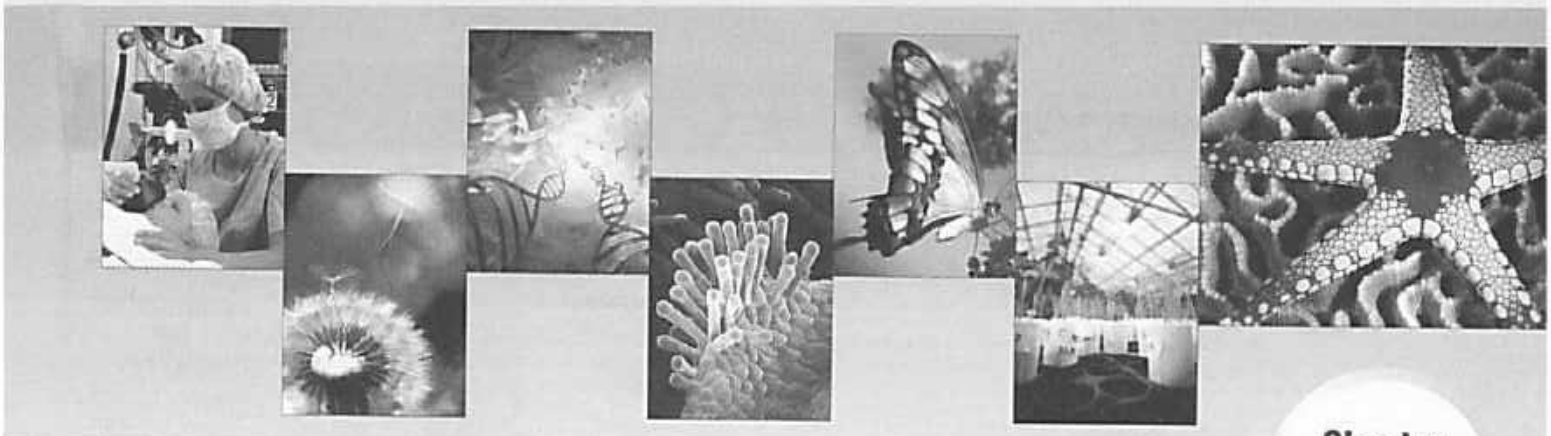


Chapter

5.1

Digestion and Absorption

Animals are not able to synthesise their own food, therefore they depend on ready-made food for their nutritional requirements. The term nutrition refers to the sum total of all the processes related with the conversion of the raw foodstuff into the stuff of the body to supply energy for different metabolic activities and also for the repair and growth. In other word we can define nutrition as the process by which an organism derives energy to work and other materials, required for growth and maintenance of the various activities of life.

Food intake : Different organisms obtain food in different ways but carry out similar chemical reactions to utilize it. To take food, protozoans use pseudopodia, flagella or cilia; sponges and mussels, a current of water; Hydra, tentacles beset with stinging cells; planarians and earthworms, a muscular pharynx; flukes and leeches, oral sucker; insects and other arthropods, mouth parts of various kinds; and seastars and sea urchins, tubefeet. Sharks capture prey with the jaws; frog and lizard with the tongue; birds with beaks of sorts; rabbit and hare use forepaws, lips and teeth; cattle, lips and teeth; carnivores, claws and teeth; giraffes, tongue; elephants, proboscis (trunk); humans, monkeys and apes use hands.

Digestion

The process by which complex food is converted into simplest food with the help of digestive enzymes (Hydrolytic enzymes) is called digestion. Hence process of digestion is a hydrolytic process.

Types of digestion

(1) **Intracellular :** When the process of digestion occurs within the cell in the food vacuole. Examples : Protozoa, Porifera, Coelenterata and free living platyhelminthes.

(2) **Extracellular :** When the process of digestion occurs outside the cell. Examples : Coelenterates and phylum platyhelminthes to phylum chordata.

Digestive system of human

Digestion in vertebrates occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly grouped in two groups –

(i) Digestive tract or alimentary canal

(ii) Digestive glands

Digestive tract or alimentary canal

On the basis of the embryonic origin, the alimentary canal of vertebrates can be divided into three parts –

(1) **Fore gut / Stomodaeum :** Ectodermal. It includes buccal cavity / oral cavity, pharynx, oesophagus, stomach and small part of duodenum.

(2) **Mid gut / Mesodaeum :** Endodermal. It includes small intestine, and large intestine.

(3) **Hind gut / Proctodaeum :** Ectodermal. It includes anal canal and anus.

Parts of alimentary canal and its histology

Mouth

The mouth is a transverse slit bounded by two movable lips or labia, upper lip and lower lip. Upper lip has small ridges on the sides, a tubercle in the middle and a vertical groove (philtrum) above.

Vestibule

It is a narrow space between lips and gums in front and gums and cheeks on the sides. Its lining contains mucous glands. In the vestibule, a small median fold of mucous membrane, the superior labial frenulum, connects the middle of the upper lip to the gum and usually a similar but smaller inferior labial frenulum connects the middle of the lower lip to the gum.

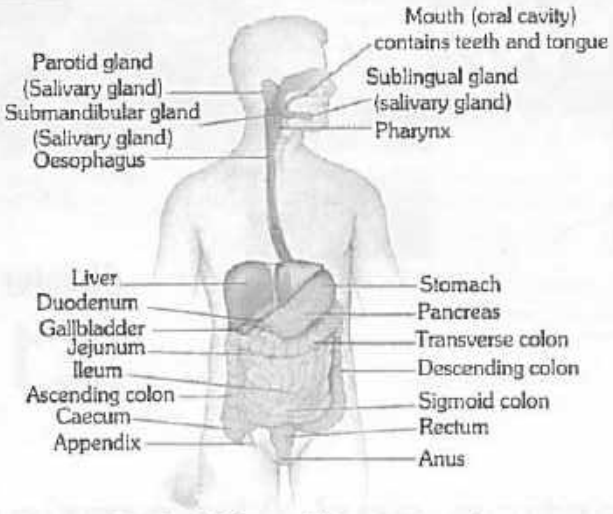


Fig : 5.1-1 Human Alimentary canal

Buccopharyngeal cavity

It includes anterior buccal cavity lined by stratified squamous epithelial cells and posterior pharyngeal cavity lined by columnar epithelial cells. It is distinguished into three region. Pharynx is a vertical canal beyond the soft palate. The food and air passages cross here. Pharynx may be divided into three parts; Nasopharynx, Oropharynx and Laryngopharynx.

Main structures of Buccopharyngeal cavity are –

(1) **Palate :** The roof of buccal cavity is called Palate. In crocodiles and mammals horizontal shelf like processes of premaxilla and maxilla and the palatine bones of upper jaw fuses and forms a secondary palate which separates the buccal cavity from nasal cavity. Palate is distinguished into three regions –

(i) **Hard palate :** Anterior, bony portion formed of maxilla and palatine bones in human and premaxilla, maxilla and palatine bones in rabbit. Hard palate have transverse ridges called palatine rugae. Such rugae or ridges are more developed in carnivorous mammals because their function is to firmly grip the food and prevent it from slipping out the cavity.

(ii) **Soft palate :** Posterior soft part, made up of connective tissue and muscles.

(iii) **Vellum palati/uvula :** Posterior most part of soft palate, which hangs in the region of pharynx. It closes the internal nostrils during **degglutition**.

(2) **Palatine glands :** Numerous mucous glands. Chiefly present in soft palate, secretes mucous for lubrication.

(3) **Naso-palatine duct :** One pair, present in rabbit, extends from nasal passage to the buccal passage, contains Jacobson's organ concerned with olfaction.

(4) **Vibrissae :** A tuft of hairs on upper lip of rabbit.

(5) **Hare-cleft :** A cleft on the upper lip of rabbit, which makes it bilobed.

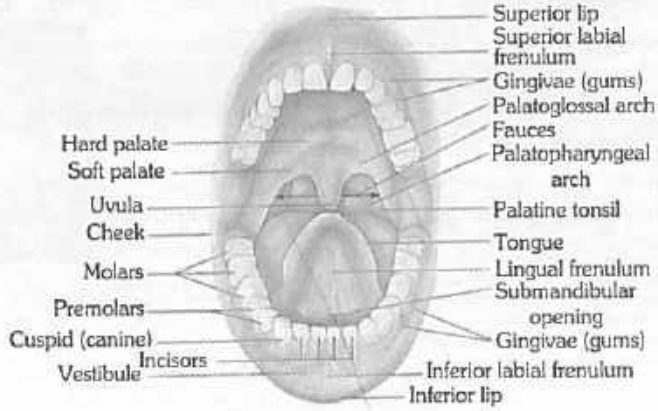


Fig : 5.1-2 Structures of the Oral cavity

(6) **Tongue (linguae) :** Ectodermal, single, pinkish, oval, elongated highly muscular (mesodermal) and protrusible present on the floor of buccopharyngeal cavity the cells present are stratified squamous epithelial cells. A furrow termed the sulcus terminalis divides the oral part and pharyngeal part of the tongue. The limbs of the sulcus terminalis run laterally and forward from a median pit, named the foramen caecum.

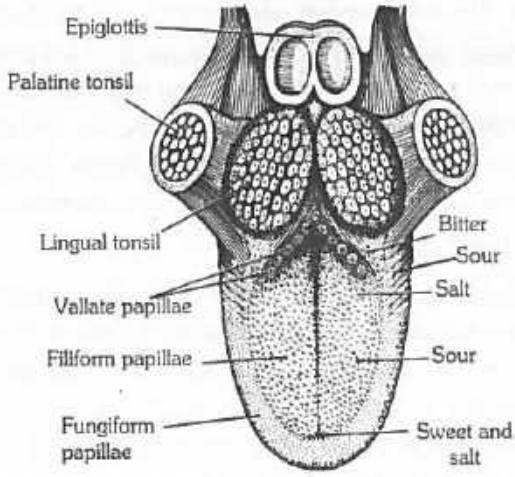


Fig : 5.1-3 Locations of papillae and areas of taste on the tongue

Posterior part of tongue (endodermal) is attached with hyoid, middle one with the floor of buccopharyngeal cavity with the help of frenulum lingum and anterior part is free. The tongue is provided with two specialized structure viz. lingual papillae and lingual glands or weber's gland. Lingual glands are the mucous glands, which secretes mucous. Lingual papillae are numerous, minute projections chiefly present on the dorsum of the tongue. All these lingual papillae can be grouped as simple lingual papillae and taste papillae. Taste papillae are of following types –

(i) **Circumvallate :** Circular largest 8-12 in number, present in the posterior part of the tongue extending from one side to another. They possess taste buds. These are the largest of all the papillae.

(ii) **Fungiform :** Mushroom shaped (Fungi – shaped), numerous, present at the anterior margins and tip of the tongue. They have 200 taste buds.

(iii) **Foliate :** Leaf like flat, less 8-10 in number, present at the posterior margin of the tongue. They are absent in human and found in rabbit.

(iv) **Filiform :** Conical shaped, smallest and most numerous distributed throughout tongue. They are without taste buds.

Hence, in human taste is recognized with the help of circumvallate and fungiform taste papillae. In man the anterior end of tongue feels sweet taste, posterior part feel bitter taste, sides feel sour taste and a small part behind the anterior end feel salty taste.

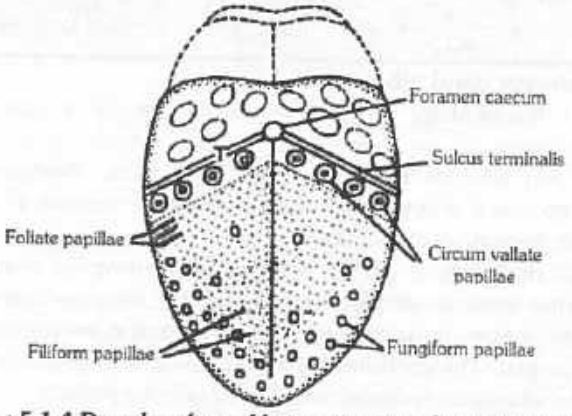


Fig : 5.1-4 Dorsal surface of human tongue, showing three kinds of papillae and some other associated structures

Functions of tongue : Important function of tongue are as follows –

(i) Acts as universal toothbrush, as it helps in tooth cleaning.

(ii) Helps in speaking.

(iii) Helps in degglutition.

