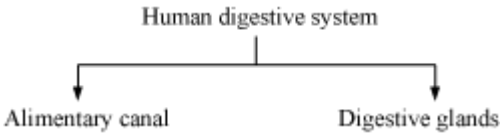
Digestion and Absorption

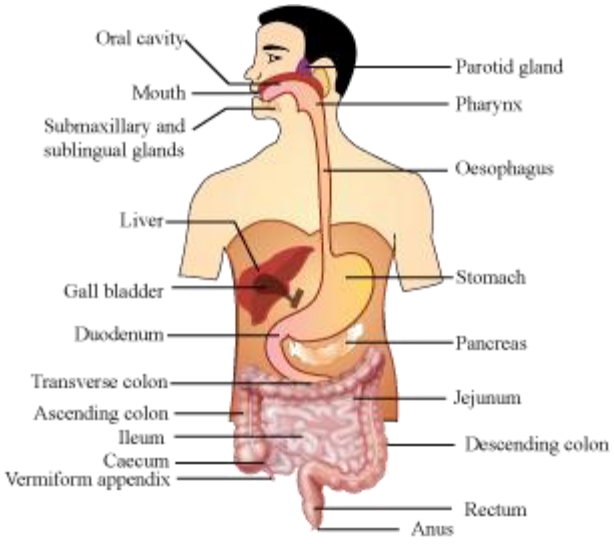
Structures Involved in Human Alimentary Canal

Digestion in Human Beings

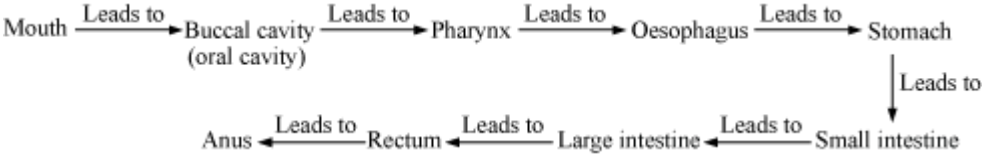
- Major components of food – carbohydrates, fats, proteins along with small quantity of vitamins and minerals
- Digestion - Process of conversion of complex food substances into simpler absorbable forms to meet the energy requirements of the body
- The energy requirements of the body are expressed in the terms of calorie (cal). One calorie can be defined as the amount of energy required to raise the temperature of 1 g of water by 1º C at normal atmospheric pressure.
- The amount of heat liberated from complete combustion of 1 g of food is called its gross calorific value. Gross calorific values of carbohydrates, proteins and fats are 4.1 kcal/g, 5.65 kcal/g, and 9.45 kcal/g, respectively.



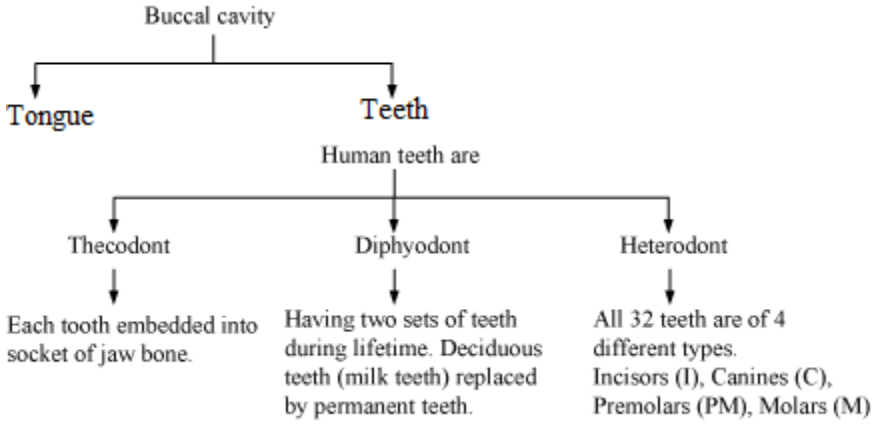
Alimentary Canal



- Parts of alimentary canal from anterior end to posterior end



- **Buccal Cavity (oral cavity)**



- Dental formula of adult human – $\frac{2123}{2123}\left(\frac{\text{I,C,PM, M upper jaw}}{\text{I,C,PM, M lower jaw}}\right)$

- Enamel forming hard surface of teeth is the hardest substance of human body. It helps in mastication of food.

- Tongue – Attaches to floor of buccal cavity by *frenulum* and bears projections called papillae, which in turn bear taste buds

- **Pharynx**

- Oesophagus (food pipe) and trachea (wind pipe) both open into pharynx.

