation	(viii)	Ingestion	(ix)	Chyme
(x)	Ulcer				

4. Distinguish between the following in tabulated form.

(i) Fat-soluble vitamins and water soluble vitamins

(ii) Marasmus and kwashiorkor

(iii) Chemical digestion and mechanical digestion

(iv) Autotrophic nutrition and heterotrophic nutrition

(v) Inorganic fertilizers and organic fertilizers

5. Write short answers of following questions.

(i) Why fertilizers are necessary for plant?

(ii) How stomach linings are protected from acidic environment?

(iii) Why nitrogen is essential for plants?

(iv) Why fats are called most efficient form of food?

(v) Why grinding and lubrication are necessary for swallowing?

6. Write detailed answers of the following questions.

(i) Describe environmental hazards related to chemical fertilizers.

(ii) Describe function of stomach and intestine with suitable diagram of human digestive system.

(iii) What are vitamins? Describe types of vitamins

(iv) Describe mineral deficiency diseases in human.

(v) Describe effects of malnutrition on human.