(iv) Helps in mixing saliva with food.

(v) Acts as a curry comb in many animals, hence help in body cleaning.

(vi) Helps in taste detection.

(vii) In dog helps in regulation of body temperature. The phenomenon is called as "Panting".

(viii) In frog and other animals, it helps in prey capturing

(7) **Teeth :** Teeth is a living structure. On the basis of embryonic origin, teeth in vertebrates are of following two types –

(i) **Horny/ectodermal/epidermal/false teeth :** The teeth which develops only from ectoderm. Examples – Cyclostomes, tadpole larva of frog, prototherian mammals etc.

(ii) **True teeth :** The teeth which develops from both ectoderm and mesoderm. Examples – Fishes, amphibians, reptiles, eutherian mammals etc.

Differentiation of teeth : Morphologically, teeth can be distinguished as homodont or heterodont.

(i) **Homodont :** When all the teeth are structurally and functionally similar. Examples – Vertebrates except metatherian and eutherian mammals.

(ii) **Heterodont :** When the teeth are different in structure and functions. They are distinguished into four types incisors, canines, premolars and molars. Examples – metatherian and eutherian mammals.

(a) **Incisors :** These are the front teeth borne by the premaxillae in upper jaw and tips of dentaries in lower jaw. They are single-rooted monocuspid and long, curved and sharp-edged. They are adapted for cutting or cropping and biting.

(b) **Canines :** There is one pointed canine in each maxillary of upper jaw and each dentary of lower jaw next to the incisors. They are meant for piercing, tearing and offence and defence. They are single rooted and monocuspid.

(c) **Premolars :** They have one root (only in upper first PM two roots) and two cusps (bicuspid). They are meant for crushing, grinding and chewing.

(d) **Molars :** They have more than two roots (upper molars have three roots and lower molars have two roots) and 4 cuspid.

Attachment of teeth : On the basis of attachment of teeth at their bases with the jaw bones, teeth can be differentiated into –

(i) **Acrodont :** Teeth are attached to the free surface or summit of the jaw bone, as in a shark or frog. Such teeth are apt to break off easily but are replaced.

(ii) **Pleurodont :** In this condition, common in urodeles and lizards, teeth are attached to the inner side of jaw bone by their base as well as one side.

(iii) **Thecodont :** Such teeth are characteristic of mammals. Teeth have well developed roots implanted in deep individual pits or sockets called alveoli or theca, in the jaw bone. These type of teeth also present in crocodilians, fossil toothed bird (*Archeaeopteryx*).

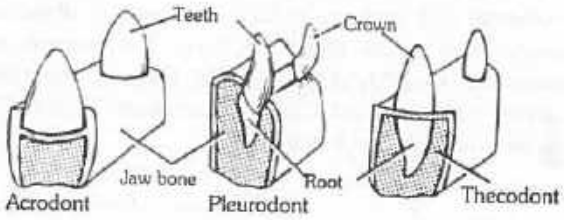


Fig : 5.1-5 Methods of attachment of teeth on jaws

Succession of teeth : According to their replacement (succession), teeth can be divided into 3 categories: polyphyodont, diphyodont and monophyodont.

(i) **Polyphyodont :** In lower vertebrates, teeth can be replaced an indefinite number of times during life. *e.g.*, – Fishes, amphibia, reptilia.

(ii) **Diphyodont :** In most mammals teeth develop during life in two successive sets, a condition known as diphyodont. Teeth of the first set are known as deciduous teeth or milk teeth or lacteal teeth whereas the second set is called permanent teeth.

(iii) **Monophyodont :** In some mammals such as platypus, marsupials, moles, sirenians, toothed whale etc. only one set of teeth develops known as monophyodont condition.

Types of cheek teeth

(i) **Bunodont :** Crown with small, blunt and round cusps as in man, monkey, pig etc. found in mixed diet mammals.

(ii) **Secodont :** With sharp cutting edges for tearing flesh as in carnivores.

(iii) **Lophodont :** Only one cusp is present with transverse ridges called lophos, *e.g.*, Elephant.

(iv) **Selenodont :** With vertical crescentic cusps as in grazing mammals like cow, sheep and goat. Selenodont teeth are two types –

(a) **Brachyodont :** Normal low crowned selenodont teeth with large roots are termed brachyodont. e.g. Ground squirrel, cattle.

(b) **Hypsodont :** In large grazing mammals teeth are elongated, prism shaped with high crown and low roots. e.g. Horse.

Structure of teeth : Teeth divided into three parts –

(i) **Root :** Inner most, attached to the bone with the help of cement (hyaluronic acid).

(ii) **Neck :** Middle, small, covered with gum. Gum provides strength to the teeth.

(iii) **Apex or crown :** External exposed part of teeth. Longest part, white in colour.

A small cavity present inside teeth called as pulp cavity or dentine pulp cavity. It contains blood vessels, lymphatic vessels, nerve fibres, connective tissue etc. and provides nutrition to odontoblast cells or osteoblast cells. The odontoblast cells are mesodermal in embryonic origin forming immediate covering of the pulp cavity. The cells secrete dentine/ivory. Bulk of tooth in a mammal is formed of dentine. Dentine is a layer of inorganic substances (62-69%), which surrounds the odontoblast cells. It is mesodermal in origin. Enamel, secreted by Ameloblast/Enameloblast cells, forms the outermost covering. It is ectodermal and made up of 92% of inorganic substances, hence considered as hardest part of the body. The inorganic substances present are $[Ca_3(PO_4)_2, Ca(OH)_2.H_2O]$ Calcium phosphate (85%), Calcium hydroxide and Calcium Carbonate. Cement/Cementum attaches the tooth root to the bone.

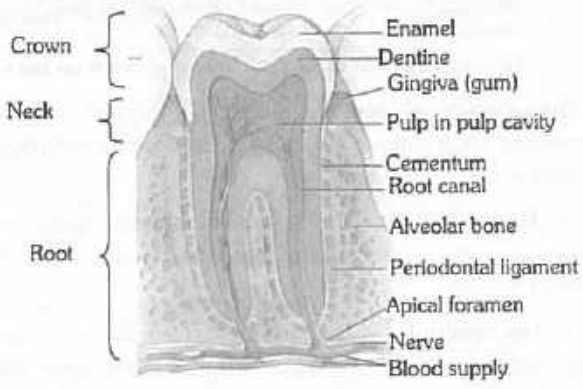


Fig : 5.1-6 Structure of tooth

Dental formula : Each mammalian species is characterized by its own specific dentition with a definite number and arrangement of teeth. Hence, dentition is of taxonomic importance. It is expressed by a dental formula as below –

Rabbit : $i\frac{2}{1}, c\frac{0}{0}, pm\frac{3}{2}, m\frac{3}{3} = \frac{8}{6} \times 2 = 28$ or briefly,

$$\frac{2033}{1023} = \frac{2+0+3+3}{1+0+2+3} \times \frac{2}{2} = \frac{16}{12} = 28$$

(i = incisors; c = canines; pm = premolars; m = molars)

Table : 5.1-1 Dental formulae of some common mammals

Horse and pig	$\frac{3.1.4.3}{3.1.4.3} \times 2 = 44$	Cat	$\frac{3.1.3.1}{3.1.2.1} \times 2 = 30$
Dog	$\frac{3.1.4.2}{3.1.4.3} \times 2 = 42$	Squirrel	$\frac{1.0.2.3}{1.0.1.3} \times 2 = 22$
Lemur	$\frac{2.1.3.3}{2.1.3.3} \times 2 = 36$	Rat	$\frac{1.0.0.3}{1.0.0.3} \times 2 = 16$
Man (adult set)	$\frac{2.1.2.3}{2.1.2.3} \times 2 = 32$	Elephant	$\frac{1.0.0.3}{0.0.0.3} \times 2 = 14$
Cow	$\frac{0.0.3.3}{3.1.3.3} \times 2 = 32$	Human set (milk set)	$\frac{2.1.0.2}{2.1.0.2} \times 2 = 20$

Oesophagus (food tube)

(1) **Morphology :** Single, ectodermal, dorsal to trachea, approximately 25 *cm* long, passes through thoracic cavity and opens into stomach present in abdominal cavity. Oesophagus anteriorly opens into pharynx through gullet and posteriorly into stomach through cardiac orifice.

(2) **Histology :** Serosa is absent but outermost layer of connective tissue is called *as* tunica adventitia. Muscular layer are striated/voluntary in anterior region and unstriated/involuntary in posterior part. The epithelial lining is made up of non-keratinized stratified squamous epithelial cells. Goblet cells are present.

Oesophagus lack digestive glands but multicellular glands are found, which extends upto submucosa. Due to the presence of these submucosal mucous glands, submucosa of oesophagus is thickest than other parts of alimentary canal.

Function : Conduction of food.

Stomach

(1) **Structure :** Single oval, elongated, unilobed present within abdominal cavity below diaphragm. It consists of three parts as cardiac/fundic (anterior), corpus/body (middle, chief part) and pyloric (posterior part) in human, whereas in rabbit stomach is bilobed and consists of three parts as cardiac (Anterior), fundic (middle, chief part) and pylorus (posterior). Two types of valves are present in the stomach *viz.* Cardiac sphincter valve between oesophagus and stomach and pyloric sphincter valve between stomach and duodenum. In new born baby cardiac sphincter is much less developed that is why regurgitation of gastric contents is very common. Inner surface of stomach is raised into numerous longitudinal folds called gastric rugae. In case of ruminant mammals (cud chewing mammals) oesophagus consists of only skeletal or voluntary muscles.

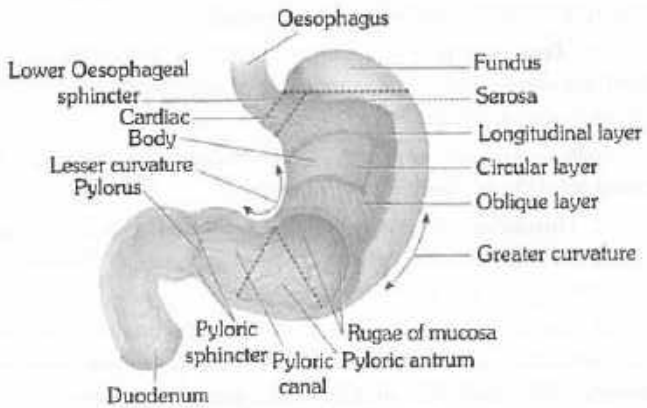


Fig : 5.1-7 Human Stomach

(2) **Histology :** Outermost layer is serosa. Muscular layer is three layered with outer longitudinal, middle circular and inner oblique. Muscles are involuntary and unstriated. Epithelial lining is made up of simple columnar epithelial cells and specialized cells present in the gastric glands. The nomenclature of gastric glands is according to the parts of the stomach. Various types of gastric glands and the cells present in them are as follows –

(i) **Anterior part :** Cardiac gastric glands in rabbit and human. Cells present are mucous neck cells secreting mucous.

(ii) **Middle part :** Fundic gastric/Main gastric glands in rabbit and corpus in human has at least four distinct types of cells –

(a) **Peptic or zymogenic or chief or central cells :** Secretes two digestive proenzymes pepsinogen and prorennin.

(b) **Oxyntic or parietal cells :** Secretes HCl and castle's intrinsic factor required for the absorption of vitamin B_{12}. Hyperacidity is abnormally high degree of acidity due to the secretion of large quantity of HCl i.e. gastric juice.

(c) **Mucous neck cells :** Secretes alkaline mucous.

(d) **Argentaffin cells or Kultchitsky or enterochromaffin cells :** Responsible for the secretion of vasoconstrictor seratonin.

(iii) **Posterior part :** Pyloric gastric glands in rabbit and human-cells are mucous neck cells secreting mucous and some cells, called "gastrin" or "G" cells, secrete a hormone, named gastrin, which increases the motility of gastric wall and stimulates gastric glands for active secretion.

