CHAPTER

8 Nutrition

Animation 8.1: Nutrition
Source & Credit: Wikispace

Recalling

Every organism needs food for growth and energy and to function normally.

The process in which food is obtained or prepared, absorbed and converted into body substances for growth and energy, is called nutrition. Nutrients are the elements and compounds that an organism obtains and uses for energy or for the synthesis of new materials.

We know that **autotrophic** organisms obtain water, carbon dioxide and minerals from their environment and prepare their food which is then used for growth and energy. On the other hand **heterotrophic** organisms obtain their food from other organisms and use it for growth and energy.

8.1 MINERAL NUTRITION IN PLANTS

Plants have the most efficient mechanisms for autotrophic mode of nutrition. Plants get carbon, hydrogen and oxygen from carbon dioxide and water. In addition to these elements, plants also require mineral elements for various activities and structures. The nutrients which are required in large quantities are called **macronutrients** e.g. carbon, hydrogen, oxygen, nitrogen, magnesium, potassium etc. Similarly, the nutrients which are required in small quantities are called **micronutrients** e.g. iron, molybdenum, boron, chlorine, zinc etc. If any of these nutrients is not available to plant, they show abnormalities and do not grow normally. Table 8.1 describes the roles of important macro and micronutrients in plants.

Animation 8.2: Nutritions
Source & Credit: spokaneschools

Animation 8.3: Minral Nutrition in Plants
Source & Credit: sites

Table 8.1: Role of important nutrients in plant life

Macronutrients	Role in plant life
Phosphorus	Component of ATP, nucleic acids, and coenzymes, necessary for seed germination, photosynthesis, protein formation etc
Potassium	Regulates the opening and closing of the stoma, reduces water loss from the leaves
Sulphur	Component of proteins, vitamins and enzymes
Calcium	Activates enzymes, is a structural component of cell wall, influences water movement in cells

Micronutrients	Role in plant life
Iron	Necessary for photosynthesis, activates many enzymes
Molybdenum	Component of the enzyme that reduces nitrates to ammonia, important in building amino acids
Boron	Important in sugar transport, cell division, and synthesizing certain enzymes
Copper	Component of several enzymes
Manganese	Involved in enzyme activity for photosynthesis, respiration, and nitrogen metabolism
Zinc	Required in a large number of enzymes
Chlorine	Involved in osmosis of water
Nickel	Required in a nitrogen metabolism

Carnivorous plants have evolved mechanisms for trapping and digesting small animals. The products of this digestion are used to supplement the plant's supply of nitrogen.

Roles of Nitrogen and Magnesium

Plants get nitrogen in the form of nitrates. Nitrogen is a major component of proteins, hormones, chlorophyll, vitamins and enzymes essential for plant life. Nitrogen metabolism is a major factor in stem and leaf growth. Too much nitrogen can delay flowering and fruiting. Deficiencies of nitrogen can reduce yields, cause yellowing of the leaves and stunt growth.

Magnesium is a structural component of chlorophyll. It is also necessary for the functioning of plant enzymes to produce carbohydrates, sugars and fats. It is used for fruit and nut formation and essential for germination of seeds. Deficiency of magnesium causes yellowing and wilting of leaves.

IMPORTANCE OF FERTILIZERS

As humans cultivated plants, it was learned that addition of certain materials to soil sometimes resulted in plants with desirable characteristics (e.g., more fruit, faster growth, more attractive flowers). Such materials were named as fertilizers. Fertilizers are broadly classified as organic or inorganic.

Naturally occurring inorganic fertilizers include rock phosphate, elemental sulfur and gypsum. These are not chemically modified. If nitrogen is the main element, they are called nitrogen fertilizers. Most inorganic fertilizers dissolve readily in water and are immediately available to plants for uptake.

Organic fertilizers are derived from plant and animal materials. They are more complex and take time to be broken down into forms usable by plants. Manure and compost are used as organic fertilizers. They can also increase soil drainage, aeration and the ability of the soil to hold nutrients.

The distinction between the organic and inorganic fertilizers is not always clear-cut. Urea, for example, is an organic compound, but chemically synthesized urea is generally grouped with inorganic fertilizers.

Animation 8.4: Importance of Fertilizers
Source & Credit: boerenbritaccommodation

Environmental hazards related to fertilizer's use

The massive quantities of inorganic fertilizers affect the soil nutrient-holding capacity. Their high solubilities also degrade ecosystems through **eutrophication** (increase in chemical nutrientsin an ecosystem). Storage and application of some nitrogen fertilizers may cause emissions of the greenhouse gas nitrous oxide. Ammonia gas may be emitted from the inorganic fertilizers. This extra ammonia can also increase soil acidity. Excessive nitrogen fertilizers can lead to pest problems by increasing their reproduction rate.

For these reasons, it is recommended that the nutrient content of the soil and nutrient requirements of the crop should be calculated before the application of inorganic fertilizers.

Excessive amounts of organic fertilizers cause environmental problems due to nitrate leaching or run off of soluble organic compounds.

?

If we supply inorganic and organic fertilizers to a plant, which one would be first available to the plant for uptake?

Inorganic fertilizer

8.2 COMPONENTS OF HUMAN FOOD

The nutritional requirements of human and other animals are relatively complex as compared to plants. Like other animals, the nutrients used by humans include carbohydrates, lipids, nucleic acids, proteins, minerals, vitamins. Besides these nutrients, they also require water.

CARBOHYDRATES

Carbohydrates are the basic source of energy for all animals. About half to 2/3 of the total calories every animal consumes daily are from carbohydrates. Glucose is the most often used carbohydrate for energy. Other useful carbohydrates are maltose, lactose, sucrose and starch. Carbohydrates contain 04 kilocalories per gram. Humans get carbohydrates from the foods like bread, pastas, beans, potatoes, bran, rice and cereals.

Carbohydrates are the most common source of energy. Proteins and lipids are vital building components for body but they can also be used for energy.

Saturated fatty acids can increase a person's cholesterol level. An increased cholesterol level may eventually result in the clogging of arteries and, ultimately, heart disease.

LIPIDS

The lipids present in food are composed of **fatty acids** bonded to **glycerol**. The fatty acids of lipids may be saturated or unsaturated.

Saturated fatty acids have all of their carbon atoms bonded to hydrogen atoms.

Unsaturated fatty acids have some of their carbon atoms double-bonded in place of a hydrogen atom. Generally, the lipids containing saturated fatty acids are solid at room temperature. The lipids containing unsaturated fatty acids are liquid at room temperature. For example butter contains nearly 70% saturated and 30% unsaturated fatty acids. On the other hand, sunflower oil contains nearly 75% unsaturated fatty acids. Lipids are used to form membranes, the sheaths surrounding neurons, and certain hormones. Lipids are also extremely useful energy sources. One gram of lipids contains 09 kilocalories of energy. Important sources of lipids include milk, butter, cheese, eggs, mutton, fish,mustard seeds, coconut and dry fruits etc

PROTEINS

Proteins are composed of amino acids. Proteins are essential components of the cytoplasm, membranes and organelles. They are also the major components of muscles, ligaments, and tendons. So we use proteins for growth. Many proteins play role as enzymes. Proteins can also be used for gaining energy. One gram of proteins contains 04 kilocalories of energy. Dietary sources of proteins are meat, eggs, grains, legumes, and dairy products such as milk and cheese.

Proteins can be converted into carbohydrates

MINERALS

Minerals are inorganic elements that originate in the Earth and cannot be made in body. They play important roles in various body functions and are necessary to maintain health. Most of the minerals in human diet come directly from plants and water, or indirectly from animal foods. Minerals are categorized into major and trace minerals. **Major minerals** are required in the amounts of 100 mg (milligrams) or more per day, while **trace minerals** are required in amounts less than 100 mg per day. The roles of major and minor minerals in human body are given in Table 8.2.

On the nutritional label of a packaged food the word “Calorie” is equal to a kilocalorie.

Table 8.2: Important minerals in human diet and their roles

Minerals	Role in body
Major minerals	
Sodium	Fluid balance in the body Helps in absorption of other nutrients Important for muscle contraction, nerve impulse transmission, heart function, and blood pressure
Potassium	Fluid balance in the body Acts as cofactor for enzymes
Chloride	Fluid balance in the body Component of hydrochloric acid
Calcium	Development and maintenance of bones and teeth blood clotting
Magnesium & Phosphorus	Development and maintenance of bones and teeth
Trace minerals	
Iron	Oxygen transport and storage Act as enzyme cofactors support immune function
Zinc	Aids insulin action Helps in growth and reproduction
Copper	Acts as enzyme cofactor
Chromium	Helps in insulin action
Fluoride	Stabilizes bone mineral and hardens tooth enamel
Iodine	Essential for normal thyroid function

Role of Calcium and Iron

Calcium is essential for the development and maintenance of bones and teeth. It is also needed for maintaining cell membranes and connective tissues and for the activation of several enzymes. Calcium also aids in blood clotting. Humans get calcium from milk, cheese, egg yolk, beans, nuts, cabbage etc. Deficiency of calcium causes spontaneous discharge of nerve impulses which may result in tetany, bones also become soft, blood clots slowly and wounds heal slowly.

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. Cellular energy production also requires iron. It acts as cofactor for many enzymes of cellular respiration. Iron also supports immune function. Humans get iron from red meat, egg yolk, whole wheat, fish, spinach, mustard etc. Its deficiency is the most common nutrient deficiency worldwide. Iron-deficiency causes anaemia.

Good calcium nutrition, along with low salt and high potassium intake, prevents from hypertension and kidney stones.

? Which of the major components of food is needed as the main structural componet of the body

proteins

VITAMINS

Vitamins are the chemical compounds that are required in low amounts but are essential for normal growth and metabolism. Vitamins may be divided into two groups: the fat-soluble vitamins (vitamins A, D, E, and K) and the water-soluble vitamins (vitamins B and vitamin C).

Vitamin A

Vitamin A was the first fat-soluble vitamin identified (in 1913). It combines with a protein called **opsin** to form **rhodopsin** in rod cells of the retina of eye. When vitamin A is inadequate, the lack of rhodopsin makes it difficult to see in dim light. It is also involved in cell differentiation, a process through which embryonic cells transform into mature cells with specific functions. Vitamin A also supports bone growth and immune function

Cooking or heating destroys the water soluble vitamins more readily than the fat-soluble vitamins.

Fat-soluble vitamins are much less excreted from the body as compared to water-soluble vitamins. This means that levels of water-soluble vitamins in the body can decrease more quickly, leading to vitamin deficiency.