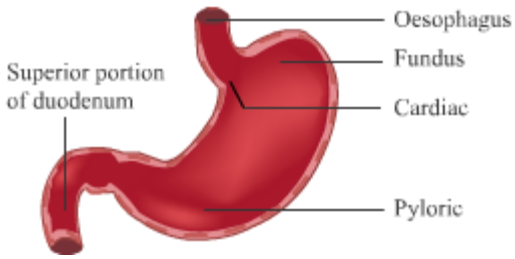
- Entry of food into glottis (the opening of trachea) is prevented by epiglottis (a cartilaginous flap).

- **Oesophagus**

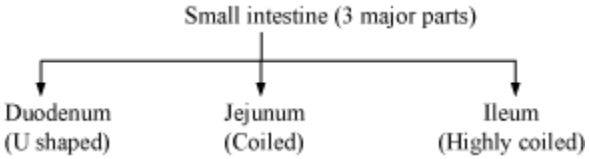
- This thin, long tube leads to stomach.

- Gastro-oesophageal sphincter regulates oesophagus opening into stomach.

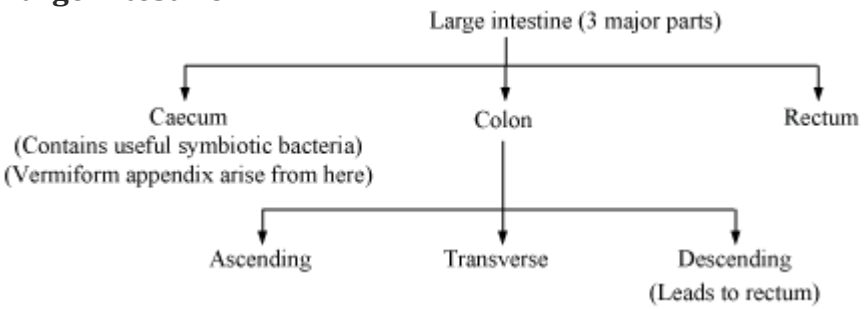
- **Stomach**
- Location – upper left part of abdominal cavity
- Three parts of stomach:
- Cardiac – where oesophagus opens
- Fundic – where food rests and undergoes digestion
- Pyloric – which opens into duodenum



- **Small Intestine**

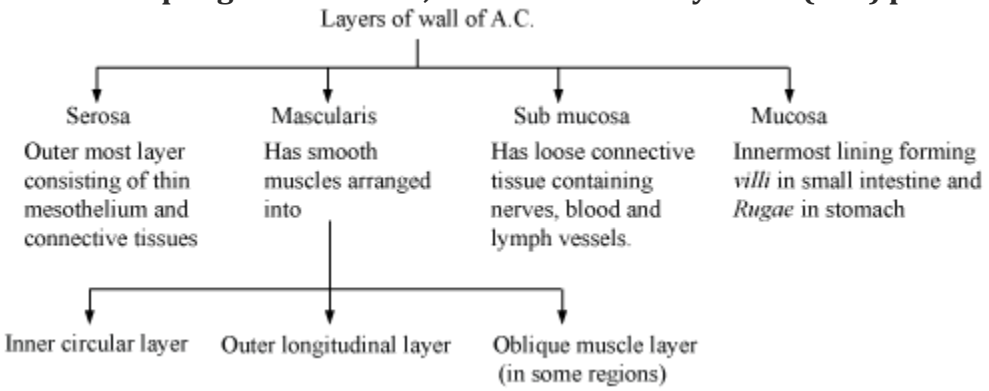


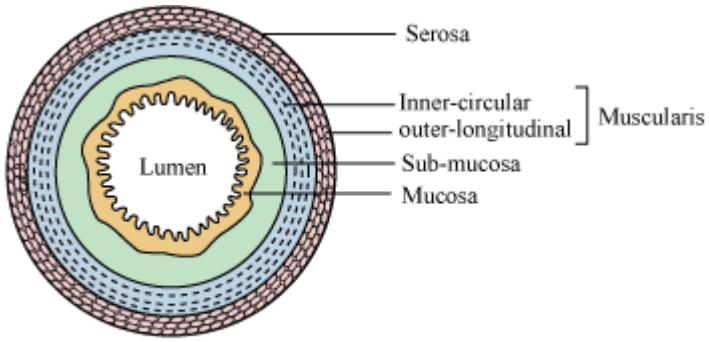
- Pyloric sphincter guards opening of stomach into duodenum.
- **Large Intestine**