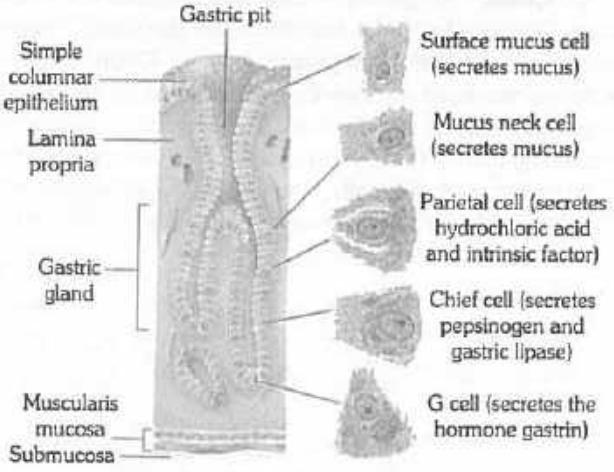


Fig : 5.1-8 L.S. Gastric gland

Functions

(1) Storage of food.

(2) Trituration or churning of food to mix with gastric juice.

(3) Functions of gastric juice (discussed along with gastric juice).

Stomach of ruminants (cud-chewing mammals) : The stomach of cattles have four parts, as rumen (paunch), reticulum(honeycomb), omasum (psalterium) and abomasum (rennet). Some authors believe that first three chambers are parts of the oesophagus, the fourth chamber is the real stomach secreting HCl and enzymes. The embryological studies have proved that all the chambers are parts of the real stomach. Camel and deer lack omasum. Reticulum is the smallest part and its cells are provided with water pockets for the storage of metabolic water.

In the rumen, food undergoes mechanical and chemical breakdown. Mechanical breakdown results from through churning brought about by muscular contractions and aided by cornified surface of villi. Chemical breakdown is caused by symbiotic microorganisms (bacteria and ciliates) that release enzyme cellulase, which act on cellulose and simplify it into short-chain fatty acids, such as acetic acid, butyric acid, propionic acid. This is called microbial digestion.

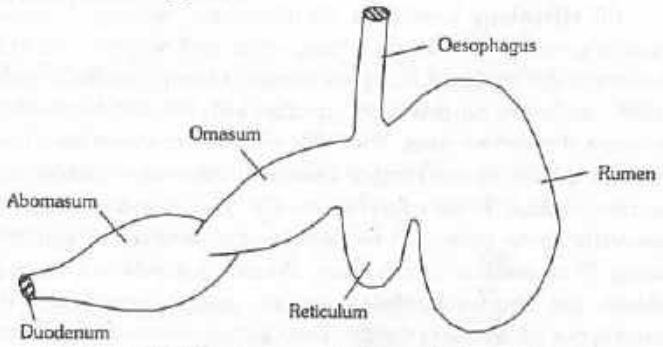


Fig : 5.1-9 The compound stomach of a ruminant

Small intestine

(1) **Structure :** Endodermal, longest part of alimentary canal present in the abdominal cavity, supported by a peritoneal membrane called mesentery. Wall of jejunum and ileum has circular or spiral internal fold called fold of kerckring or valvulae conniventes. Also numerous finger like projection called villi project from the wall of lumen, increasing internal surface area about ten time. The distal end of ileum leads into the large intestine by ileo-caecal valve in man but in rabbit sacculus rotundus and ileo-coecal valve both are present.

(2) **Parts :** It is approximately 3 metres in human. It is divisible into three parts duodenum, jejunum and ileum.

Table : 5.1-2 Parts of small intestine

Duodenum (Proximal part)	Jejunum (Middle part)	Ileum (Posterior part)
25 *cm.* Long Forming U-shaped loop before leading to jejunum, pancreas lies in the loop.	About 1 *m* long and about 4 *cm.* wide. Wall is thicker and more vascular. Villi thicker and tongue-like. Plicae best developed. Peyer's patches are lacking.	About 2 *m* long and about 3.5 *cm.* wide. Wall is thinner and less vascular. Villi thinner and finger-like. Plicae less developed. Peyer's patches are present.

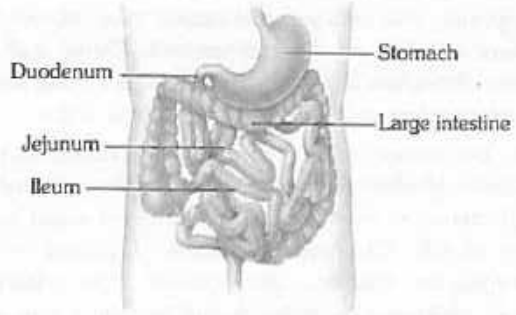


Fig : 5.1-10 Human intestine

(3) **Histology :** Serosa is the outer most covering. Muscular layer is generalized with involuntary, unstriated muscles. The cells present in the epithelial lining are simple columnar epithelial cells, which are brush- bordered *i.e.* provided with villi and microvilli to increase the surface area. The folds present are longitudinal and are called folds of kerckring or valvulae canniventes. Goblet cells secrete mucous. Peyer's patches are the oval, rounded masses of lymphatic tissue present in between lamina propria and epithelial lining. They produce lymphocytes. Brunner's glands or Duodenal glands are the multicellular mucous glands present in the submucosa of duodenum only. They secrete mucous. In addition there are also found granular arogyrophil cell.

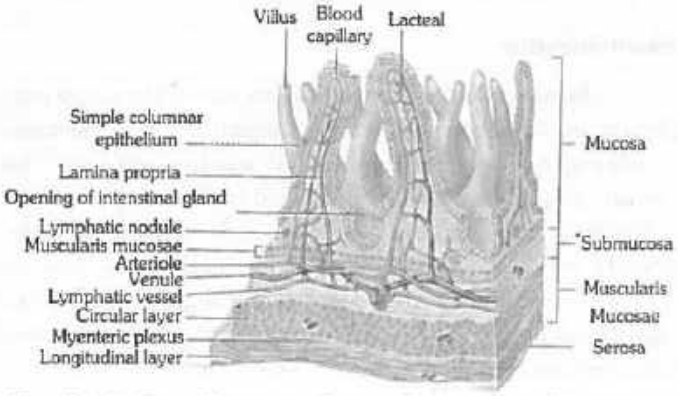


Fig : 5.1-11 Three dimensional view of layers of small intestine showing villi

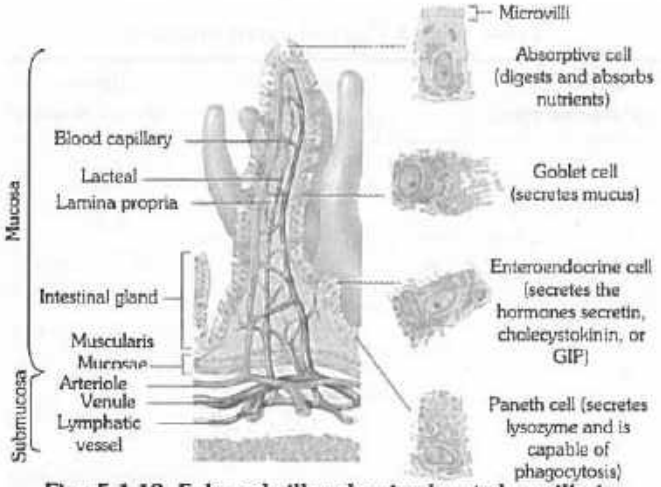


Fig : 5.1-12 Enlarged villus showing located, capillaries intestinal glands and cell types

(4) **Glands of small intestine :** Various glands found in small intestine. Each gland has three types of cells : (1) Undifferentiated epithelial cell (2) Zymogenic cell (paneth cell) and (3) Argentaffin (Enterochromaffin cell).

Table : 5.1-3 Glands of small intestine

Brunner's glands	Peyer's patches	Crypts of Leiberkuhn
Found in duodenum only.	These are lymph nodules.	Known as intestinal gland.
Mucus secreting gland as so known as mucus gland.	They produce lymphocytes.	Found in duodenum and ileum only.
	Lymphocytes are phagocytic in nature which destroy harmful bacteria.	Secrete succus entericus i.e. intestinal juice.
		Formed by folding of lamina propia.

Function : Digestion and absorption of food.

Large intestine

The name large intestine is due to large diameter (4-6 cm).

(1) **Structure :** Endodermal, approximately 1.5-1.75 metre long.

(2) **Parts :** They are following –

(i) **Caecum :** Spirally coiled 6 cm long in human and 45 cm long in rabbit. Its posterior end is present as a blind sac in abdominal cavity called vermiform appendix. Vermiform appendix is vestigeal but contains lymphatic tissue. Caecum in human is concerned with passage of food whereas in rabbit it is concerned with cellulose digestion and conduction of food.

(ii) **Colon :** Single endodermal approximately 1.3 *m* long in human distinguished into four limbs as ascending, transverse, descending and pelvic or sigmoid limb. Colon posses two specialized structures as Taeniae coli (present in the middle of colon) and Haustra, (dilated sac-like or pockets like structures surrounding taeniae). Colon is concerned with absorption of water of undigested food, 5%, salts, vitamins etc. hence concerned with faeces formation. Colon bacteria also synthesized vit. B_{12} and *K*.

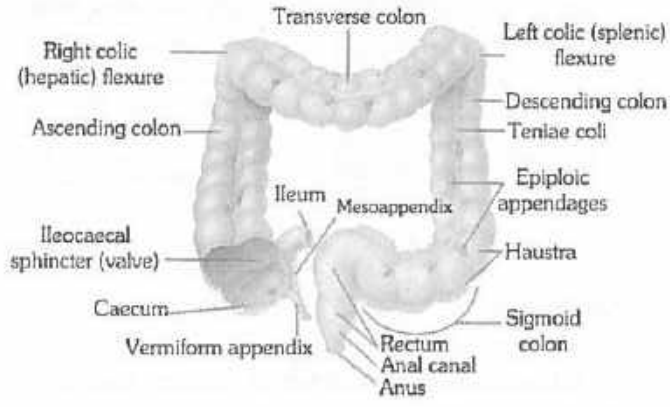


Fig : 5.1-13 Anterior view of large intestine showing major regions

(iii) **Rectum :** Single small dilated sac like in human whereas large beaded in rabbit. It is concerned with storage of faeces. Rectum has strong sphincter muscle in its wall. The sphincter keeps the canal as well as anus, closed when not used for defecation.

(iv) **Function :** Absorption of water from undigested food.

Anal canal and anus : Anal canal connects rectum with anus and it is about 3 cm. long. Anus is the terminal inferior opening of alimentary canal, which is guarded by an internal involuntary sphincter and an external voluntary sphincter.

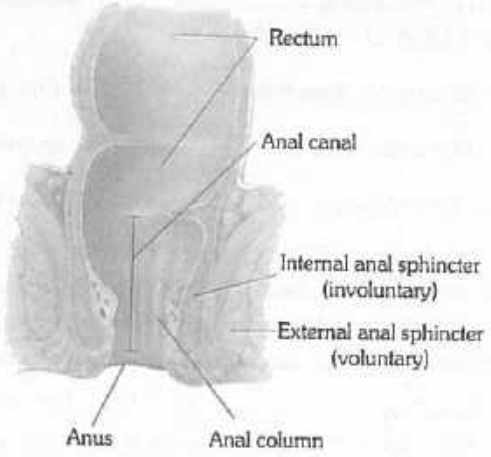


Fig : 5.1-14 Frontal section of anal canal

Digestive glands

The various types of digestive glands present in mammals are salivary glands, gastric glands, intestinal glands, pancreas and liver. The digestive glands secrete digestive juices. Parasympathetic nervous system increases the secretion of digestive juice whereas sympathetic nervous system decreases it.

(a) **Salivary glands :** The three pairs of salivary glands present in humans are as follows –

(1) **Parotid :** One-pair, largest salivary gland present below pinna. A stenson's duct arises from each gland, opening in vestibule between the 2nd molar teeth of upper jaw and cheeks. Parotid glands secrete enzymes. Viral infection of parotid glands causes "Mumps" (by paramyxo virus).

(2) **Sub-mandibular / sub-maxillary :** One-pair, present at the junction of upper and lower jaw in cheek region. A wharton's duct arises from each gland and opens on lower jaw. These are seromucous glands.

(3) **Sub-lingual :** One-pair, present in the floor of buccopharyngeal cavity. These are mucous glands 6-8 ducts, called ducts of rivinus or Bartholin's duct arises from these glands and opens below tongue on the floor of buccopharyngeal cavity.