Table 8.3: Functions, deficiencies and sources of important vitamins

Vitamin	Sources	Functions	Deficiency symptoms
Vitamin A	Leafy vegetables (spinach, carrots) Yellow fruits Fish Liver Egg, milk and butter	Vision in dim light Cell differentiation Growth Immunity	Poor growth Blindness Dry skin
Vitamin C	Citrus fruits Leafy green vegetables Beef liver	Collagen formation Healing of wounds Functioning of immune system	Scurvy: Fatigue, poor wound healing Bleeding gums & joints
Vitamin D	Fish liver oil Milk Ghee and butter Synthesized by skin	Maintenance of the concentrations of calcium and phosphorous	Rickets in children Osteomalacia in adults

Minute quantities of vitamin C are present in muscles.Since meat consists of muscles so it is not a good source of vitamin C.

Humans get vitamin A from leafy vegetables (spinach, carrots), yellow/orange fruits (mango), liver, fish, egg, milk, butter etc. Deficiency of vitamin A is the leading cause of blindness in children worldwide. One of the symptoms of vitamin-A deficiency is **night blindness**. It is a temporary condition, but if left untreated it can cause permanent blindness. Vitamin-A deficiency can also cause a condition in which hair follicles become plugged with keratin, giving dry texture to skin.

Vitamin C: (Ascorbic Acid)

Vitamin C participates in many reactions. It is needed to form collagen (a fibrous protein) that gives strength to connective tissues. Collagen is also needed for the healing of wounds. Vitamin C in white blood cells enables the immune system to function properly.

We get vitamin C from citrus fruits (e.g. oranges, lemons, and grape fruit), leafy green vegetables, beef liver etc. Deficiency of vitamin C causes connective tissue changes throughout the body. The disease known as **scurvy** results from lack of vitamin C. In this condition the synthesized collagen is unstable. Symptoms of scurvy include muscle and joint pain, swollen and bleeding gums, slow wounds healing, and dry skin.

Vitamin D

The best-known function of vitamin D is to help regulate blood levels of calcium and phosphorous. Vitamin D increases the absorption of these minerals from intestine and their deposition in bones. Vitamin D is mainly found in fish liver oil, milk, ghee, and butter etc. It is also synthesized by skin when ultraviolet (UV) radiations from the Sun are used to convert a compound into vitamin D. Long-term deficiency of vitamin D affects bones. In children, vitamin-D deficiency leads to **rickets**, a condition in which bones weaken and bow under pressure. In adults, vitamin-D deficiency causes **osteomalacia**, or "softening of bones,"increasing the risk for fractures in bones.

Practical work:

Tests for starch (iodine test); reducing sugars (Benedict's test); protein (Biuret test); and lipids (ethanol emulsion test).

The food of animals contains organic macromolecules e.g. lipids, proteins, carbohydrates and nucleic acids.

Problem:

Test a variety of food samples for the presence of starch, simple reducing sugars, proteins and lipids.

Material required: Biuret reagent, test tubes, pipettes, various items (milk, yogurt, cheese,meat, bread, table sugar, flour, corn starch, various oils and fats etc), Sudan red solution,Benedict solution, iodine solution

Problem:

Test a variety of food samples for the presence of starch, simple reducing sugars, proteins and lipids.

Material required: Biuret reagent, test tubes, pipettes, various items (milk, yogurt, cheese,meat, bread, table sugar, flour, corn starch, various oils and fats etc), Sudan red solution,Benedict solution, iodine solution

Background information:

- Testing for the presence of starch is done through iodine solution, which changes from yellowish-brown to dark purple/black.
- Testing for simple carbohydrates (reducing sugars) is done through Benedict's solution. It is a blue colored liquid that contains copper ions. When Benedict's solution and simple carbohydrates are heated, the solution changes to orange red/ brick red.
- Starch does not react positive with the Benedict's test unless they are broken down through heating.
- Table sugar (disaccharide) is a non-reducing sugar and does not react with iodine and Benedict solution.
- Testing for proteins is done through Buiret test. Buiret solution is a blue liquid that changes to purple when proteins are present and to pink in the presence of short chains of polypeptides.
- Lipids are organic compounds that can supply as much as double the amount of energy as carbohydrates or proteins. Testing for lipids can be done through Sudan red test. Sudan red is a fat-soluble dye that stains lipids red. Using Sudan red can show the amount and the location of lipids.

Procedure:

Put on safety goggles and a lab apron.

1. Iodine Test:

i. To perform the iodine test, select three clean test tubes. With a wax pencil, label the tops of the test tubes "1", "2" and "3".

- To test tube 1, add 40 drops of glucose
- To test tube 2, add 40 drops of starch
- To test tube 3, add 40 drops of water

ii. Add iodine solution to the three test tubes.

In test tube "2" a dark purple / black colour will appear which indicates a positive result for starch.

2. Benedict's Test:

i. Get the three empty test tubes. Label the tops of the test tubes "1", "2" and "3".

- To test tube 1, add 40 drops of glucose.
- To test tube 2, add 40 drops of starch
- To test tube 3, add 40 drops of water

ii. Add 10 drops of Benedict's solution to each test tube.

The solution in test tube "1" will look blue and then it will make an orange to red-brick precipitate, which indicates a positive result for reducing sugars.

3. Biuret Test:

i. Select two clean test tubes. With a wax pencil, label the tops of the test tubes "1" and "2".

- To test tube 1, add 40 drops of albumin solution (a protein)
- To test tube 2, add 40 drops of water

ii. Add 3 drops of Buiret solution to each test tube.

The positive - purple or pink color in test tube "1" indicates the presence of protein.

4. Sudan Red Test:

i. To perform the Sudan red test, select two clean test tubes. With a wax pencil, label the tops of the test tubes "1" and "2".

- To test tube 1, add 5 drops of vegetable oil
- To test tube 2, add 40 drops of water

ii. Add 3 drops of Sudan red solution to each test tube. Sudan red will stain the lipid molecules in test tube "1".

5. Dispose of your materials according to the directions from teacher

Observation: Record your observation regarding the color changes in the experimental and the control test tubes. (Figure 8.1)

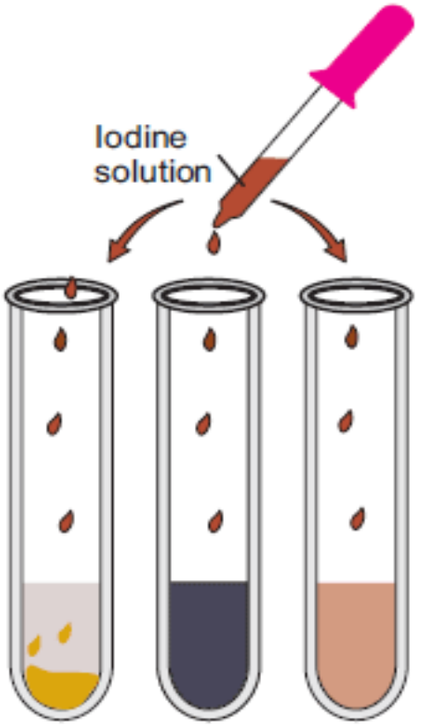
Evaluation:

I. What color changes did you observe in the presence of glucose, starch, protein, and lipids.

ii. Which test tubes contain standards that you could use for comparing tests on unknown substances?

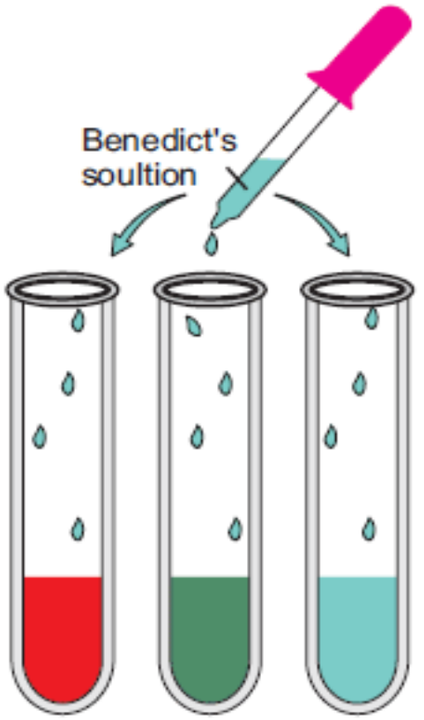
iii. What are the controls in this lab?

iv. You are asked to analyze and compare a food substance with standards for organic compounds. You observe a positive response with iodine solution and Biuret solution. What can you conclude about this food?



TEST FOR STARCH

1: No results with glucose
2: Dark purple/black colour with starch
3: No result with water

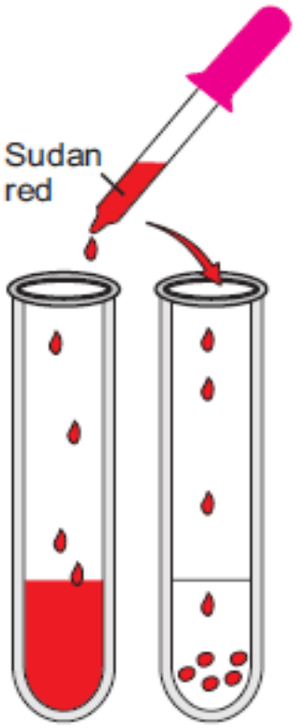


TEST FOR GLUCOSE

1: Red-brick colour with glucose
2: Starch does not make red colour
3: No result with water

TEST FOR PROTEINS

1: Purple colour with egg albumin (protein)
2: No result with water



TEST FOR LIPIDS

1: Red stain with vegetable oil (lipids)
2: No result with water

Analyzing and Interpreting

Investigate your daily food intake and present it in a tabulated data form (in terms of nutrients and calories).

8.2.1 EFFECTS OF WATER AND DIETARY FIBRE

Strictly speaking, water and dietary fibre are not considered as nutrients, but they do play important role in life.

WATER

Approximately 60% of the adult human body is composed of water. Nearly all life sustaining chemical reactions require an aqueous (watery) environment. Water also functions as the environment in which water-soluble foodstuff is absorbed in the intestines and the waste products are eliminated in urine. Another essential role of water is to maintain body temperature through evaporation, as in sweating. Severe dehydration may result in cardiovascular problems. The estimated water requirement of an average adult is two litres per day. Important sources of daily water intake are natural water, milk, juicy fruits and vegetables.