Layers Forming Alimentary Canal

- **From Oesophagus to Rectum, wall of Alimentary canal (A.C.) possesses 4 layers:**





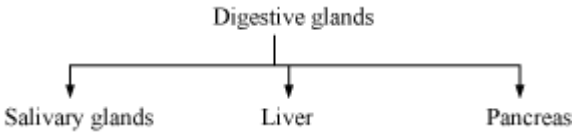
T.S. of Alimentary canal displaying wall layers

- **Rugae** – irregular folds formed by mucosa in stomach
- **Villi** – These are finger-like folding formed by mucosa in small intestine. Cells that line villi bear microscopic projections called microvilli. These increase the surface area.
- Villi have a network of capillaries and lacteal (a large lymph vessel). This helps in absorption of food in small intestine.
- Importance of mucosa layer:
- Bears villi and rugae
- Bears *Goblet cells*, which secrete mucus, facilitating lubrication
- Forms glands in stomach (Gastric glands)
- Forms crypts of Lieberkuhn in between bases of villi that secrete various enzymes

Openings and Sphincters

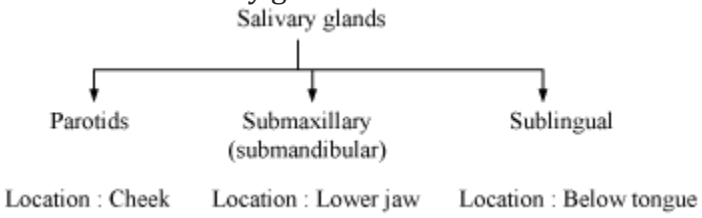
- Glottis – opening of trachea
- Epiglottis – flap that prevents entry of food into wind pipe
- Gastro-oesophageal sphincter – guards opening of oesophagus into stomach
- Pyloric sphincter – guards opening of stomach into duodenum
- Sphincter of Oddi – guards opening of hepato-pancreatic duct into duodenum
- Ileo-Caecal valve – guards opening of ileum into caecum

Digestive Glands

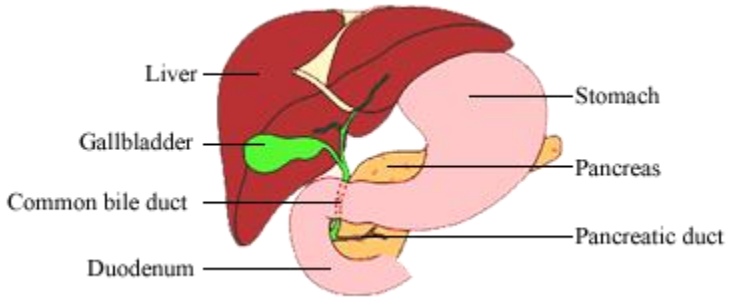


Salivary Glands

- Location – just outside buccal cavity
- Division of salivary glands:



Liver

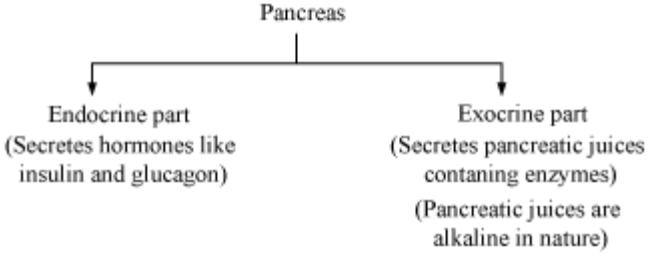


- Largest gland
- Location – Right side of abdominal cavity, just below the diaphragm

- Weight – 1. 2. to 1.5 kg in human adult
- Liver contains hepatic lobules – structural and functional unit of liver; covered by Glisson's capsule (a sheath of connective tissue)
- Lobules contain hepatic cells that secrete bile.
- Bile passing through hepatic ducts gets stored in gall bladder (a muscular sac-like structure).
- Common Bile duct = Hepatic duct (liver duct) + Cystic duct (gall bladder duct)
- Hepato pancreatic duct = Common Bile duct + Pancreatic duct
- Hepato pancreatic duct opens into duodenum.
- Sphincter of Oddi guards the opening of hepato-pancreatic duct.