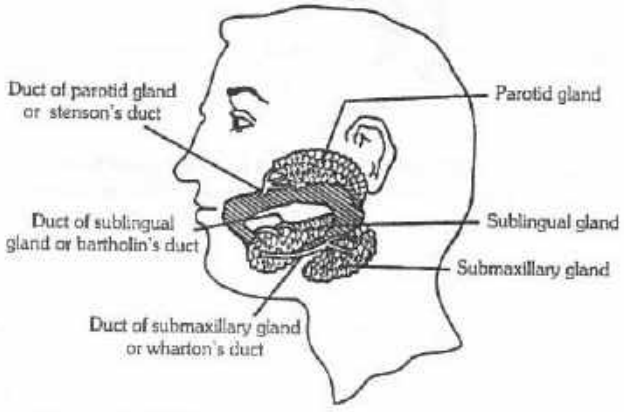


Fig : 5.1-15 Location of salivary glands in man

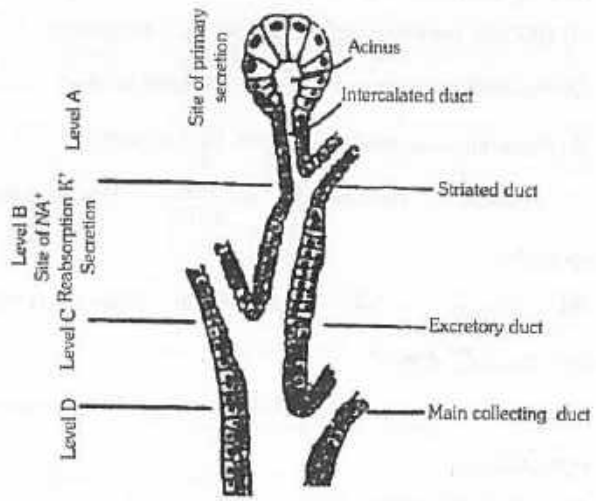


Fig : 5.1-16 An acinus of salivary gland

Saliva / salivary juice : The secretion of salivary glands is called saliva or salivary juice. Some of the characteristics are as follows –

(1) Amount : 1.0-1.5 litre/day

(2) Chemical nature : Slightly acidic.

(3) *pH* : 6.3 – 6.8

(4) Control of secretion : Autonomic reflex (parasympathetic nervous system increases salivation while sympathetic nervous system inhibit secretion.)

(5) Chemical composition : Water (99.5%), mucous (acts as lubricant), salts (*NaCl*, $NaHCO_3$ etc.), enzymes (ptyalin, lysozyme) etc.

Functions : Salivary juice and its enzymes –

(1) Makes the medium slightly acidic for the action of its enzyme.

(2) Help in taste detection, deglutition, speaking etc.

(3) Starch $\xrightarrow[\text{(Salivary amylase)}]{\text{Ptyalin/Diastase}}$ Maltose + Isomaltose + Limit dextrin.

(4) Bacteria (living) $\xrightarrow{\text{Lysozyme}}$ Bacteria killed.

Gastric glands : There are approximately 35 million of gastric glands present in human stomach and grouped into three categories as already described along with stomach. The gastric gland secretes gastric juice.

Gastric juice

(1) Amount : 2-3 liters/day.

(2) Chemical nature : Highly acidic

(3) *pH* : 1.0 – 3.5 (due to presence of *HCl*)

(4) Control of secretion : By gastric hormone.

(5) Chemical composition : Water (99%), mucous, inorganic salts, castle's intrinsic factor, *HCl* (0.5%, conc.) and enzymes prorennin and pepsinogen and gastric lipase.

Functions of gastric juice and its enzymes

(1) Inactivates the action of ptyalin.

(2) Makes the medium acidic for the action of gastric enzymes.

(3) *HCl* kills micro organisms.

(4) *HCl* kills the living organism (prey etc.) if ingested.

(5) Pepsinogen (inactive) $\xrightarrow{HCl}$ Pepsin (active).

(6) Prorennin (inactive) $\xrightarrow{HCl}$ Rennin (active).

(7) Proteins + Peptones $\xrightarrow[pH\text{-}1\text{-}3]{\text{Pepsin}}$ Polypeptides + Oligopeptides.

(8) Casein (milk protein) $\xrightarrow[Ca^{2+}]{\text{Rennin}}$ Paracasienate Above phenomenon is called "curdling of milk".

(9) Lipids $\xrightarrow[\text{negligible in human stomach acts at } pH\ 4-6]{\text{Gastric Lipase}}$ Triglycerides + Monoglycerides.

(10) *HCl* is antiseptic.

(11) It act as preservative.

Lactose intolerance : Among mammals, man alone takes milk even after becoming adult. In some humans, secretion of lactase decreases or ceases with age. This condition is called lactose intolerance. Lactose intolerant persons fail to digest lactose of milk. In their large intestine, lactose is fermented by bacteria, producing gases and acids.

Intestinal glands : Intestinal glands in mammals is a collective name for crypts of Lieberkuhn (secretes alkaline enzymatic juice) and Brunner's glands (secretes mucous). Intestinal glands secrete intestinal juice.

Succus entericus (intestinal juice)

(1) Amount : 1.5 – 2.0 *l*/day.

(2) Chemical nature : Alkaline.

(3) *pH* : 7.6-8.3

(4) Control of secretion : Nervous and hormonal (Enterocrinin Duocrinin etc.)

(5) Chemical composition : Water (99%), mucous, inorganic salts, enzymes etc.

Function of Intestinal juice and its enzymes.

(1) Inhibits the action of gastric enzymes.

(2) Makes the medium alkaline for the action of it's enzymes.

(3) Starch $\xrightarrow{\text{Amylase}}$ Maltose + Isomaltose + limit dextrin.

(4) Maltose $\xrightarrow[(\alpha\text{-glucosidase})]{\text{Maltase}}$ Glucose + Glucose.

(5) Isomaltose $\xrightarrow{\text{Isomaltase}}$ Glucose + Glucose.

(6) Lactose (milk sugar) $\xrightarrow[(\beta\text{-galactosidase})]{\text{Lactase}}$ Glucose +Galactose.

(7) Sucrose (cane sugar) $\xrightarrow[(\beta\text{-fructosidase})]{\text{Sucrase / Invertase}}$ Glucose + Fructose.

(8) Polypeptides + Oligopeptides $\xrightarrow[(\text{Amino-peptidase})]{\text{Erepsin}}$ Amino acids.

(9) Trypsinogen (inactive) $\xrightarrow{\text{Enterokinase}}$ Trypsin (active).

(10) Lipids $\xrightarrow{\text{Lipase}}$ Fatty acids + Glycerol + Monoglycerides.

(11) Phospholipids $\xrightarrow{\text{Phospholipase}}$ phosphorous + Fatty acids + Glycerol + Monoglycerides.

(12) Organic phosphate $\xrightarrow{\text{Phosphatase}}$ Free phosphate.

(13) Nucleic acid $\xrightarrow{\text{Polynucleotidase}}$ Nucleotides.

(14) Nucleosides $\xrightarrow{\text{Nucleosidase}}$ Nitrogenous bases.

Pancreas : Single, endodermal, flat, leaf-like yellowish, heterocrine (mixed) gland, present between the ascending and descending limb of duodenum and opens into duodenum through pancreatic duct. It can be divided into following parts –

Exocrine : It is the major part (about 99%) of pancreas. The exocrine tissue of the pancreas consists of rounded lobules (acini) that secrete an alkaline pancreatic juice. The juice is carried by the main pancreatic duct, also called duct of Wirsung, into the duodenum through the hepatopancreatic ampulla (ampulla of vater). An accessory pancreatic duct, also named duct of Santorini, may sometimes lead directly into the duodenum.

Endocrine : Minor part (1% only) also called as islets of Langerhans scattered in the exocrine part. It consist of four various type of cells, as α(A) cells, β(B) cells, δ(D) cells and F or PP cells. α-cells secretes glucagon hormone, β-cells secretes insulin hormone and δ cells secrets somatostatin. The PP or F-cells secrete pancreatic polypeptid hormone to control somatostatin. The secretion passes directly into blood.

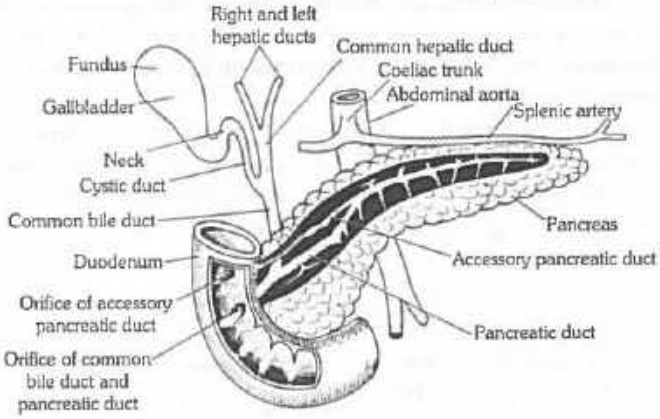


Fig : 5.1-17 The gallbladder and pancreas and their systems of ducts. Both empty into the duodenum, often by a common orifice

Pancreatic juice

(1) Amount : 1-1.5 *l*/day

(2) Chemical nature : alkaline

(3) *pH* : 7.1-8.2

(4) Control of secretion : Hormonal and normal mechanism.

Secretin hormones stimulate the production of more alkaline pancreatic juice but low in enzyme content. Pancreozymin or Cholecystokinin stimulates the production of enzyme rich pancreatic juice.

(5) Chemical composition : Water (99%), enzymes and salts.

Functions of pancreas and its enzymes

(1) The islets of Langerhans secrete insulin and glucagon hormones.

(2) The exocrine part of pancreas secretes pancreatic juice.

(3) Elastase : It act upon elastin protein.

(4) Trypsinogen $\xrightarrow[\text{Intestinal juice}]{\text{Enterokinase of}}$ Trypsin.

(5) Trypsinogen $\xrightarrow[\text{(Autocatalysis)}]{\text{Trypsin}}$ Trypsin.

(6) Chymotrypsinogen $\xrightarrow[\text{Autocatalysis}]{\text{Trypsin}}$ chymotrypsin.

(7) Polypeptides + peptones $\xrightarrow[\text{(Pancreatic protease)}]{\text{Trypsin}}$ Tripeptides + Dipeptides + Oligopeptides.

(8) Starch $\xrightarrow[\text{(Pancreatic amylase)}]{\text{Amylopsin}}$ Maltose + Isomaltose + limit dextrin.

(9) Emulsified Lipids $\xrightarrow[\text{(Pancreatic lipase)}]{\text{Steapsin}}$ Fatty acids + Glycerol + Monoglycerides.

(10) Nucleic acid $\xrightarrow{\text{Nuclease}}$ Nucleotides + Nucleosides.

(11) Nucleic acid $\xrightarrow{\text{Nucleosidase}}$ Purines + Pyrimidines.

(12) Polypeptides $\xrightarrow{\text{Chymotrypsin}}$ Oligopeptides.

Liver

(1) **Structure :** The liver is largest and heaviest gland in the body. Its upper and anterior surfaces are smooth and curved to fit the under surface of the diaphragm; the posterior surface is irregular in outline. It consists of three lobes in frog: right, left and median; five lobes in rabbit: left lateral, left central, spigelian, right central and caudate; four lobes in man: right, left, quadrates and caudate lobe. It is divided into two main lobes : right and left lobes separated by the falciform ligament.

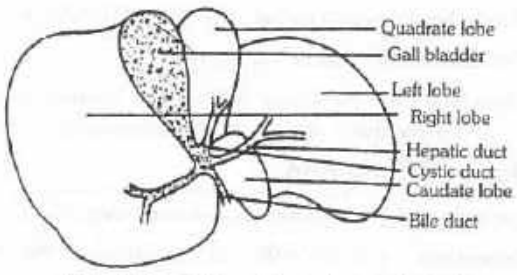


Fig : 5.1-18 Liver of man (ventral view)

A pear-shaped sac, the gall bladder is attached to the posterior surface of the liver by connective tissue. The right and left hepatic ducts join to form the common hepatic duct. The latter joins the cystic duct, which arises from the gall bladder. The cystic duct and common hepatic duct join to form common bile duct or ductus cholidochus which passes downwards posteriorly to join the main pancreatic duct to form the hepatopancreatic ampulla (ampulla of Vater). The ampulla opens into the duodenum. The opening is guarded by the sphincter of Oddi. The sphincter of Boyden surrounds the opening of the bile duct before it is joined with the pancreatic duct. The basic structural and functional unit of the liver is the hepatic lobule.