DIETARY FIBRE

Dietary fibre (also known as “roughage”) is the part of human food that is indigestible. It is found only in plant foods and it moves undigested through stomach and small intestine and into colon. The **insoluble dietary fibre** travels quickly through small intestines. Its sources are wheat bran, cereals and skins of many fruits and vegetables. The **soluble dietary fibre** breaks down as it passes through alimentary canal. Its sources are oats, beans, barley, and many fruits and vegetables.

Fibre prevents and relieves constipation by stimulating the contraction of intestinal muscles. Avoiding constipation reduces the risk of many other diseases. Soluble fibre helps in lowering blood cholesterol and sugar levels. Insoluble fibre speeds up the movement of carcinogens (cancer causing agents) from intestine.

Fibre supplements (such as Ispaghol husk) should be used only with a physician’s recommendations. Taken properly, these supplements may help in constipation and in lowering cholesterol levels.

8.2.2 BALANCED DIET

Humans require various types of nutrients in order to keep them healthy and fit. These nutrients should be taken appropriately in diet. A balanced diet may be defined as the one which contains all the essential nutrients in correct proportion for the normal growth and development of body. A balanced diet is related to one's age, gender and activity. It should include different types of nutrients and should be according to the energy requirements. The following chart shows some of the common foods, taken in Pakistan, and the percentage of carbohydrates, lipids and proteins in each of them.

Common foods and the percentage of nutrients

Food	Carbohydrates	Lipids	Proteins
Bread (Roti)	52%	03%	09%
Rice	23%	0.1%	2.2%
Potato	19%	0.1%	02%
Apple	12.8%	0.5%	0.3%
Eggs	0.7%	12%	13%
Milk	04%	04%	03%
Butter	0.4%	81%	0.6%
Chicken	0	11%	20%

Relation of balanced diet with age, gender and activity

During growth period of the body, there is higher metabolic rate in body cells and so body needs a balanced diet that contains more energy. Adults need less proteins per kilogram body weights, but a growing boy or girl needs more proteins per kilogram weight. Similarly, children need more calcium and iron for their growing bones and red blood cells respectively.

"Let thy food be thy medicine":
Hippocrates

Gender has an impact on the requirements of a balanced diet. Women have comparatively less metabolic rate than men of the same age and weight. So men need a balanced diet that provides comparatively more energy.

Different people have different lifestyles and varied nature of work. A man with sedentary habits does not require as much energy as the man who is on his feet for most of the day.

Table 8.4: Estimated energy requirements (in Kilocalories) according to age, gender and activity

Gender	Age (years)	Activity Level		
		Sedentary	Moderately active	Active
Child Male/ Female	2-3	1,000	1,000-1,400	1,000-1,400
Female	4-8	1,200	1,400-1,600	1,400-1,800
	9-13	1,600	1,600-2,000	1,800-2,200
	14-18	1,800	2,000	2,400
	19-30	2,000	2,000-2,200	2,400
	31-50	1,800	2,000	2,200
	50+	1,600	1,800	2,000-2,200
Male	4-8	1,400	1,400-1,600	1,600-2,000
	9-13	1,800	1,800-2,200	2,000-2,600
	14-18	2,200	2,400-2,800	2,800-3,200
	19-30	2,400	2,600-2,800	3,000
	31-50	2,200	2,400-2,600	2,800-3,000
	50+	2,000	2,200-2,400	2,400-2,800

Analyzing and Interpreting:
What do we eat?
Record everything we eat and drink daily in a chart like this and calculate the amount of energy got from carbohydrates, lipids and proteins. Compare the results with the energy requirements given in Table 8.4.

Time	Sun	Mon	Tues	Wed	Thur	Fri	Sat
Breakfast							
Mid-morning							
Lunch							
Mid-afternoon							
Tea							
Dinner							
Extra							

?

A physician advises us; " you should start taking whole wheat bread instead of enriched white bread." The purpose of this advice is that we should take more------(component of food)

Dietary fibre

8.2.3 PROBLEMS RELATED TO NUTRITION (MALNUTRITION)

Problems related to nutrition are grouped as malnutrition. It often refers to undernutrition resulting from inadequate consumption, poor absorption, or excessive loss of nutrients. Malnutrition also includes over-nutrition, resulting from overeating or excessive intake of specific nutrients.

Most commonly, malnourished people either do not have enough calories in their diet, or eat a diet that lacks protein, vitamins, or trace minerals. Malnutrition weakens the immune system, impairs physical and mental health, slows thinking, stunts growth and affects fetal development.

Common forms of malnutrition include protein-energy malnutrition (PEM), mineral deficiency disease (MDD), and over-intake of nutrients (OIN).

According to the United Nations Children's Fund (UNICEF), malnutrition contributes to the deaths of more than 6 million children (under age five) each year.

a- Protein-Energy Malnutrition

Protein-energy malnutrition means inadequate availability or absorption of energy and proteins in the body. It is the leading cause of death in children in developing countries. It may lead to diseases such as Kwashiorkor and marasmus.

1. Kwashiorkor is due to protein deficiency at the age of about 12 months when breast feeding is discontinued. It can also develop at any time during a child's growing years. Children may grow to normal height but are abnormally thin.

2. Marasmus usually develops between the ages of six months and one year. Patients lose all their body fat and muscle strength, and acquire a skeletal appearance. Children with marasmus show poor growth and look small for their age

b- Mineral Deficiency Diseases

Diseases resulting from the deficiency of a mineral are relatively rare among humans. Some examples are given below;

1. Goiter is a condition 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. If sufficient iodine is not available in a person's diet, thyroid gland becomes enlarged and it results in swelling in neck. This condition is known as goitre.

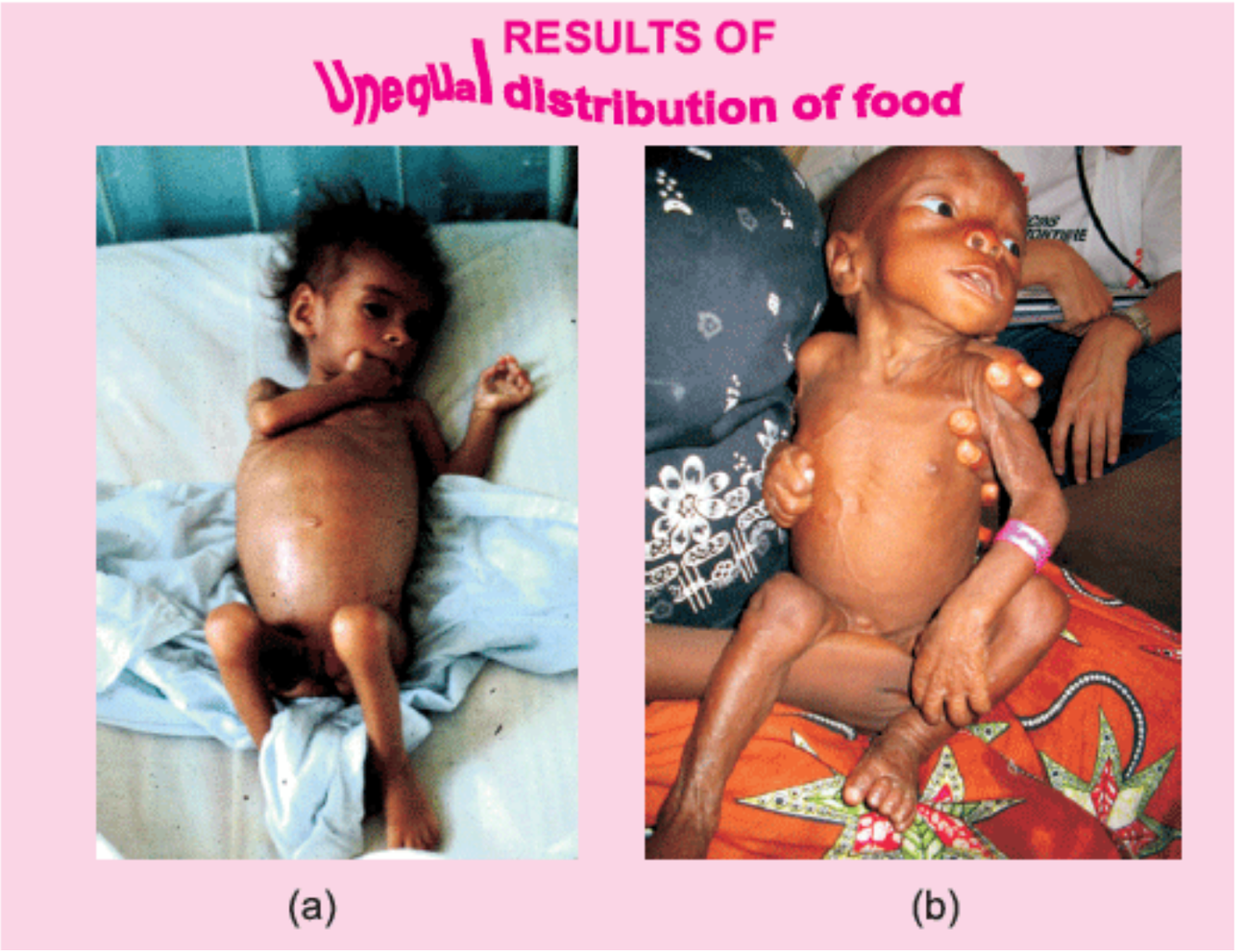


Figure 8.2: Children suffering from (a) Kawshiorkar, (b) Marasmus

2. Anemia is the most common of all mineral deficiency diseases. The term anemia literally means "a lack of blood." It is caused when the number of red blood cells is reduced than the normal. Haemoglobin molecule contains a single atom of iron at its centre. If body fails to receive sufficient amounts of iron, adequate number of haemoglobin molecules are not formed. In this case, there are not enough functioning of red blood cells. The patient is weak and there is shortage of oxygen supply to body's cells.

c- Over-Intake of Nutrients

Over-intake of nutrients (OIN) 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).

Over-intake of nutrients causes a number of health problems. For example 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 intake of vitamin D can lead to deposition of calcium in various tissues.

EFFECTS OF MALNUTRITION

An extended period of malnutrition can lead to problems like starvation, heart diseases, constipation and obesity.

Starvation is a severe reduction in nutrient and energy intake and is the most horrible effect of malnutrition. In humans, prolonged starvation causes permanent organ damage and eventually results in death.

Heart diseases are also increasing on the global level. One of the causes of heart diseases is malnutrition. People who take unbalanced diet (high in fats) are more exposed to heart problems.

Constipation: Malnutrition often leads to situations where people cannot schedule their meals. This irregularity results in many health problems including constipation.