Pancreas

- Location – Between limbs of 'U'-shaped duodenum
- Compound gland having both endocrine and exocrine parts



Digestion and Absorption of Food

Process of digestion of food

- Includes both mechanical and chemical processes
- Digestion of carbohydrates – mainly in mouth and small intestine
- Digestion of fats – mainly in small intestine
- Digestion of proteins – mainly in stomach and small intestine

- Absorption – Nutrients are mainly absorbed in small intestine while the absorption of water is carried out by large intestine.

Digestion in Mouth

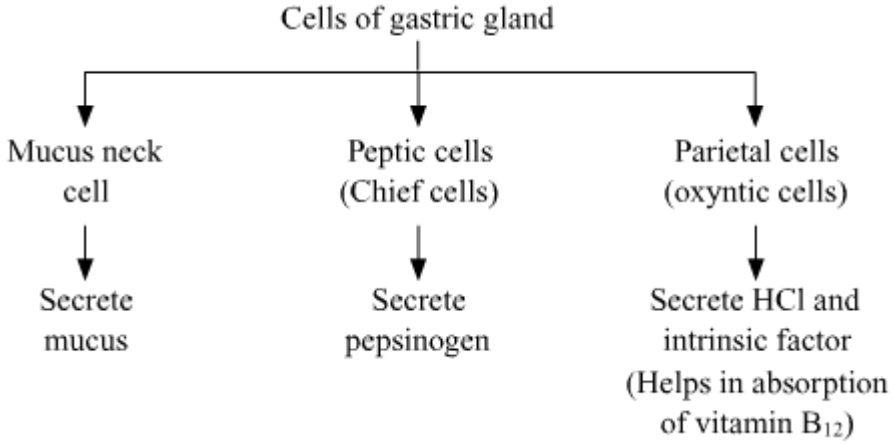
- Saliva contains enzymes salivary amylase, lysozyme, and electrolytes.
- Salivary amylase basically helps in starch digestion up to 30%.

$$\text{Starch} \xrightarrow[\text{pH6.8}]{\text{Salivary amylase}} \text{Maltose}$$

- 2 basic functions performed by buccal cavity – mastication of food and facilitation of swallowing
- Mucus in saliva lubricates and adheres food particles into *Bolus*.
- Deglutition or swallowing conveys the bolus to pharynx and then to oesophagus.
- Peristalsis conveys the bolus from oesophagus to stomach.
- Peristalsis - process of wave-like muscle contractions of the alimentary tract that moves food along
- Lysozyme present in saliva acts as an antibacterial agent.

Digestion in Stomach

- Mucosa of stomach has gastric glands containing 3 types of cells.



- Food rests in stomach for about 4-5 hours, then gets mixed with acidic gastric juices by churning movement of muscular wall and is called chyme at this stage.
- Gastric juice contains HCl, pepsinogen, rennin, and lipase.

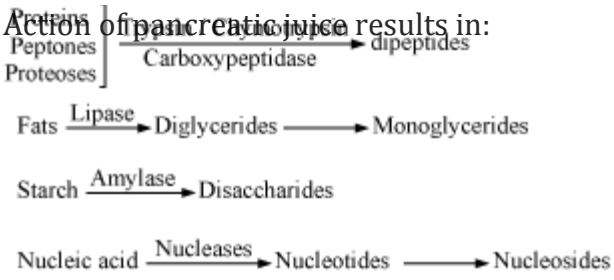
- Proenzyme pepsinogen $\xrightarrow{HCl}$ Pepsin (active enzyme)
- Mucus and bicarbonate lubricate the gastric epithelium and protect it from action of HCl.
- Small amount of protein digestion (by pepsin) occurs here.
  $\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Proteases} + \text{Peptides}$
- Rennin (proteolytic enzyme) in infants helps milk digestion.

Digestion in Small Intestine

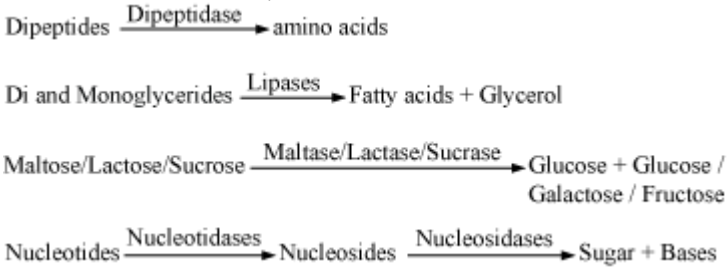
- 3 types of secretions are released into the intestine.