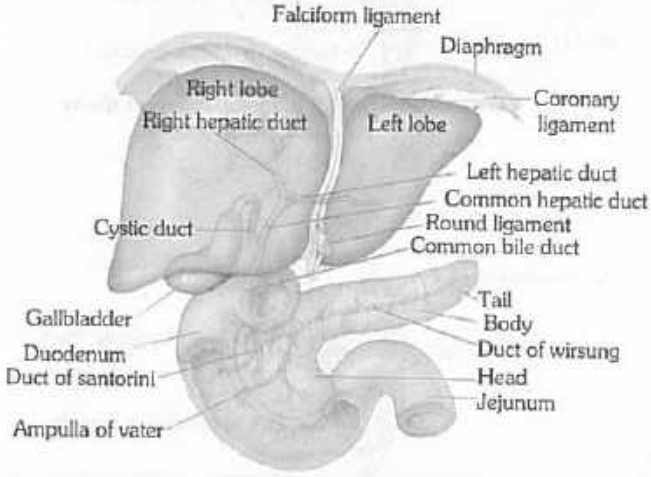


Fig : 5.1-19 Relation of Pancreas to the liver, gallbladder and duodenum

Each lobule is composed of plates of polyhedral, glycogen-rich cells, the hepatocytes, arranged radially around a central vein. Between the plates are radial blood sinusoids. At the periphery of the lobules, the branches of portal vein, hepatic artery, bile ducts, and lymphatics course together. A network of tubular spaces between the hepatocytes represents the bile canaliculi. At the periphery of the lobule the bile canaliculi empty into small hering's canals walled by cuboidal epithelium. These canals lead into bile ducts walled by columnar epithelium. The sinusoids are lined by incomplete endothelium with scattered phagocytic Kupffer cells, that eat bacteria and foreign substances

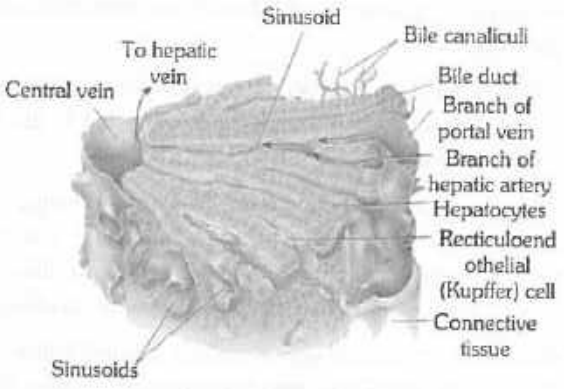


Fig : 5.1-20 Histology of a lobule

Gall bladder : The gall bladder is a slate-blue, pear-shaped sac connected with an supported from liver by a small omentum or ligament. Its distal part is called fundus, while the narrow part, continued as cystic duct, is called the neck.

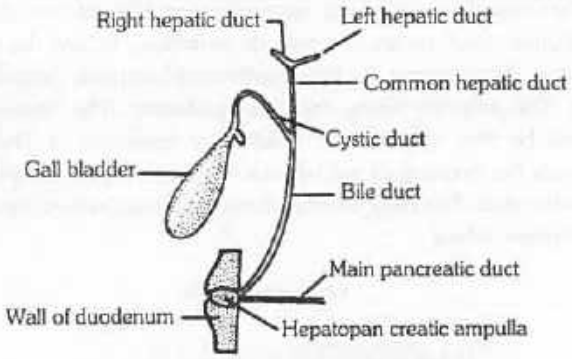


Fig : 5.1-21 Showing gall bladder, different ducts and hepatopancreatic ampulla

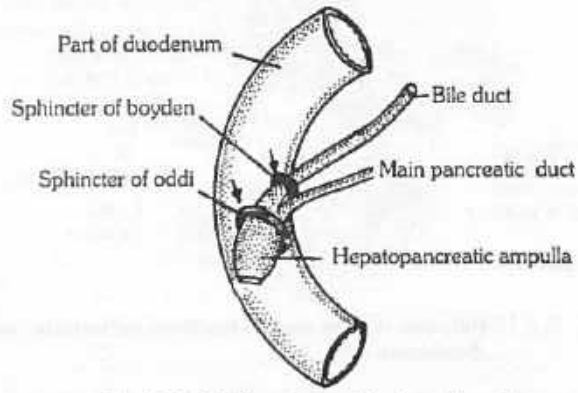


Fig : 5.1-22 Showing sphincter of boyden and sphincter of oddi

Functions of liver : Liver, the largest gland of vertebrate body, is an essential organ, which performs many functions –

(1) It secretes bile which is a complex watery fluid containing bile salts (Na taurocholate and Na glycocholate), bile pigments (biliverdin and bilirubin), cholesterol, mucin, lecithin and fats etc. It breaks and emulsifies the fat.

(2) In the liver, haemoglobin of the worn out erythrocytes breaks down to bile pigments bilirubin and biliverdin. The bile pigments are also converted in the bowel into stercobilin which colours the faeces.

(3) Excess quantities of carbohydrates (glucose) are converted to glycogen (Glycogenesis) in the presence of insulin in the liver cells, and stored therein.

(4) Glycogen is a reserve food material, which is changed into glucose (Glycogenolysis) and released into the blood at concentrations maintained constant by the liver. In this way, blood–sugar level is maintained under diverse dietary conditions.

(5) Under abnormal conditions, liver can convert proteins and fats into glucose by complex chemical reactions. Formation of this "new sugar" *i.e.* from non–carbohydrate sources, is called gluconeogenesis.

(6) If the level of blood–glucose rises beyond normal even after glycogenesis and catabolism, the excess glucose is converted into fat and stored in the liver. The process is termed lipogenesis.

(7) Amino acids resulting from protein digestion finally come into the liver from the intestine. They are partly released into the blood for distribution and protein synthesis, partly transaminated into other amino-acids and deaminated.

(8) In the embryo, red blood cells are manufactured by the liver. In the adult, liver stores inorganic salts of iron, copper and vitamin B_{12} (anti–anaemic factor) and thus helps in the formation of red blood cells and haemoglobin.

(9) Liver functions as a store–house for blood and regulates blood–volume.

(10) Fibrinogen, prothrombin and certain other blood coagulation factors are formed in the liver. Heparin is an intravascular anticoagulant that is stored in the liver.

(11) The plasma proteins serum albumin and serum globulin are synthesized by the liver from the amino acids.

(12) Liver synthesizes vitamin A from the provitamins A (carotenoid pigments). Liver cells also store fat–soluble vitamins A, D, E and K. Besides, it is the principal storage organ for vitamin B_{12}.

(13) The liver is the site of detoxification of different toxic substances either produced in the body or taken along with food.

(14) It is the main heat producing organ of the body.

(15) Kupffer cells in the liver sinusoids phagocytose and remove bacteria, worn-out blood elements and foreign particles.

(16) Liver is an important site of lymph formation.

Bile/chole

(1) Amount : 800-1000 *ml* daily. On the average about 700 *ml*.

(2) Source : Secreted by hepatic cells

(3) Storage site : Gall bladder

(4) Colour : Greenish-blue

(5) Chemical nature : Alkaline

(6) *pH* : 7.6–8.6

Functions of bile

(1) Emulsification of fats.

(2) Helps in absorption of fat-soluble vitamins.

(3) Increases alkalinity to make the medium suitable for enzymatic action.

(4) Elimination of heavy metals such as *Cu, Hg, Zn* etc.

(5) Elimination of excess of bile pigments.

(6) Stercobilin and urobilin (urobilin found in urine) is formed by bilirubin and biliverdin is responsible for colouration of faeces.

Physiology of digestion

The process of digestion involves following steps –

(1) **Ingestion :** It is the intake of food most of the animals capture the prey/food with the help of mouth or tongue.

(2) **Mastication :** The process occurs in the buccopharyngeal cavity of mammals with the help of teeth. During this process food is broken down into small pieces, which increases its surface area. In frog teeth are not meant for mastication but prevents the escape of prey from mouth.

(3) **Deglutition / swallowing :** The passage of food from buccopharyngeal cavity to oesophagus/stomach. In mammals bolus of the masticated food is formed in buccopharyngeal cavity which easily slides into oesophagus. It is a voluntary reflex mechanism. Peristalsis is alternative contraction and relaxation of circular and longitudinal muscles produces the wave of contraction due to which the food passes from front to backward direction in the lumen of alimentary canal. The phenomenon is called as peristalsis. Beside alimentary canal, it is also found in vas deference, ureter etc. Peristalsis is maximum in oesophagus and minimum in rectum.

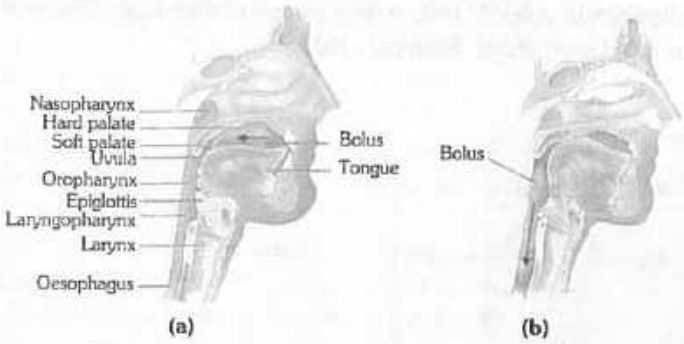


Fig : 5.1-23 Deglutition (swallowing); (a) Position of structures before swallowing, (b) During the pharyngeal stage of swallowing

Antiperistalsis is the peristaltic wave occuring in the reverse direction. It occurs in alimentary canal and results in vomiting. The phenomenon is called as "Regurgitation".

(4) **Digestion :** The process by which complex food is converted into simple food with the help of digestive enzymes. The process of digestion in mammals starts in buccopharyngeal cavity.

(i) **Digestion in buccopharyngeal cavity :** In buccopharyngeal cavity of mammals only starch is digested which is 5% of total food or 20-30% of carbohydrates.

(ii) **Digestion in stomach :** Chiefly proteins is digested in stomach.

(iii) **Digestion in small intestine :** All three component carbohydrates, proteins and fats digested in small intestine with the help of enzymes secreted by pancreas and intestinal glands.

(5) **Absorption :** Ingestion and digestion are the first two phases of the physiological processes occuring in the alimentary tract. The third phase is that of absorption by which the digested nutrients are absorb through the wall of gut into blood.

(i) **Absorption from the mouth :** Normally, there is no absorption from the mouth, but a few drugs may be absorbed into the blood through the mucous membrane, if allowed to dissolve under the tongue, *e.g.*, isoprenaline, glyceryl trinitrate.

(ii) **Absorption from the stomach :** In the stomach, absorption takes place to a limited degree. The only substances normally absorbed from the stomach are some water, glucose and considerable amounts of alcohol. These substances are absorbed through the walls of the stomach into the venous circulation. Although iron absorption takes place in the small intestine, it is dissolved out of foods most effectively in the stomach in the presence of *HCl*.

(iii) **Absorption from the small intestine :** The small intestine is the main absorptive organ. About 90% of the ingested foodstuffs are absorbed in the course of passage through the small intestine.

There are two general pathways for the transport of materials absorbed by the intestine; the veins of the hepatic portal system which lead directly to the liver; and the lymphatic vessels of the intestinal area, which eventually lead to the blood by way of the lymphatic system and the thoracic duct.

Absorption of carbohydrates : The products of carbohydrate digestion are absorbed from the intestine into blood of the portal venous system in the form of monosaccharides, chiefly the hexoses (glucose, fructose, mannose and galactose).

Absorption of amino acids and protein : It is probable that under normal circumstances the dietary proteins are almost completely digested to their constituent amino acids and that these end products of protein digestion are then actively transported from the intestine into the portal blood. Surplus amino acids are also withdrawn from portal blood by liver cells and deaminated into ammonia and keto acids. The ammonia is converted to urea and released into blood for excretion by kidneys, while the keto acids are converted to glucose or pyruvic acid and utilized for energy-production or for storage as glycogen and fat.

Absorption of fats : The dietary fat is digested, by the action of the pancreatic lipase present in the intestine, partially into glycerol and fatty acids and partially to split products such as monoacyl glycerols. These products of fat digestion enter the mucosal cells of the small intestine in the forms of micelles, fatty acids and glycerol.