Obesity means becoming over-weight and it may also be due to malnutrition. People who take food that contains energy more than their requirement and do very little physical work can become obese. Obesity is known as the mother-disease and may lead to heart problems, hypertension, diabetes etc

According to the Food and Agriculture Organization of the United Nations, more than 25,000 people die of starvation every day. On average, every five seconds a child dies from starvation.

The World Health Organization (WHO)estimates that, within the next few years, diseases due to malnutrition will become the principal global causes of mortality.

FAMINE - THE MAJOR CAUSE OF MALNUTRITION

Famine means the lack of enough food to feed all people living in an area. The most terrible famines of the twentieth century are the Ethiopian famine (1983-85) and the North Korean famine (1990s). The major causes of famine are unequal distribution of food, drought, flooding or increasing population.

Unequal distribution of food

The achievements in science have enabled human beings to produce better food in terms of quality and quantity. Today the agricultural practices produce more than enough food that can be supplied to every one on the Earth. But due to political and administrative problems, food is not equally distributed to different regions of the world. The result is that there is always surplus food in countries like America, UK, and Canada etc. and at the same time people have nothing to eat in countries like Ethiopia, Somalia etc.

Famines may also be due to the problems created by humans e.g. wars and wrong economic policies

The World Food Program (WFP) is the food aid branch of the United Nations. It is the world's largest agency providing food to more than 90 million people in 80 countries.

Drought

A drought is a period of time when there is not enough water to support agricultural and human needs. Drought is usually due to a long period of below-normal rainfall. Droughts decrease or even stop the crop yields and it results in famine.

Analyzing and Interpreting

In the comparative chart of daily diet and balanced diet requirements, mention the visible symptoms caused by nutrient deficiencies.

Flooding

It occurs due to more than normal rainfall or due to weak water distribution system. Rivers and canals overflow their banks and destroy the soil quality of agricultural lands. It becomes impossible to grow crops immediately after flooding. In this way, flooding may be a reason for short-term famine.

Increasing population

In spite of the global increase in food production, millions of human beings are undernourished. In the over-populated regions of world, large populations overuse natural resources to grow maximum food in order to meet the problems of food shortage. It leads to dry and infertile lands and depletion of resources. In such situations crops can no longer be grown and famines result.

8.3 DIGESTION IN HUMAN

Our cells require oxygen, water, salts, amino acids, simple sugars, fatty acids, and vitamins. These can cross cell membranes to enter cells. Amino acids, simple sugars and fatty acids are rare in our environment. Such substances are usually parts of larger molecules like proteins, polysaccharides and lipids, which cannot cross the membranes. There is a need of converting such large and non-diffusible molecules into smaller and diffusible molecules (that can cross the membranes). This is achieved through the process of digestion.

After digestion, the diffusible molecules from the digestive system reach body cells through blood. Here, they are assimilated (to get energy and to synthesize our own structures). At the same time, the indigestible part of food is eliminated out of body through the process of defecation. In simple words, the nutrition in humans comprises of the following phases.

1- Ingestion	The process of taking in food.
2- Digestion	The process of breaking up complex substances into simpler substances.
3- Absorption	Diffusion of digested food into blood and lymph.
4- Assimilation	Conversion or incorporation of absorbed simple food into the complex substances constituting the body.
5- Defecation	Elimination of undigested food from the body.

We eat mutton and digest its proteins into amino acids. These amino acids are used to synthesize our proteins.

8.3.1 HUMAN ALIMENTARY CANAL

The digestive system of human consists of a long tube that extends from mouth to anus.This tube is called alimentary canal. Its main sections are oral cavity, pharynx,oesophagus, stomach, small intestines and large intestine. In addition, there are many glands associated with alimentary canal. These are in the form of three pairs of salivary glands, a pancreas and a liver.

We will go through the structure and functioning of digestive system by assuming how a bite of bread 'roti' taken with some dish (like mutton) is digested and how small molecules like amino acids, simple sugars, fatty acids, vitamins, salts and water are provided to cells.

Oral cavity - Selection, grinding, partial digestion

Oral cavity is the space behind mouth and has many important functions in the whole process of digestion. **Food selection** is one of them. When food enters oral cavity, it is tasted and felt. If the taste of mutton suggests that it is old, we reject it. If teeth or tongue detect some hard object, such as dirt, we also reject that bite. The senses of smell and vision also help oral cavity in the selection of food.

The second function of oral cavity is the grinding of food by teeth. It is known as chewing or **mastication**. This is useful because oesophagus can pass only small pieces. Enzymes also cannot act on large pieces of food. They require small pieces with large surface areas to attack.

The third and fourth function of oral cavity are **lubrication** and **chemical digestion** of food. The chewing process stimulates the three pairs of salivary glands (under tongue, behind jaws, and in front of ears) to release a juice called **saliva** in oral cavity. Saliva adds water and mucous to food which act as lubricant to ease the passage of food through oesophagus. Saliva also contains an enzyme **salivary amylase**, which helps in the semi-digestion of starch.

During the processes of chewing, lubrication and semi-digestion, the pieces of food are rolled up by the tongue into small, slippery, spherical mass called bolus. We swallow **bolus** and push it in oesophagus through pharynx.

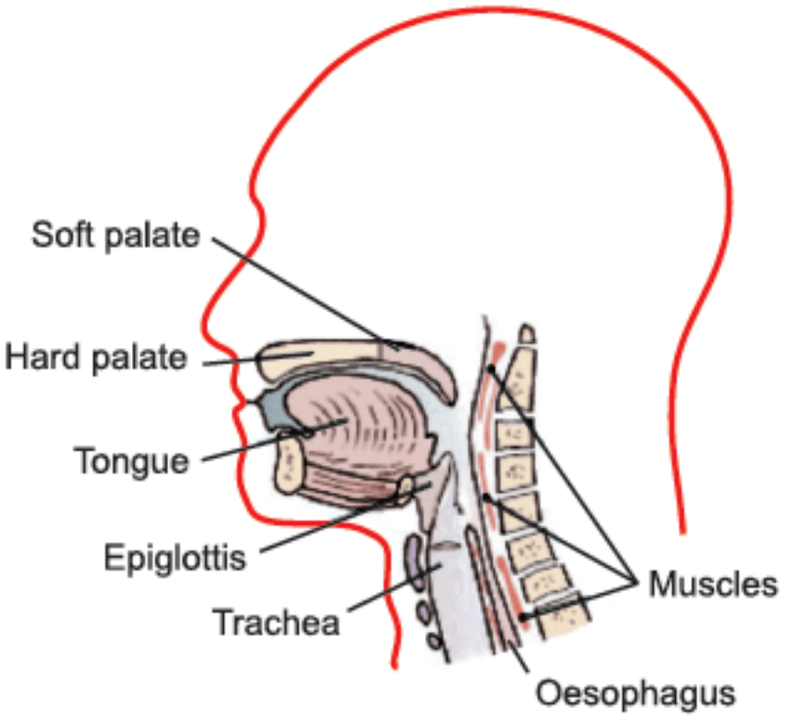


Figure 8.4: Steps in swallowing

Pharynx and Oesophagus - Swallowing and Peristalsis

During swallowing, bolus is pushed to the back of mouth by tongue. When tongue pushes bolus, the soft palate also moves upward and to rear. In this way, the opening of nasal cavity is closed. When swallowed, the bolus passes pharynx to enter oesophagus. Pharynx has adaptations to prevent the entry of bolus particles in trachea (wind pipe to lungs).

In adult human, oesophagus is about 25 cm long.

During swallowing, larynx (the top of trachea) moves upward and forces the epiglottis (a flap of cartilage) into horizontal position. Thus glottis i.e. the opening of trachea is closed. The beginning of swallowing action is voluntary, but once food reaches the back of mouth, swallowing becomes automatic.

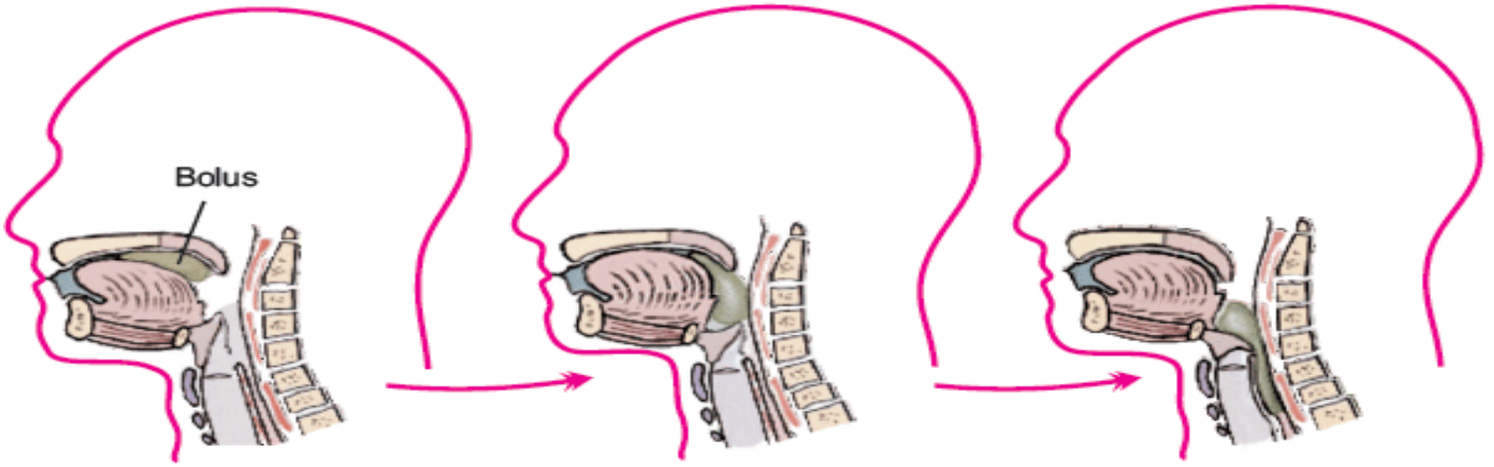


Figure 8.4: Steps in swallowing

After being swallowed, food enters the tube called oesophagus, which connects pharynx to stomach. Neither pharynx nor oesophagus contributes to digestion and the previous digestive actions of saliva continue.

Peristalsis moves food from oral cavity to rectum. **Peristalsis** is defined as the waves of contraction and relaxation in the smooth muscles of alimentary canal walls.

? If due to any reason, the direction of peristalsis reverses,what would be the result?