	Pancreatic juice **released by hepatopancreatic duct**	**Bile**	**Intestinal juice (succus entericus)**
1.	Contains inactive enzymes such as trypsinogen, chymotrypsinogen, procarboxypeptidase, amylase, lipase, nuclease, etc.	Contains bile pigments (Bilirubin and biliverdin), bile salts, cholesterol phospholipids	Contains enzymes such as maltase dipeptidase, lipase nucleosidase, etc.
2	$\text{Trypsinogen} \xrightarrow{\text{Enterokinase}} \text{trypsin}$ ↓ Activate other enzymes	Bile contains no enzyme.	Also contains mucus which in combination with bicarbonates released by pancreas provides alkaline medium and prevents intestinal mucosa from acid
3.		It emulsifies fats into micelles and activates lipases.	

- Action of pancreatic juice results in:



- Action of intestinal juice results in:



- Digestion occurs in – Duodenum|
  Absorption occurs in – Ileum and jejunum

Absorption of Digested Food

- Absorption of food is the process by which the end products of digestion pass through the intestinal mucosa into the blood or lymph.

- Mechanism of absorption

- **Simple diffusion** – Glucose, amino acid, electrolytes such as Cl^- follow this method; depends upon concentration gradient

- **Facilitated transport** – Fructose and some amino acids are absorbed by this method. Absorption occurs with the help of carrier ion such as Na^+.

- **Active transport** – Glucose, some amino acids, Na^+ follow this method. Absorption is against concentration gradient. Thus, it requires energy.

- Fatty acids are insoluble; hence first broken into small droplets called micelle, which further reform into small protein-coated fat globule called chylomicron (in intestinal mucosa), which are then transported into lacteals in villi, which finally release them into blood stream.

- Substances absorbed in mouth – Certain drugs are absorbed in blood capillaries, lining lower parts of tongue.

- Substances absorbed in stomach – water, simple sugars, alcohol
- Substances absorbed in small intestine – almost all nutrients
  Maximum nutrition occurs here.
- Substances absorbed in large intestine – water, minerals, drugs
- Absorbed substances finally reach tissues where they are utilized. This process is called **assimilation.**

Egestion

- Mucus secreted by large intestine adhere the undigested particles into faeces.
- Faeces enter caecum through ileo-caecal valve. Back flow of faeces is prevented by this valve.
- Faeces are stored in rectum.
- In rectum, a neural reflex is initiated causing an urge for removal of faecal matter.
- Defaecation is a voluntary process carried out by mass peristaltic movement.

Disorders of Digestive System

Infections

- Bacterial and viral infections cause inflammation of intestinal tract.
- Intestinal parasites such as tape worm, hook worm, thread worm, etc. also cause infections.

Jaundice

- Caused by Hepatitis virus
- It affects liver.
- Bile pigments deposit leading to yellowing of eyes and skin.

Vomiting

- Ejection of stomach contents through mouth
- It is a reflex action, controlled by vomit centre in medulla.

Diarrhoea

- Abnormal frequency of bowel movements
- Increased liquidity of faecal discharge
- Decreased absorption of food

Constipation

- Bowel movements – irregular
- Faecal matter retained within rectum

Indigestion

- Food is not fully digested leading to feeling of fullness.
- Causes may include an inadequate enzyme secretion, anxiety, food poisoning, overeating, intake of spicy food, etc.

Malnutrition and Deficiency Diseases

Malnutrition is defined as the lack of sufficient food or the non availability of proper nutrients in the food we consume or the physical inability to absorb and metabolize the nutrients.

It can be classified into-

Under nutrition: this condition results when there is insufficient amount of food consumed over a period of several days. It is also known as starvation. It affects the physical and mental abilities of the person.

Over nutrition: it is caused by the over consumption of food over extended period of time. It may lead to a condition called obesity.

Deficiency Diseases

Diseases that occur due to the lack of nutrients are called **deficiency diseases**. Deficiency diseases can be of various types:

Vitamin Deficiency

Vitamins are needed by the body in small amounts yet their deficiency leads to various deficiency diseases. Vitamins are of two types – fat soluble (vitamins A, D and K) and water soluble (Vitamin B and C).

If taken in excess, the water soluble vitamins are excreted with the urine but if fat soluble vitamins are taken in excess, they are not excreted easily and harm the body and cause restlessness and nausea.