By the lacteals, the fat is carried to the cisterna chyli (meaning 'the receiver of the chyle') and then by the thoracic (lymph) duct to the left branchiocephalic vein, where it enters the blood. The lymph reaching the thoracic duct from the intestines contains an excess of fat giving it a milky appearance. It is called chyle. In this way, fatty acids and glycerol are eventually brought into the blood stream and so, by a circuitous route, to the liver. In the liver, they are reorganized and recombined to form human fat.

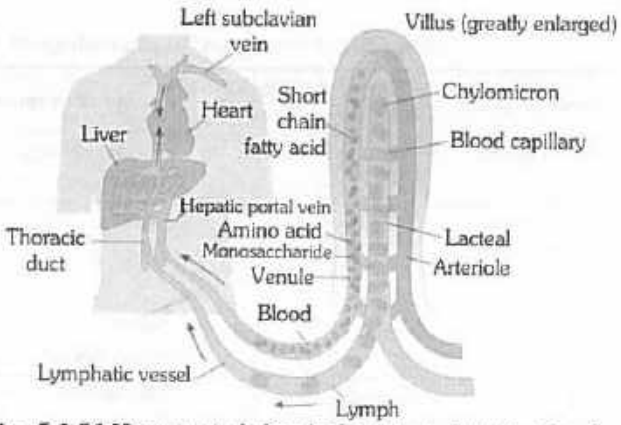


Fig : 5.1-24 Movement of absorbed nutrients into the blood and lymph

Absorption of vitamins : Water-soluble vitamins like members of B complex (except B_{12}) and vitamin C readily diffuse across the walls of the intestine into the blood. The fat-soluble vitamins *A, D, E* and *K* are dissolved in micelles, which enter the mucosal cells of the intestine, by simple diffusion. The absorption of these fat-soluble vitamins is markedly decreased in the absence of bile.

(iv) **Absorption in large intestine :** About 100-200 *ml.* of the water of undigested food is absorbed in the colon. It helps in maintaining the body water level. Some amount of mineral salts and vitamins are also absorbed. The symbiotic bacteria (*E. coli*) present in the large intestine, converts the inactive vitamins into active forms (*i.e.*, they synthesizes vitamins (vitamin *B* complex and vitamin *K*) which are absorbed.

(6) **Assimilation :** Conversion of absorbed food into active cytoplasm within cell is called as assimilation.

(7) **Faeces formation :** The phenomenon occurs in colon due to absorption of water, salts, minerals and vitamins. The peristalsis in colon also helps in faeces formation.

(8) **Egestion / defaecation :** The elimination of faeces from the alimentary canal is called egestion or defaecation. The faeces is waste matter discharged from the alimentary canal.

Pseudo-rumination or coprophagy : Animals swallows night faeces and recycle it through the gut to complete the digestion of cellulose and, making full use of their food. This habit is called coprophagy. Example – Rabbit.

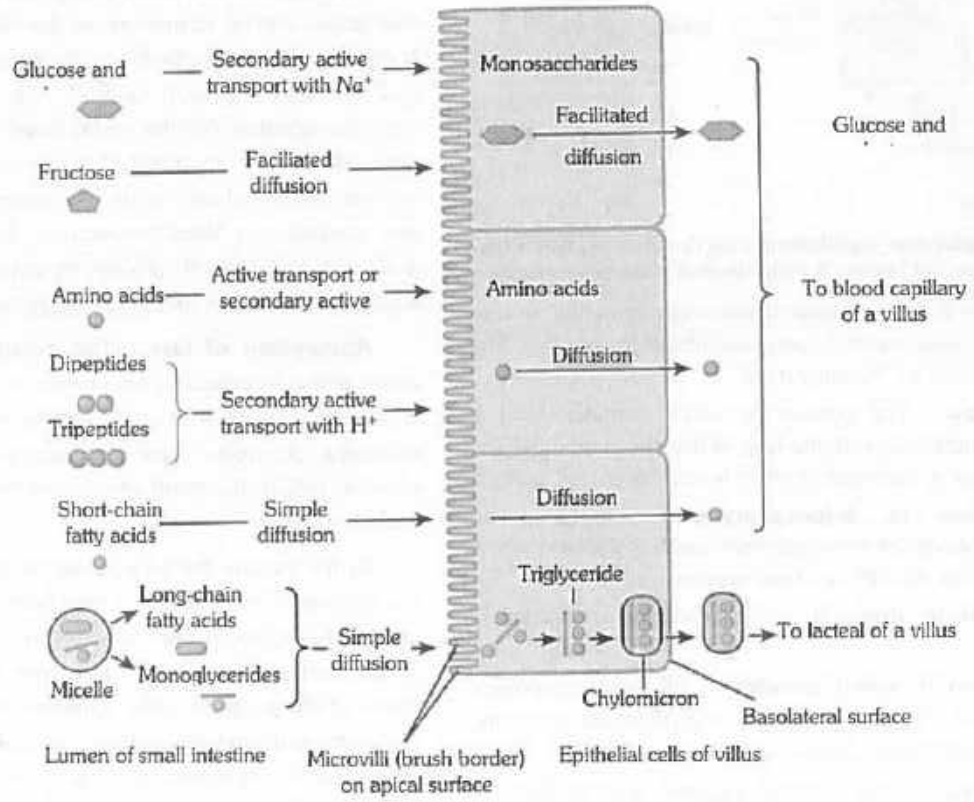


Fig : 5.1-25 Absorption of digested nutrients in the small intestine

Table : 5.1-4 Summary of physiology of digestion Major gastrointestinal enzyme in mammals

Name of gland	Name of digestive juice & optimum pH	Name of enzyme	Site of action	Substrates	Products
Salivary glands	Saliva (6.3 – 6.8)	Ptyalin / Salivary amylase	Mouth	Starch, dextrins, glycogen	Dextrins, maltose, isomaltose and limit dextrin.
Gastric glands	Gastric Juice (1-3)	Pepsin	Stomach	Proteins, casein (Milk)	Peptones, paracasein (curd). Proteoses
		Rennin	Stomach	Casein	Paracasein
		Gastric lipase	Stomach	Fats	Fatty acid and Glycerol.
Liver	Bile juice (7.6-8.6)	No enzymes	Duodenum	Fat	Makes the food alkaline, emulsifies fat and kills the harmful bacteria.

Liver	Bile (7.6 – 8.6)	No enzyme but useful digestive juice, provides alkaline medium, stops the action of HCl. Emulsifies fats and kills harmful bacteria.			
Pancreas	Pancreatic Juice (7.1 – 8.2)	Amylase/Diastase	Small intestine	Starch, dextrins, glycogen.	'Limits' dextrins, maltose, isomaltose.
		Trypsin	Small intestine	Proteins, Chymotrypsinogen (inactive) procarboxy peptidases (inactive) Fibrinogen (blood) Casein (milk)	Peptides, Chymotrypsin (active) carboxy peptidases (active) Elastase (active), Fibrin (clot) Paracasein (curd)
		Chymotrypsin	Small intestine	Peptones	Peptides
		Carboxypeptidases	Small intestine	Peptides	Smaller peptides and Amino acids.
		Lipase / Steapsin	Small intestine	Triglycerides	Mono-glycerides, fatty acids
		DNAase	Small intestine	DNA	Deoxyribonucleotides
		RNAase	Small intestine	RNA	Ribonucleotides
Intestinal glands	Intestinal Juice (7.5–8.3)	Enteropeptidase (enterokinase)	Small Intestine	Trypsinogen (inactive)	Trypsin (active)
		Aminopeptidase	Small Intestine	Peptides	Smaller peptides and amino acid
		Dipeptidases	Small Intestine	Dipeptides 'Limit dextrins'	Amino acids
		Isomaltase	Small Intestine	Isomaltose	Glucose
		Maltase	Small Intestine	Maltose	Glucose
		Sucrase/Invertase	Small Intestine	Sucrose	Glucose, fructose
		Lactase	Small Intestine	Lactose	Glucose, galactose
		Lipase	Small Intestine	Triglycerides	Monoglycerides, fatty acids
		Nucleotidase	Small Intestine	Nucleotides	Nucleosides, inorganic phosphate
		Nucleosidase Phosphorylases	Small Intestine	Nucleosides Phosphate	Purine, pyrimidine, pentose, phosphate

(9) **Hormonal control of digestion :** Activities of digestive tract are coordinated by nervous and endocrine systems. Sight and smell of food stimulates nervous system which induces the salivary glands to produce large quantity of saliva, stomach to release its hormone gastrin and intestine to produce intestinal hormones. Other hormones are produced in sequential order. All of them are polypeptide hormones.

Table : 5.1-5 Gastrointestinal hormones in mammals

Hormone	Source	Stimulus for secretion	Target organ	Action
Gastrin	Mucosa of pyloric stomach	Distension of stomach on food entry	Stomach	Stimulates secretion of gastric juice. Constricts cardiac sphincter.
Enterogastrone	Duodenal epithelium	Chyme entry into duodenum	Stomach	Slows gastric contractions to delay its emptying. Stops secretion of gastric juice.
Secretin	Duodenal epithelium	Acidic chyme entry into duodenum	Pancreas Liver Stomach	Release of sodium bicarbonate in pancreatic juice. Steps up secretion of bile. Inhibits secretion of gastrin.
Cholecystokinin (Pancreozymin)	Duodenal epithelium	Presence of fats in duodenum	Pancreas Gall Bladder	Release of enzymes in pancreatic juice. Release of bile from gall bladder.
Villikinin	Intestinal epithelium	Food in small intestine	Intestine	Accelerates movements of villi.
Duocrinin	Intestinal epithelium (Duodenal mucosa)	Acidic chyme in intestine	Intestine (Brunner's gland)	Release of viscous mucous from Brunner's glands.
Enterocrinin	Intestinal epithelium (Duodenal mucosa)	Acidic chyme in intestine	Intestine (crypts of Lieberkuhn's)	Release of enzymes from Lieberkuhn's crypts.

Nutrition

The substance used for nutrition are called nutrients. Nutreology is the study of food and their use in diet and therapy.

Types of nutrition

(1) **Autotrophic / Holophytic :** The individuals, which synthesizes their own food. It can be grouped into two following categories –

(i) **Photoautotrophs :** The individual, which synthesizes their own food from CO_2 and H_2O in presence of sunlight. Examples – Green plants, euglena, green sulphur bacteria, chlorobium.

(ii) **Chemoautotrophs :** The individuals which synthesizes their food with the help of chemical. Examples – Sulphur bacteria, nitrite bacteria, nitrate bacteria, nitrosomonas, nitrifying bacteria–nitrosomonas, nitrobacter etc.

(2) **Heterotrophic :** The animals derive organic food materials by consuming bodies or products of other living or dead plants or animals. Heterotrophs are of following three types on the basis of their mode of feeding.

(i) **Holotrophic or Holozoic :** These individuals ingest mostly solid food. Example – Animals.

(ii) **Saprotrophic or Saprobiotic :** They feed on dead organic matter. They absorb food through their body surface, organic fluids formed due to putrefaction of dead organism. Example – Bacteria, fungi, some protozoans etc.

(iii) **Parasitic :** These individuals derive their food from the body of their host. These may live inside or upon the bodies of their hosts, or may only periodically visit them for feeding. e.g., Ectoparasites (Lice) and endoparasites (Ascaris, Taenia solium).

(3) **Myxotrophic nutrition :** They carry out autotrophic as well as heterotrophic nutrition. Example – *Euglena*.

Modes of animal nutrition

On the basis of food, holozoic or holotrophic or ingestive nutritionally animals are classified into following –

(1) **Herbivorous :** The animal which exclusively feeds on plants. Their length of alimentary canal is more as compared to others. Examples – Tadpole larva of frog, rabbit, cow, horse, sheep etc.

(2) **Carnivorous :** The animal which kills and feeds on other animals. The length of their alimentary canal is minimum. Examples – Tiger, lion etc.

(3) **Omnivorous :** The animal which can take both plant and animal product as food. They have maximum type of digestive enzymes. Example – Human, Dog, Prawn.

(4) **Insectivorous :** The animal which feeds on insects. Example – Frog, Common bats, wall lizards.

(5) **Sanguivorous :** The animal which feeds on blood of other animal. Examples – Leech, body louse, mosquito, vampire bat etc.

(6) **Carrion Eaters (Scavangers) :** They feeds on dead animals also termed as scavangers. Examples – Hyaena, neltura, kites etc.