Vomiting

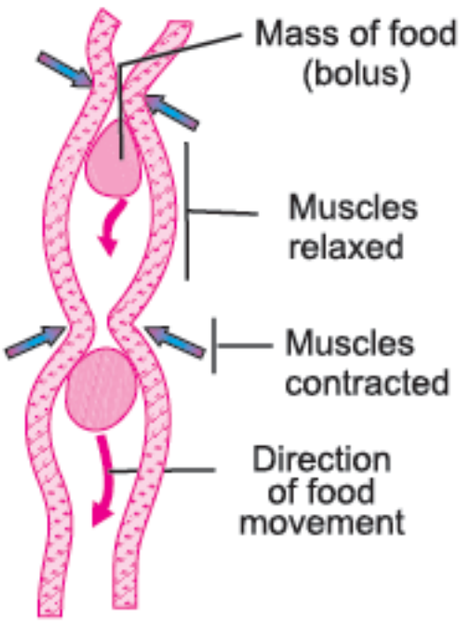
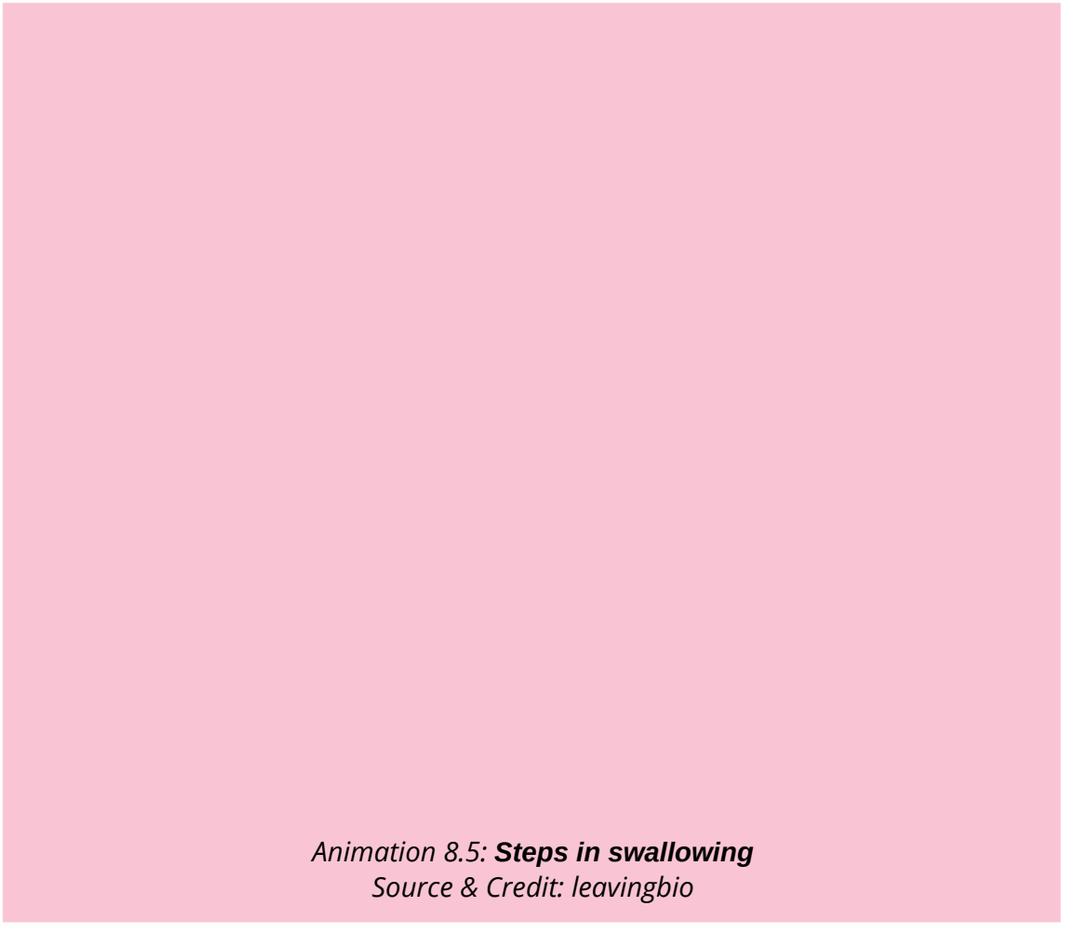
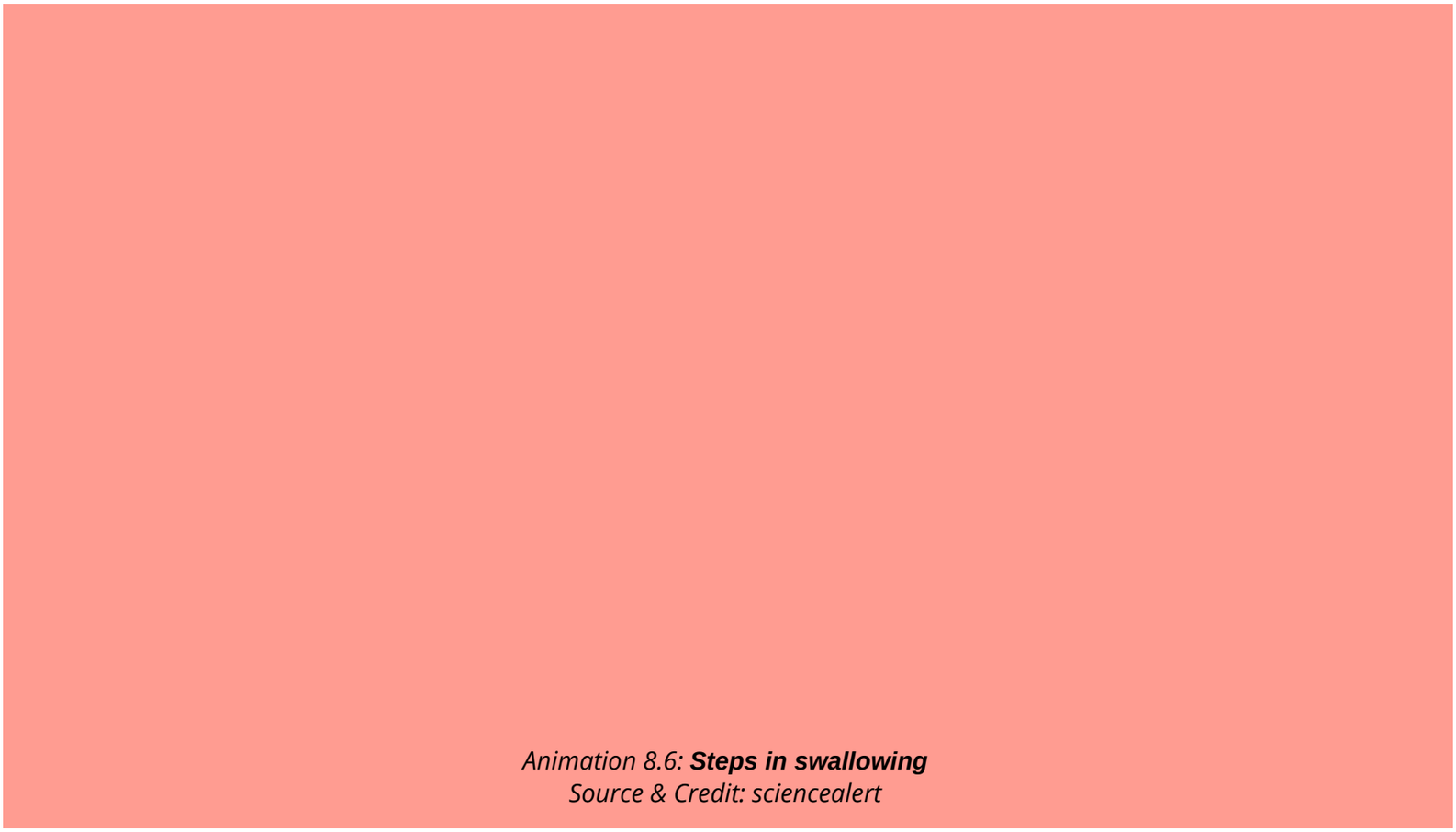


Figure 8.5: Peristalsis



Animation 8.5: ***Steps in swallowing***
Source & Credit: leavingbio



Animation 8.6: ***Steps in swallowing***
Source & Credit: sciencealert

Stomach - Digestion, churning and melting

Stomach is a dilated part of alimentary canal. It is J-shaped, located in the left of abdomen, just beneath diaphragm. Stomach has two main portions. **Cardiac portion** of stomach is present immediately after oesophagus and **pyloric portion** is located beneath cardiac portion. Stomach has two sphincters (openings which are guarded by muscles). **Cardiac sphincter** is between stomach and oesophagus while **pyloric sphincter** is between stomach and small intestine. Bolus enters stomach from oesophagus through cardiac sphincter.

When food enters stomach, the **gastric glands** found in the stomach wall are stimulated to secrete **gastric juice.** Gastric juice is composed chiefly of mucous, hydrochloric acid, and a protein-digesting enzyme **pepsinogen**. Hydrochloric acid converts the inactive enzyme pepsinogen into its active form i.e. **pepsin.** HCl also kills microorganisms present in food. Pepsin partially digests the protein portion of food (bulk of mutton) into polypeptides and shorter peptide chains.