The sources, uses and associated deficiency diseases for various vitamins are given the following table

	Vitamin	Sources	Essential for	Deficiency disease
1.	**Vitamin A**	Milk, butter, cheese, tomatoes, carrots, cod liver oil, yellow fruits	Good eyesight	**Night-blindness** (poor night vision)
2.	**Vitamin B complex** (mixture of several vitamins)	Milk, eggs, cheese, meat, liver, husk of cereals and pulses	Digestion, growth	**Beri-beri** (nervousness, loss of appetite, paralysis)
3.	**Vitamin C** (ascorbic acid	Citrus fruits (orange, lemon, lime), green vegetables, tomatoes	Muscles and teeth	**Scurvy** (bleeding of gums and swelling of joints)
4.	**Vitamin D** (produced by sun in skin)	Milk, yellow of egg, liver, fish liver oil, especially sunlight, cod liver oil.	Strong bones and teeth	**Rickets** (decaying teeth, weak bones) in children and **osteomalacia** in adults
5.	**Vitamin K** (made by bacteria in large intestine)	Leafy green vegetables (spinach, cabbage)	Blood clotting	**Haemorrhage** (bleeding)

Mineral Deficiency

Some important sources of minerals are vegetables, spices, and fruits. Though they are needed in small quantities, they are indispensable for proper growth of the body and to protect the body from various diseases.

The detail information on various vitamins is given in the following table

	Chemical element	Sources	Functions	Deficiency effect/disease
1.	**Calcium**	Cheese, milk, green leafy vegetables, pulses, eggs, meat	Bone and teeth formation, blood clotting, Muscle activity	**Rickets**, Brittle bones, excessive bleeding, bad muscle movement
2.	**Phosphorus**	Fish, eggs, meat, milk, cheese, potatoes	Bone and teeth formation, nucleic acid formation, energy transfer, ATP	Bad bones and teeth body weakness
3.	**Potassium**	Beef, eggs, milk, cheese, potatoes	Osmocontrol-blood and tissue fluid, nerve impulse conduction	Muscle weakness and paralysis
4.	**Sodium**	Salt, cheese, bread, butter	Osmocontrol-blood and tissue fluid, nerve impulse conduction, Gastric juice, HCl acid	Dehydration, extreme weakness
5.	**Magnesium**	Cheese and green vegetables	Energy transfer, bone and teeth formation	Activity of muscles and nerves, weakness
6.	**Iron**	meat, liver, eggs, green leafy vegetables	Blood haemoglobin formation, Muscle myoglobin formation, Enzyme activity	**Anaemia**
7.	**Iodine**	Sea fish, iodised salt	Thyroid gland function	**Goitre** (enlarged thyroid), abnormal metabolism
8.	**Fluorine**	Sea fish, tea, and some drinking water	Bone and teeth formation	Dental cavities

Protein and Carbohydartes/Energy (Calorie) Deficiency

There are certain diseases which are caused due to the deficiency of proteins or proteins and energy (calories). These are termed as Protein Energy Malnutrition (PEM). Deficiency of proteins leads to Kwashiorkar whereas deficiency of proteins and carbohydrates/calories/energy leads to marasmus.

The diet that is poor in proteins lead to a disease called **kwashiorkor** in which the growth of the infant is retarded. This disease affects the children in age group of 1 to 5 years. The symptoms of this disease are

- Stick like thin legs
- Protruding belly
- Water retention
- Bulging eyes
- Discolouration of hair
- Mental retardation

The deficiency of both proteins and carbohydrates in the diet leads to a condition called **marasmus**. It occurs when the child under the age of one year does not get sufficient food. The symptoms of marasmus are as follows

- Lean and weak body
- Prominent ribs
- Dry, thin, wrinkled skin with folds of loose skin.
- Mental retardation

Do you know that improper cooking methods such as cooking in iron vessels, overcooking, and boiling can lead to the loss of taste and nutrients from vegetables?

This happens because during cooking, some volatile acids and gases are released from the vegetables. These acids and gases spoil the taste and look of the food.

Hence, cooking should be fast to prevent the loss of taste and look of the food.

- Repeated washing of rice, pulses, and some fruits should be avoided as the vitamins and minerals present in them may also get washed away.

- The skins of many fruits and vegetables contain vitamins and minerals. Hence, they should not be peeled before eating.

- Vegetables and fruits should not be washed after they have been cut or peeled.

- Water (in which grains are soaked) should not be thrown away as it contains many useful proteins and minerals.

  Therefore, the loss of nutrients while preparing food can be minimized by keeping the above mentioned points in mind.