(7) **Cannibalus :** Organisms which feeds on its own species. Examples – Cockroaches, some fishes, frog, snakes etc.

(8) **Detritus :** Animals feed chiefly upon organic matters present in the humus. Examples – Earthworm.

(9) **Coprophagus or pseudorumination or refection :** Animals which feeds on their own faeces. Example – Rabbit, Guinea pig

(10) **Larvivorous :** Feeds on larva. Example – Gambusia (mosquito fish) and Dragon fly.

(11) **Frugivorous :** Feeding on fruits. Example – Parrot, Bat, Squirrel.

(12) **Food robbers :** Feed upon food formed in alimentary canal. Example – Ascaris, Taenia solium.

(13) **Filter feeder :** *Paramecium, Unio*, Sponge.

Feeding mechanism

(1) **Feeding mechanism in liquid feeders (fluid feeders)** are as follows –

(i) **Diffusion :** Many parasitic organisms (protozoans, tapeworm) absorb the dissolved organic food through general body surface.

(ii) **Pinocytosis (cell drinking) :** Ingestion of liquid food by invagination through surface of body. Pinocytosis channels are formed at body surface to enclose the fluid food from surrounding medium. Lower ends of channels are pinched off as pinocytic vesicle or pinosomes.

(iii) **Blood sucking :** Their mouthparts are modified for sucking blood. Examples – Vampire bat, mosquito etc.

(2) **Feeding mechanism in microphagus animals (filter feeders) :** The food of such animals (paramecium, sponges, corals, bivalves, tadpole etc.) is suspended in water fluid and they have filtering devices (clusters of pseudopodia, cilia, flagella, sheets of mucous etc.) or feeding on small microscopic animals like – *Amoeba, Paramecium* etc.

Nutritional requirements

(1) **Food :** All living organism needs food. Animals are unable to synthesize their own food hence they obtain it from outside sources. Animals require food for three main purposes, such as food as a fuel which provides energy and material for body maintenance, food for movement of body includes muscles contraction etc., food for growth as well as for the synthesis of body substances.

(2) **Components of food :** These are of following types –

(i) **Carbohydrates :** They are made up of $C : H : O$, having H and O in the ratio of 2 : 1 and the general formula is $(CH_2O)_n$. They are the chief source of energy. The source of carbohydrates in our food is cereals and pulses.

Table : 5.1-6 Types and examples of carbohydrates

Types of carbohydrate	Examples
Monosaccharides	Glucose (the main blood sugar) Fructose (found in fruits) Galactose (in milk sugar) Deoxyribose (in DNA) Ribose (in RNA)
Disaccharides	Sucrose (table sugar) = glucose + fructose Lactose (milk sugar) = glucose + galactose Maltose = glucose + glucose
Polysaccharides	Glycogen, the stored form of carbohydrate in animals Starch, the stored form of carbohydrate in food Cellulose, part of cell walls in plants; not digested by humans but aids movement of food through intestines

Specific features

(1) Storage amount : 900 gm approx.

(2) Storage site : Chiefly liver and muscles.

(3) Daily requirement : 500 gm approx.

(4) Source : Chiefly cereals (rice, wheat, maize), pulses, potato, fruits, sugarcane, milk, honey, sugar etc.

(5) Caloric value : 4.1 *k cal./gm*

(6) Physiological value : 4.0 *k cal./gm*

Functions of carbohydrates

(1) Carbohydrates, especially glucose, are the main respiratory fuels.

(2) Ribose and deoxyribose sugars are components of nucleic acids (DNA and RNA). Galactose is a structural component of medullary sheath.

(3) Monosugars act as monomers for the formation of disaccharides and polysaccharides.

(4) Starch and glycogen, serve as reserve fuel.

(5) Excess of glucose may also be changed into fats (lipogenesis) and stored in liver, adipose tissue and mesenteries.

(6) Glucose has antiketogenic role as it prevents the incomplete oxidation of fats and formation of ketonic bodies in the blood.

(7) Glucose spares the amino acids for protein synthesis.

(8) Sucrose is the major form in which sugar is transported in the plant body. Sucrose is storage sugar of sugarcane and sugar beet.

(9) Cellulose, hemicellulose etc. are the main components of cell wall of plants.

(10) Chitin is main component of cell wall of fungi and exoskeleton of crustaceans.

(11) Heparin prevents the blood clotting inside the blood vessels (Anticoagulants).

(12) Glycoproteins form a protective layer, glycocalyx, on intestinal cells.

(13) Hyaluronic acid acts as a lubricating fluid in the synovial joints between the limb bones.

(14) Blood antigens like *A*, *B* and Rh-factor are glycoproteinaceous and provide immunity to the individual.

(15) Sugars are also important components of some glycoproteinaceous hormones like FSH (Follicular stimulating hormone), LH (Luteinizing hormone) etc. FSH controls gametogenesis while LH controls the ovulation and formation of corpus luteum.

(16) Carbohydrates may be changed into amino acids.

(17) Oligosaccharides of cell membrane help in cellular recognition.

(18) Cellulose forms roughage of food which stimulates the secretion of digestive juices. It also helps in peristalsis.

(19) Cellulose nitrate is used in explosives.

(20) Carboxy-methyl cellulose is used in cosmetics and medicines.

(21) Cellulose acetate is used in preparing cellulose plastics, shatter-proof glass, fabrics etc.

(ii) **Lipids and fats :** Fats and all fat like substances are called lipids. They are composed of *C*, *H* and *O*. They are insoluble in water but soluble in ether, alcohol, chloroform etc.

Table : 5.1-7 Types of lipids in the body

Types of Lipid	Functions
Triglycerides (fats and oils)	Protection, insulation, energy storage.
Phospholipids	Major lipid component of cell membranes.
Steroids	
Cholesterol	Minor component of all animal cell membranes; precursor of bile salts, vitamin D, and steroid hormones.
Bile salts	Needed for absorption of dietary lipids.
Vitamin D	Helps regulate calcium level in the body; needed for bone growth and repair.
Adrenocortical hormones	Help regulate metabolism, resistance to stress, and salt and water balance.
Sex hormones	Stimulate reproductive functions and sexual characteristics.
Eicosanoids	Have diverse effects on blood clotting, inflammation, immunity, stomach acid secretion, airway diameter, lipid breakdown, and smooth muscle contraction.
Other Lipids	
Fatty acids	Catabolized to generate adenosine triphosphate (ATP) or used to synthesize triglycerides and phospholipids.
Carotenes	Needed for synthesis of vitamin A, which is used to make visual pigments in the eyes.
Vitamin E	Promotes wound healing, prevents tissue scarring, contributes to the normal structure and function of the nervous system, and functions as an antioxidant.
Vitamin K	Required for synthesis of blood-clotting proteins.
Lipoproteins	Transport lipids in the blood, carry triglycerides and cholesterol to tissues, and remove excess cholesterol from the blood.

Specific features

(1) Source : Butter, ghee, liver oil, vegetable cooking oil etc.

(2) Daily requirement : 50 *gm*.

(3) Storage site : Subcutaneous fat, adipose cells.

(4) Caloric value : 9.45 k *cal/gm*.

(5) Actual value : 9.0 *k cal/gm*.

Functions of lipids

(1) The fats acts as concentrated fuel. The caloric fuel value of 1 *gm* of fats is 9.45 *kcal*, while the physiological fuel value of 1 *gm* of fats is 9.0 *kcal* (37 *kJ*), which is about 2.25 times more than the energy provided by same amount of glucose.

(2) The fats are also highly suitable for storage as the reserve food material. It is mainly stored in the liver, beneath the skin, in the brown deposits and in the fat bodies. Normally, the fats constitute about 4% of liver by weight.

(3) Fats stored in the subcutaneous tissue insulate the body against the loss of heat energy, so conserve the body heat. Thus, fats help in homeothermy.

(4) Medullary sheath is formed of white fatty substance, myelin, which insulates the nerve fibres and prevents the loss of energy.

(5) Fats forms the protective shock absorbing cushions around a number of organs like the eye balls, kidneys (renal fat), ovaries, etc.

(6) These help in the absorption of fat-soluble vitamins like *A*, *D*, *E* and *K*.

(iii) **Proteins :** They are composed of *C*. *H*. *O*. *N* and some in addition contain *S* and *P*. They are complex, versatile, macromolecules with very high molecular weight. Their unit is amino acids. Out of the 20 amino acids, required in human to build proteins, half of them are essential and rest are non-essential amino acid. Essential amino acids are those, not synthesized by human body and are present in food. The non-essential amino acids are those which can be synthesized by human body.

Table : 5.1-8 Types of amino acids

Dispensable or Essential amino acids	Non-dispensable or Nonessential amino acids
Arginine	Glycine
Histidine	Alanine
Isoleucine	Serine
Leucine	Aspartic acid
Methionine	Asparagine
Phenylalanine	Cystine
Threonine	Glutamic acid
Tryptophan	Glutamine
Lysine	Proline
Valine	Tyrosine

Arginine and histidine are considered semi indispensable amino acids. These two are not essential in the adult organisms.

Classification of proteins : They are following types –

(1) On the basis of structure of molecules

(i) **Fibrous :** Examples – Collagen, myosin, keratin, fibrin of coagulated blood etc.

(ii) **Globular :** Examples – Albumin, globulin, haemoglobin, enzymes, snake venom etc.

(2) **On the basis of their chemical nature :** The proteins are divided into three categories –

(i) **Simple proteins :** These are formed of peptide chains and yield only amino acids on hydrolysis. On the basis of shape, these may be fibrous proteins *e.g.* collagen of white fibres, elastin of yellow fibres, keratin of exoskeletal structures like nails, horns, hoofs, hair, feather etc.; globular proteins *e.g.* albumins and globulin of blood plasma, protamines, histones, glutelins etc.

(ii) **Conjugated proteins :** These are formed of a proteinaceous and a non-proteinaceous prosthetic group. These include nucleoproteins (of chromosomes-DNA and proteins; and ribosomes-RNA and proteins), glycoproteins (of blood-antigens), phosphoproteins (casein of milk), lipoproteins (lipovitellin of egg-yolk), chromoproteins (haemoglobin of RBCs), haemocyanin, rhodopsin (visual purple), iodopsin (visual violet), cytochromes), metalloproteins (carbonic anhydrase enzyme with Zn^{2+}) etc.

(iii) **Derived proteins :** These are formed by the partial hydrolysis of simple proteins and include peptones, proteoses etc.

Specific features

(1) Source : Chief source is pulses, egg, milk, meat, fish, leafy vegetables, soyabean, groundnut etc.

(2) Daily requirement : 70-100 *gm*.

(3) Caloric value : 5.6 *k cal/gm*.

(4) Physiological caloric value : 4 *k cal/gm*.

Table : 5.1-9 Types and functions of protein

Types of Protein	Functions
Structural	Form structural framework or various parts of the body. *Examples* : Collagen in bone and other connective tissues, and keratin in skin, hair, and fingernails.
Regulatory	Functions as hormones that regulate various physiological processes; control growth and development; as neurotransmitters, mediate responses of the nervous system. *Examples* : The hormone insulin, which regulates blood glucose level, and a neurotransmitter known as substance P, which mediates sensation of pain in the nervous system.
Contractile	Allow shortening of muscle cells, which produces movment. *Examples* : Myosin and actin.
Immunological	Aid responses that protect body against foreign substances and invading pathogens. *Examples* : Haemoglobin, which transports most oxygen and some carbon dioxide in the blood.
Catalytic	Act as enzymes that regulate biochemical reactions. *Examples* : Salivary amylase, sucrase and ATPase.

(iv) **Vitamins**

Historical review

N. I. Lunin (1881) discovered vitamins. The term 'vitamin' was first used by Funk in 1912. Hopkins and Funk (1912) propounded a 'vitamin theory'.

Definition : Vitamin are complex organic compounds needed daily in minute quantities and act as growth and metabolic regulatory substances.

Sources : Vitamins can only be synthesized by green plants, hence animals depend for their vitamin requirement upon the plants. Human body manufactures vitamin *D* using ultraviolet rays of sunlight and can store A, D, E, K and B_{12}. The chemical compositions of vitamins are known and it is possible to synthesize them.

Importance : The vitamins are not a sources of energy. They regulate the various metabolic processes. They mostly act as the constituents of coenzymes in the cells.