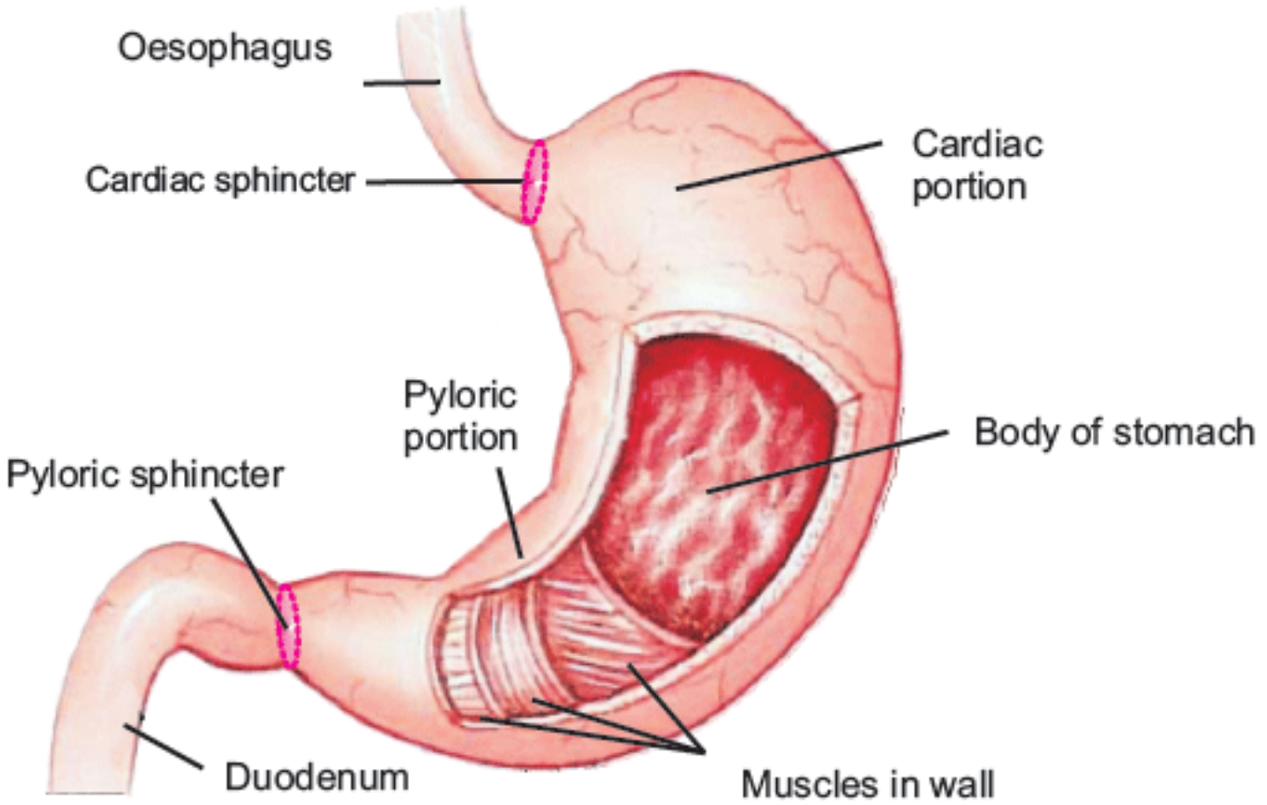


Figure 8.6: Structure of stomach

Animation 8.7: Stomach - Digestion
Source & Credit: gifsoup

An interesting problem is raised here. Pepsin is a powerful protein-digesting enzyme. Why does not it digest the stomach walls, which are mostly proteins? We saw that pepsin is not released in its active form. Rather it is secreted as inactive pepsinogen, which requires HCl for activation. The mucous of gastric juice forms a thick coating over the inner walls of stomach and neutralizes the HCl there. It makes pepsinogen difficult to be activated and to attack stomach walls.

In stomach, food is further broken apart through a process of **churning**. The walls of stomach contract and relax and these movements help in thorough mixing of gastric juice and food. The churning action also produces heat which helps to melt the lipid content of food.

The starch in our bite of bread and the protein in mutton have been partially digested and the food has been converted to a soup-like mixture called **chyme.** After it, the pyloric sphincter allows a little mass of chyme to enter duodenum.

Some quantity of gastric juice is always present in stomach. When bite is in oral cavity, brain sends messages to stomach walls to secrete some gastric juice. When food reaches stomach, more gastric juice is secreted according to needs. If there is little or no protein in food, stomach does not secrete more gastric juice. On the other hand, if more proteins are present in food, abundant gastric juice is secreted. In this case, already present gastric juice begins the digestion of huge proteins into peptides. These peptides stimulate some cells of stomach walls to release a hormone called **gastrin.** This hormone enters blood and is distributed to all parts of body. In stomach, it has specific effect and stimulates the gastric glands to secrete more gastric juice.

Bile also contains pigments that are the by-products of red blood cell destruction in liver; these bile pigments are eliminated from body with faeces.

Small Intestine - Complete digestion and absorption

Duodenum comprises of the first 10 inches (25 cm) of small intestine and it is the part of alimentary canal where most of the digestive process occurs. Here, food is further mixed with 3 different secretions:

1. **Bile** from liver helps in the digestion of lipids through **emulsification** i.e. by keeping the lipid droplets separate from one another.
2. **Pancreatic juice** from pancreas contains enzymes **trypsin**, **pancreatic amylase** and **lipase** which digest proteins, carbohydrates and lipids respectively.
3. **Intestinal juice** from intestine walls contains many enzymes for the complete digestion of all kinds of food.

Next to the duodenum is 2.4 meters long **jejunum**. It is concerned with the rest of the digestion of proteins, carbohydrates and lipids of our bite.

Last 3.5 meters long part of small intestine is **ileum**. It is concerned with the absorption of digested food. There are circular folds in the inner wall of ileum. These folds have numerous finger-like projections called **villi** (singular: villus). **Villi** increase the surface area of the inner walls and it helps a lot in the absorption of digested food.

Each villus is richly supplied with blood **capillaries** and a vessel of lymphatic system, called **lacteal**. The walls of villus are only single-cell thick. The digested molecules i.e. simple sugars and amino acids are absorbed from intestine into the blood capillaries present in villi.Blood carries them away from small intestine via the hepatic portal vein and goes to liver for filtering. Here, toxins are removed and extra food is stored. From liver, the required food molecules go towards heart via the hepatic vein. Fatty acids and glycerol, present in small intestine, are absorbed into the lacteal of villus. Lacteal carries them to the main lymphatic duct, from where they enter in bloodstream.

A non-functional finger-like process called **appendix** arises from the blind end of caecum. Inflammation of appendix due to infection causes severe pain. The infected appendix must be removed surgically otherwise it may burst and inflammation may spread in abdomen.

Large intestine - Absorption of water and defecation

After the digested products of our bite have been absorbed in blood, the remaining mass enters large intestine. It has 3 parts; caecum (or pouch that forms the T-junction with small intestine), colon and rectum. From colon, water is absorbed into blood.As water is absorbed, the solid remains of food are called **faeces**.

Faeces mainly consists of the undigested material. Large number of bacteria,sloughed off cells of alimentary canal, bile pigments and water are also part of faeces.

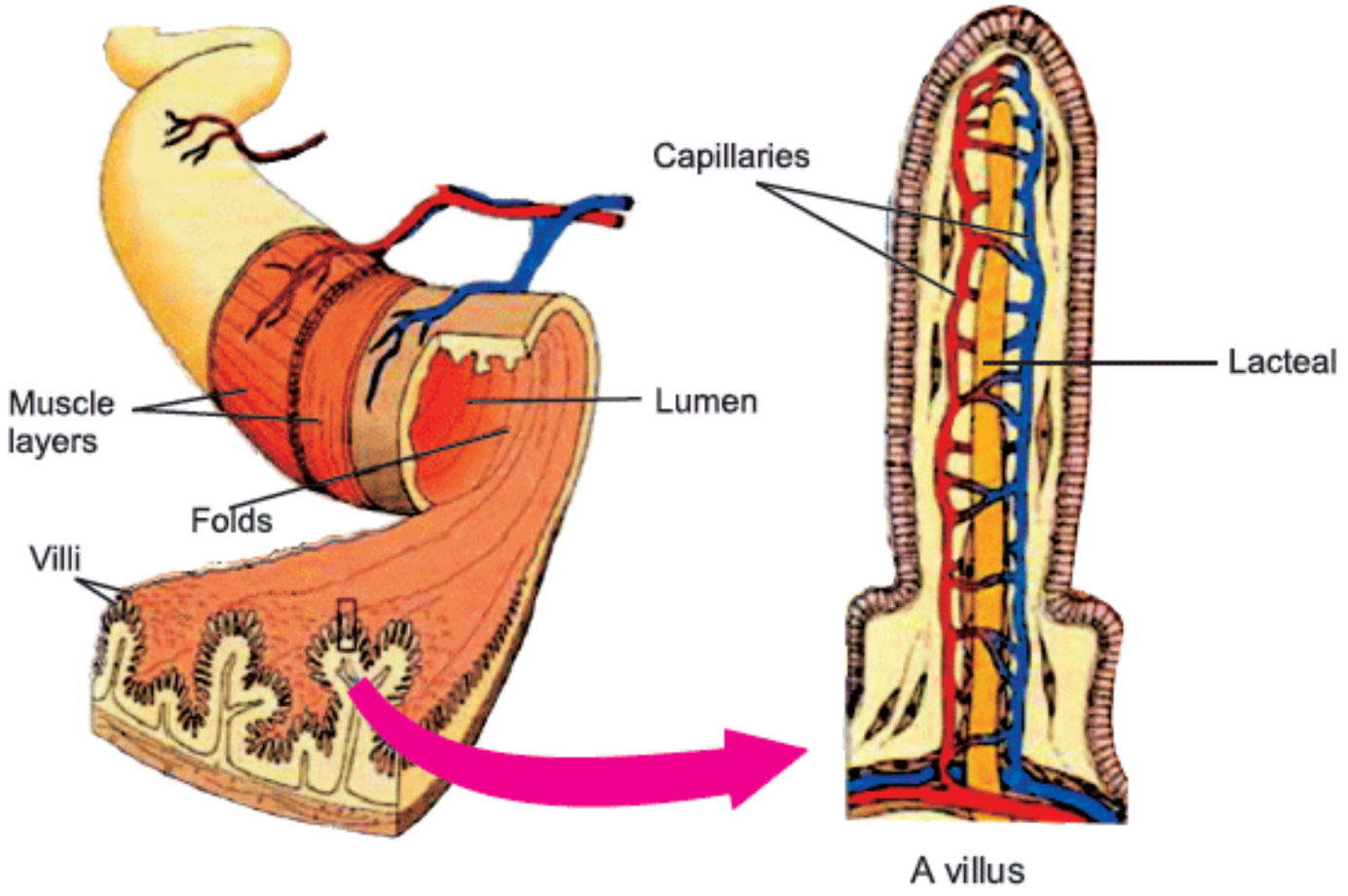


Figure 8.7: Folds and villi in small intestine

Faeces are temporarily stored in rectum, which opens out through anus. Under normal conditions when the rectum is filled up with faeces, it gives rise to a reflex and anus is opened for defecation. This reflex is consciously inhibited in adults but in infants it is controlled involuntarily. During growth, child learns to bring this reflex under voluntary control.

? Functions of large intestine include the elimination of faeces and .....

Absorption of water and salts

8.3.2 ROLE OF LIVER

Liver is the largest gland of body. It is multi-lobed and dark reddish in appearance. It lies beneath the diaphragm on the right side of abdomen. In an adult human, it weighs about 1.5 kg and is the size of a football. A pear-shaped greenish yellow sac i.e. **gallbladder** lies along the right lobe of liver on ventral side.

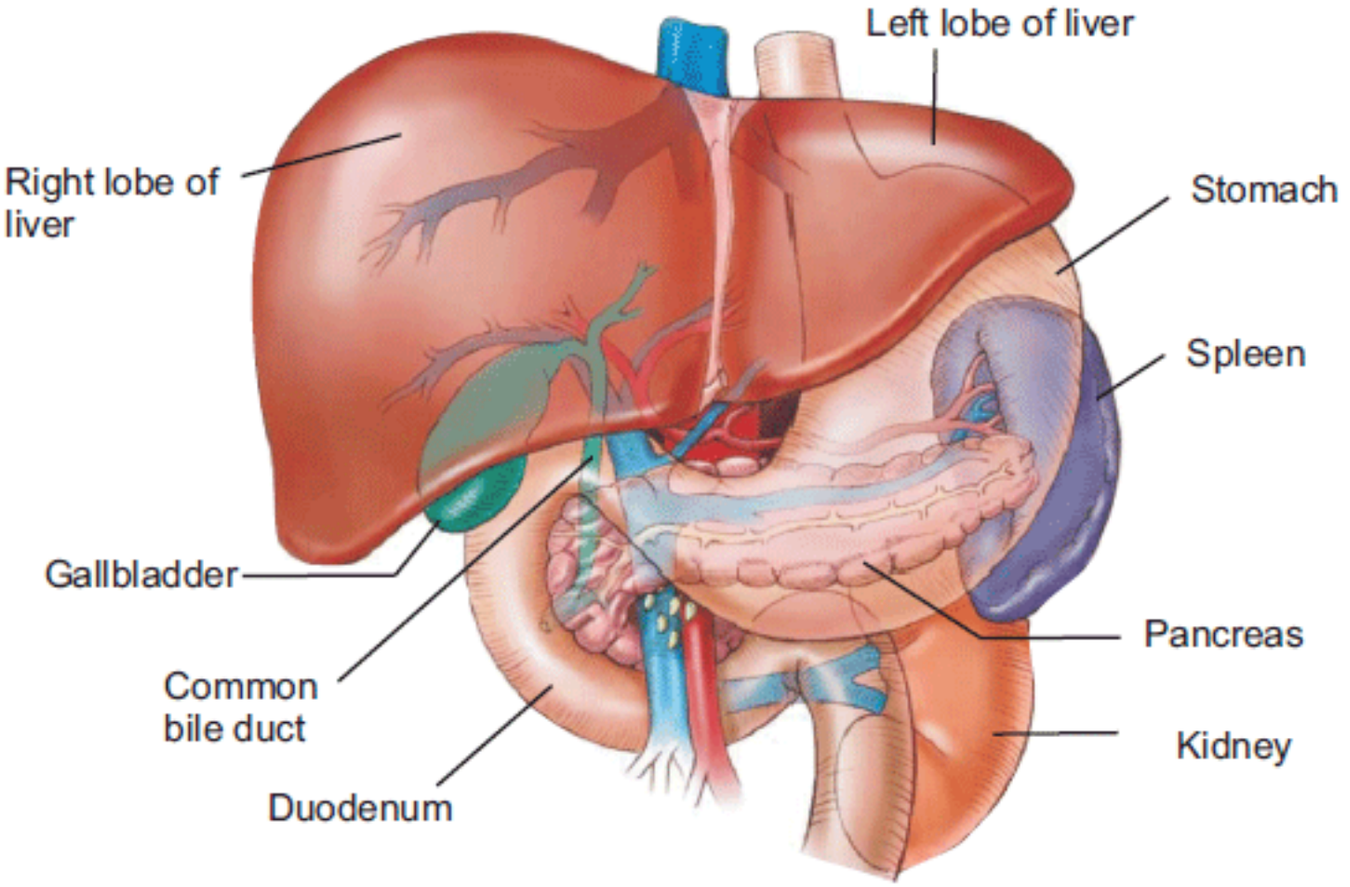
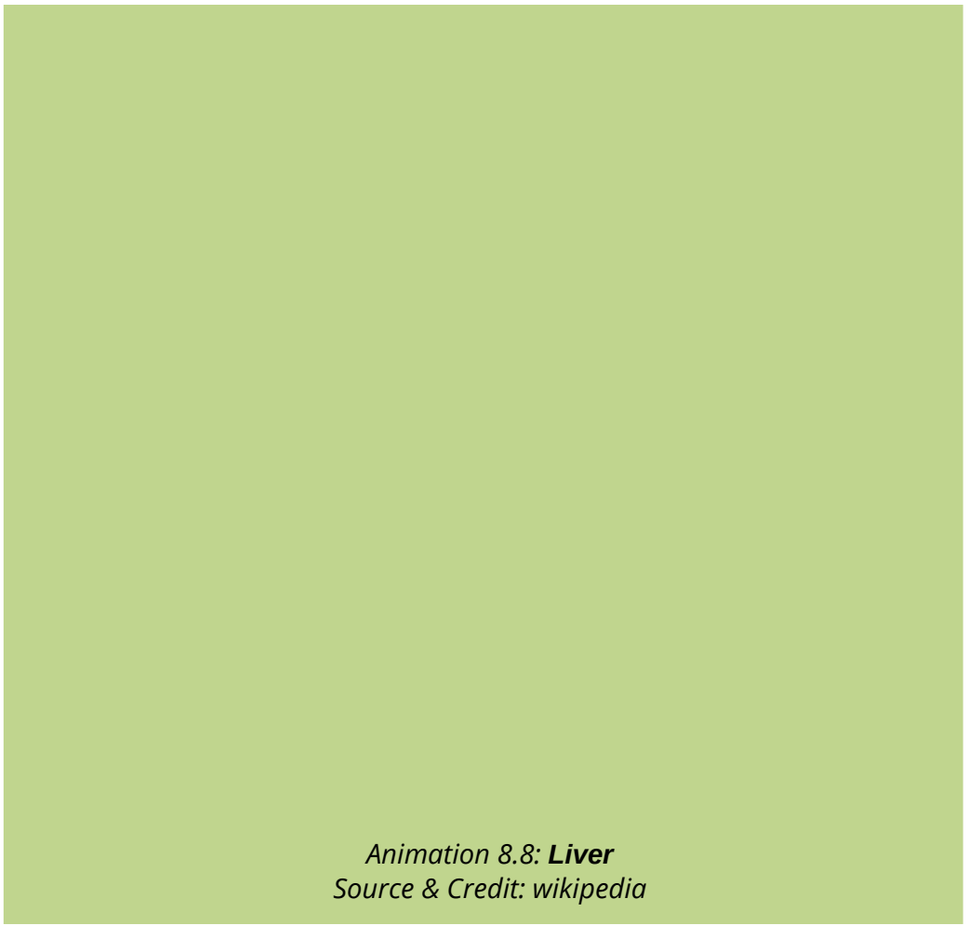
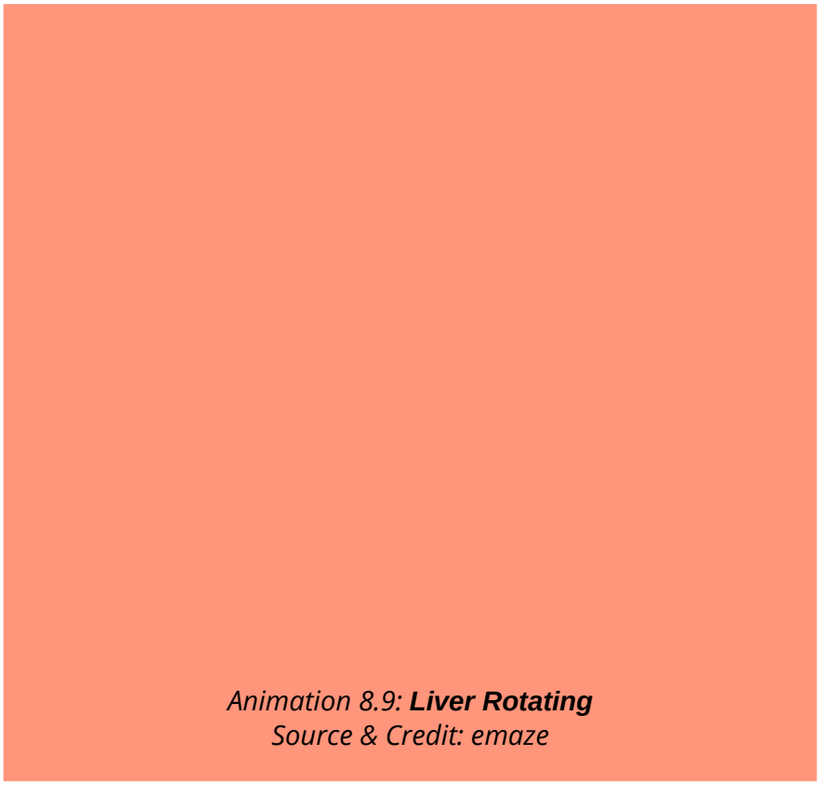


Figure 8.8: Liver and associated organs

Many bacteria live in colon.They produce vitamin K, which is necessary for the coagulation of blood.



Animation 8.8: ***Liver***
Source & Credit: wikipedia



Animation 8.9: ***Liver Rotating***
Source & Credit: emaze

Liver secretes bile, which is stored in gallbladder. When gallbladder contracts, bile is released into duodenum through **common bile duct**. Bile has no enzymes but contains bile salts for the **emulsification** of lipids. It helps the lipid-digesting enzymes to attack on lipids. Besides digestion, liver carries out a number of other functions, some of which are summarized here;

- Removes amino groups from amino acids **(de-amination).**
- Converts ammonia to a less toxic form i.e **urea.**
- Destroys the old red blood cells.
- Manufactures blood clotting proteins called **fibrinogen.**
- Converts glucose into glycogen and, when required, breaks glycogen into glucose.
- Converts carbohydrates and proteins into lipids and produces cholesterol.
- Produces heat to maintain body temperature.
- Stores fat-soluble vitamins (A, D, E, and K) and mineral ions, such as iron.

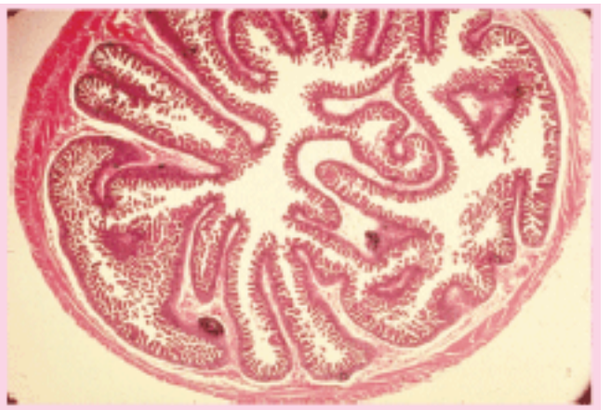
?

In which part of the alimentary canal,the maximum absorption of nutrients occurs?

small intestine

There is a growing concern about the harmful effects of carbonated soft drinks. They are very acidic and make our bodies poor in oxygen. They contain phosphoric acid which dissolves calcium out of the bones. This results in bones weakening. The caffeine present in colas increases the heart rate and raises blood pressure.

Analyzing and Interpreting:
Identify the villus, epithelium, capillary network and lacteal while examining the transverse sections of small intestine (like the one given on right).



?

Write in correct sequence the parts of the alimentary canal where digestion of proteins,lipids and carbohydrates begins.

Stomach,small intestine,oral cavity

8.4 DISORDERS OF GUT

Diarrhoea, constipation and ulcer are the most common disorders of the gut that affect a number of people in Pakistan.

DIARRHOEA

Diarrhoea is a condition in which the sufferer has frequent watery, loose bowel movements. This condition may be accompanied by abdominal pain, nausea and vomiting. It occurs when required water is not absorbed in blood from colon.

The main causes of diarrhoea include lack of adequate safe water. Diarrhoea is also caused by viral or bacterial infections of large intestine. If sufficient food and water is available, the patient of diarrhoea recovers in a few days.

However, for malnourished individuals diarrhoea can lead to severe dehydration and can become life-threatening. The treatment for diarrhoea involves consuming adequate amounts of water (to replace the loss), preferably mixed with essential salts and some amount of nutrients. Antibiotics may be required if diarrhoea is due to bacterial infection. Preventions of diarrhoea include taking clean water and essential salts, eating regularly and taking hygienic measures.

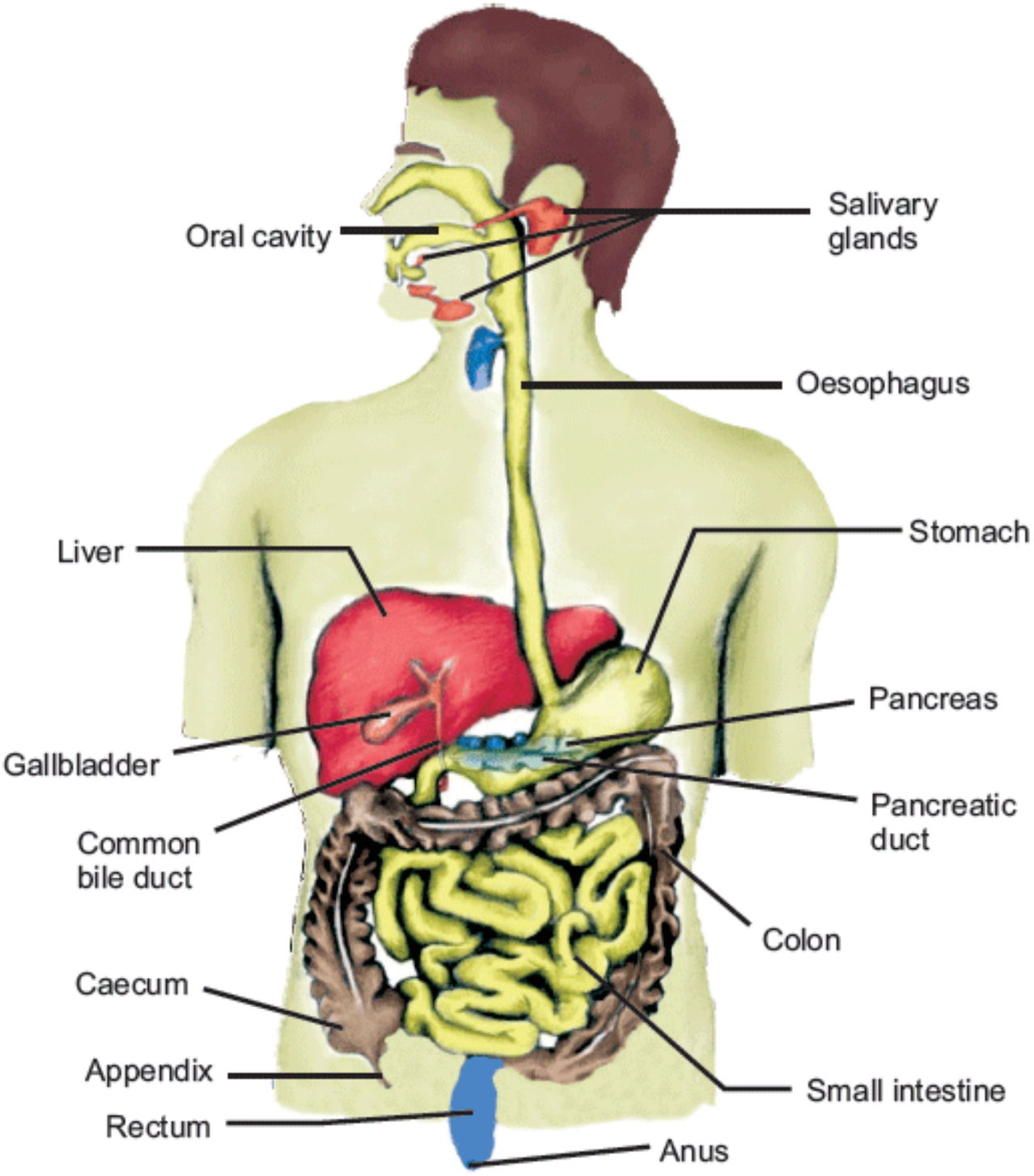


Figure 8.9: Human digestive system

Animation 8.10: Human Digestive System
Source & Credit: wikia

Animation 8.11: Human Digestive System
Source & Credit: makeagif

CONSTIPATION

Constipation is a condition where a person experiences hard faeces that are difficult to eliminate. The main causes of constipation include excessive absorption of water through colon, insufficient intake of dietary fibre, dehydration, use of medicines (e.g. those containing iron, calcium, and aluminium) and tumours in rectum or anus. Treatment of constipation is with a change in dietary and exercise habits. The medicines called laxatives (e.g. paraffin) are used for treatment. Constipation is usually easier to prevent than to treat. One should take the required quantities of water and dietary fibres.

ULCER

Ulcer (peptic ulcer) is a sore in the inner wall of gut (in oesophagus, duodenum or stomach). In ulcer, the acidic gastric juice gradually breaks down the tissue of the inner wall. Ulcer of stomach is called gastric ulcer. The causes of ulcer include excess acid, infection, long term use of anti-inflammatory medicines (including aspirin), smoking, drinking coffee, colas, and eating spicy foods.

The signs and symptoms of ulcer include abdominal burning after meals or at midnight. Severe ulcers may cause abdominal pain, rush of saliva after an episode of regurgitation, nausea, loss of appetite and weight loss. Ulcer is treated with medicines, which neutralize the acidic affects of gastric juice. Spicy, acidic foods and smoking should be avoided as preventive measures.

UNDERSTANDING THE CONCEPTS

1. What are the effects of the lack of nitrate and magnesium ions on plant growth?
2. How are inorganic and organic fertilizers important in agriculture?
3. Draw a table that can show sources, energy values and functions of carbohydrates, proteins and fats.
4. How are vitamins A, C and D important in our diets?
5. Which foods contain calcium and iron and what role these minerals play in our bodies?
6. Why are water and dietary fibres considered important in our diets?
7. Define balanced diet. How would you relate it with age, gender and activity?
8. Describe how protein energy malnutrition, mineral deficiency diseases and over intake of nutrients are the major forms of malnutrition?
9. How would you advocate the unequal distribution of food as the major factor that contribut to famine.

10. Describe structures and functions of the main regions of alimentary canal.
11. Describe swallowing and peristalsis.
12. Briefly give the signs and symptoms, causes, treatments and prevention of diarrhoea, constipation, and ulcer.

SHORT QUESTIONS

1. What are the health risks if we take more saturated fatty acids in our diet?
2. How can the deficiency of vitamin A cause blindness?
3. How will you differentiate between bolus and chyme?
4. Which sphincters play role in the movement of food in and out of stomach?
5. Stomach is an organ of the digestive system, but it also secretes a hormone. What hormone is it and what function it performs?

ACTIVITIES

- Perform tests for starch, reducing sugars, proteins and fats.

INITIATING AND PLANNING

1. Investigate and present in a tabulated data from your daily food intake (in terms of nutrients and calories).
2. Identify the villus; epithelium, capillary network and lacteal while examining the transverse section of small intestine.

TERMS TO KNOW

Amylase	Gastrin	Pharynx
Anemia	Goiter	Protein energy malnutrition
Appendix	Ileum	Pyloric sphincter
Assimilation	Intestinal juice	Rectum
Balanced diet	Jejunum	Saliva
Bolus	Kwashiorkor	Starvation
Cardiac sphincter	Lacteal	Stomach
Chyme	Laxatives	Swallowing
Colon	Lipase	Trace minerals
Constipation	Liver	Trypsin
Diarrhoea	Malnutrition	Ulcer
Dietary fibre	Marasmus	Villus
Digestion	Nutrition	Vitamins
Duodenum	Oesphagus	
Emulsification	Oral cavity	
Epiglottis	Pancreas	
Famine	Pancreatic juice	
Fat soluble vitamins	Pepsin	
Fertilizer	Peristalsis	
Gastric juice		

SCIENCE, TECHNOLOGY AND SOCIETY

1. Explain why farmers use chemical fertilizers for better growth of their plants.
2. Describe ways in which research about nutrition has brought about improvements in human health (e.g., development of nutritional supplements, and diets based on the needs of age, gender and activity).
3. Exemplify the societies suffering from famine due to unequal distribution of food and due to over-population.
4. Explain how the customary food habits contribute to digestive tract disorders (e.g. diarrhoea, constipation).

ON-LINE LEARNING

1. nutrition.about.com/od/foodpyramid/
2. www.enchantedlearning.com/subjects/anatomy/digestive/
3. kitses.com/animation/swfs/digestion.swf
4. healthresources.caremark.com/topic/digestivesystem