Types : Vitamins are divided into two groups –

(a) **Fat soluble vitamin :** *A*, *D*, *E* and *K*.

(b) **Water soluble vitamin :** *B* complex and *C*.

Table : 5.1-10 Fat soluble vitamins

Name of vitamins and chemical formula	Discovery	Sources	Daily requirement per day	Functions	Name of Deficiency Disease	Symptoms	Other Features
Vitamin A or Retinol or anti xero-phthalmic or anti infection vitamin $C_{20}H_{29}O$	Mc-Collumn and Davis (1913)	Butter, liver oils, egg yolk, mango and orange, carrot, yellow, green vegetables.	2 mg	Part of visual pigment, maintenance of epithelia and prevention of keratinization of epithelium. Beta carotene act as Antioxidants.	Xerophthalmia Night blindness or nyctalopia Keratomalacia. Dermatosis	Drying of eyeball Unable to see in dim light Epithelium keratinised Dry scaly skin	Synthesized and stored in the liver. Destroyed by - strong light.
Vitamin D or Ergocalciferol or sunshine vitamin or anti ricket vitamin $C_{28}H_{44}O$	Steenbock and Hess 1924)	Cod liver oil, butter, fish, eggs, milk, brain, lung, and spleen.	0.01 mg	Facilitates absorption of calcium and phosphorus by intestine and their retention in body and deposition in bones.	Rickets in children Osteomalacia in adults.	Deformities of bones like bowlegs, pigeon chest Weak bones liable to easy fracture	Synthesized in the body on exposure of skin (7-hydroxy cholesterol) to light. Destroyed by – oral contraceptives
Vitamin E or α Tocopherol or anti sterility vitamin $C_{29}H_{46}O_2$	Evan and sore (1922)	Fresh green vegetables, meat, yolk, vegetable oils, butter and cheese, peanuts wheat germs.	20 mg	Antioxidant and some role in ETS. DNA / RNA/RBC formation promote wound healing.	Anaemia Sterility Muscular atrophy	Destruction of RBC. In male causes sterility and in female abortion may occur. Effect not proved in man. Degeneration of muscles	Destroyed by UV – rays. It is also used for curing tumour and cancer
Vitamin K or Phylloquinone or anti haemorrhagic vitamin $C_{31}H_{46}O_2$	Dam and Droisy (1935)	Fresh green vegetables. tomatoes, liver, soyabean, cheese, egg.	0.07 – 0.14 mg	Synthesis of prothrombin for normal clotting of blood.	Haemorrhage	Reduced ability of blood to clot and also leads to haemorrhages.	Vitamin K is synthesised by intestinal microbes present in the intestine. Destroyed by– prolonged use of antibiotics.

Table : 5.1-11 Water soluble vitamins

Name of Vitamins and Chemical Formula	Discovery	Sources	D.R.	Function	Name of Deficiency Disease	Symptoms	Other Features
Vitamin B_1 or Thiamine or anti neuritic or antiberiberi $C_{12}H_{16}N_4SO$	C. Funk (1926)	Branrice, whole wheat flour, egg, meat, liver yeast etc.	1-1.5 mg	Act as an enzyme in cellular respiration, role in nutrition of nerve cells. Essential for carbohydrate metabolism, protein synthesis and control water balance in body. Major component of co-enzyme carboxylase.	Beri- beri or Dry beri - beri (man) Polyneuritis or wet beri – beri (animals) Cardiovascular atrophy	Loss of appetite and weight, retarded growth, muscular dystrophy. Nerves become extremely irritable. Heart enlargement	Beri-beri disease was discovered by Eijkman Destroyed by – cooking

Vitamin B_2 or G or yellow enzyme or Riboflavin or Lactoflavin or ovaflavin or hepatoflavin $C_{17}H_{26}N_4O_6$	Warburg and Christain	Cheese, egg, yeast, meat, liver, cereals, green, vegetable.	1-2 mg	Required for cell growth. Form pair of coenzyme (FMN, FAD).	Cheilosis Glossitis Keratitis	Cracking of skin at corners of mouth Inflammation of tongue Inflammation of skin	Stored in liver, Excess of this is eliminated in urine. It is associated with the physiology of vision
Vitamin B_3 Yeast factor or pantothenic acid or anti greying factor on chick antidermatitis factor $C_9H_{17}O_5N$	Williams (1933)	All foods, more in yeast, kidney, liver, egg, meat, milk, ground nut	5-10 mg	Part of co-enzyme A. needed for cell respiration, necessary for normal skin and nerves.	Burning feet syndrome. Nervous disorder	Nerve degeneration	It occurs in all types of plants and animal tissues. Its deficiency cause greying of hair
Vitamin B_5 or Niacin or Nicotinic acid or pellagra preventing factor $C_6H_5NO_2$	Goldberger (1912)	Fresh meat, liver, fish, milk, cereals, pulses, yeast etc.	16-20 mg	It is an essential component of NAD and NADP thus form coenzymes, metabolism of carbohydrates, functioning of gastrointestinal tract and nervous system	Pellagra, Dermatitis, Diarrhoea Dementia Death (4-D syndrome)	Rough skin Inflammation of skin which becomes scaly and papillated Dehydration Neural deterioration which may lead to madness	It is characterised by 3D's *i.e.* dermatitis diarrhoea and dementia Destroyed by – cooking Pellagra preventing factor Goldberger also called Goldberger's p-p factor It is also synthesized by colon bacteria
Vitamin B_6 or pyrido-xine or anti dermatitis factor $C_8H_{11}O_3N$	Gyorgyi (1928)	Brewer's yeast, liver, egg, yolk, kidney, milk, and vegetables.	2 mg	It is essential component of coenzyme pyridoxal phosphate. It promotes growth in rats used for curing tuberculosis.	Anaemia Dermatitis, paralysis & death of rats. Mental disorder Dermatitis	Nausea, lack of RBC (blood) Disturbance of central nervous system Skin leisons	Term B_6 was coined by Gyorgy. Destroyed by – cooking and oral contraceptives
Vitamin H or B_7 or Biotin or coenzyme R $C_{10}H_{16}N_2O_3S$	Bateman and Allison (1916)	Yeast, vegetables and egg yolk	150-300 mg	It acts as coenzymes and essential for fat synthesis and energy production.	Dermatitis	Scaly and itchy skin	It is synthesized by intestinal bacteria Destroyed by – prolonged use of antibiotics
Folic Acid or Vitamin M or folacin or Anti anaemic factor	Day (1935)	Green vegetable (spinach) Banana, orange and Liver.	0.4 mg	It forms coenzymes and play essential role in cell metabolism, Necessary for erythropoiesis, required for DNA synthesis.	Megaloblastic anaemia. Sprue	Enlarged RBCs Ulceration of mouth	It is also synthesized by intestinal bacteria Destroyed by - cooking

Vitamin B_{12} or Cyanocobalamine or Animal protein factor (APF) or Intrinsic factor of castle $C_{63}H_{88}O_{14}N_{14}PCo$	Rickets (1948)	Meat, egg, liver, fish, synthesized by intestinal bacteria.	0.003 mg	Required for chromosome duplication and formation of blood corpuscles.	Pernicious anaemia	Reduced formation of erythrocytes in bone marrow	It is also known as anti pernicious factor Also synthesized by intestinal bacteria in human colon Destroyed by – excessive heat
Vitamin C or Ascorbic Acid $C_6H_6O_6$	Szent Gyorgyi (1928)	Citrus fruits such as lemon, mango, amla, plumes, guava.	40-60 mg	Functions as part of oxidation-reduction system. Helps in secretion of collagen cement dentine. Helps body to develop resistance to diseases. Helps in absorption of Ca and Fe in the intestine. Wound healing.	Scurvy.	Spongy and bleeding gums, fragile blood vessels and bones.	Required by primates, all other vertebrates and some other invertebrates can synthesize vitamin C. It is the earliest known vitamin. It is wound healing vitamin. Destroyed by heating

Table : 5.1-12 Other Types of vitamins, functions and deficiency symptoms

Name of Vitamin	Function	Symptoms of deficiency
Inositol or mouse antialopecia factor	Stimulate growth of mice. Spectacle-eye condition in rat can be treated. Keep a limit on the cholesterol level in the blood of man.	Causes reduced growth and alopecia (loss of hair) in the mice. Also causes haemorrhagic degeneration of the adrenal gland.
Choline	It is an important lipotropic factor which prevent excessive development of fatty liver. It takes part in the formation of acetylcholine which is involved conduction of nerve impulse.	Chronic deficiency causes cirrhosis in the liver also causes haemorrhagic changes in kidney.
Vit.P or citrin	Control the permeability and fragility of the capillary wall to plasma protein works as the co-factor with vitamin C.	Its deficiency causes subcutaneous bleeding due to break down of capillary walls.

(vii) **Mineral elements :** They forms approximately 4% of body weight. They are essential to regulate the various metabolic activities of the animals. The various types of mineral are group into two categories as minor element. Examples – *Ca, S, P, Na* etc. and trace element examples – *Cu, Zn, Mn* etc. Some of these minerals are described as follows –

Table : 5.1-13 Chart of important minerals required in animal bodies

Mineral elements	Sources	Significance	Effects of deficiency
Minor elements (1) Calcium–*Ca*	Milk, Cereals, Cheese, Green Vegetables, Pods.	Required for formation of teeth and bones, blood clotting, functions of nerves and muscles.	Weak teeth and bones; retarded body growth.
(2) Phosphorus–*P*	Milk, Meat, Cereals.	Required for formation of teeth and bones and acid-base balance; component of ATP, DNA, RNA.	Weak teeth and bones; retarded body growth and physiology.
(3) Sulphur–*S*	Many proteins of food.	Component of many amino acids.	Disturbed protein metabolism
(4) Potassium–*K*	Meat, Milk, Cereals, Fruits and Vegetables.	Required for acid-base balance; water regulation and function of nerves.	Low blood pressure, weak muscles; risk of paralysis.
(5) Chlorine–*Cl*	Table Salt.	Required for acid-base balance; component of gastric juice.	Loss of appetite; muscle cramps.
(6) Sodium–*Na*	Table Salt.	Required for acid-base and water balances and nervous functions.	Low blood pressure, loss of appetite; muscle cramps.
(7) Magnesium–*Mg*	Cereals, Green Vegetables.	Cofactor of many enzymes of glycolysis and a number of other metabolic reactions dependent upon ATP.	Irregularities of metabolism, principally affecting nervous functions.

(8) Iron–*Fe*	Meat, Eggs, Pods, Cereals, Green Vegetables.	Component of haemoglobin and cytochromes.	Anaemia weakness and weak immunity.
(9) Iodine–*I*	Milk, Cheese, Seafood, Iodized salt.	Important component of thyroxin hormone and regulate metabolism of cell.	Goitre, cretinism.
Trace Elements (10) Fluorine–*F*	Drinking water, Tea, Seafood	Maintenance of bones and teeth.	Weak teeth. Larger amount causes mottling of teeth.
(11) Zinc–*Zn*	Cereals, Milk, Eggs, Meat, Seafood	Cofactor of digestive and many other enzymes.	Retarded growth, anaemia, rough skin, weak immunity and fertility.
(12) Copper–*Cu*	Meat, Dry fruits, Pods, Green Vegetables, Seafood.	Cofactor of cytochrome oxidase enzyme. Necessary for iron metabolism and development of blood vessels and connective tissues.	Anaemia, weak blood vessels and connective tissue and damage to central nervous system.
(13) Manganese–*Mn*	Dry fruits, cereals, Tea, Fruits and Green Vegetables.	Cofactor of some enzymes of urea synthesis and transfer of phosphate group.	Irregular growth of bones, cartilages and connective tissues.
(14) Cobalt–*Co*	Milk, Cheese, Meat.	Important component of vitamin B_{12}	Anaemia.
(15) Selenium–*Se*	Meat, Cereals, Sea food.	Cofactor of many enzymes; assists vitamin E.	Muscular pain; weakness of cardiac muscles.
(16) Chromium–*Cr*	Yeast, Seafood, Meat, Some vegetables.	Important for catabolic metabolism.	Irregularities of catabolic metabolism and ATP production.
(17) Molybdenum–*Mo*	Cereals, Pods, Some Vegetable	Cofactor of some enzymes.	Irregular excretion of nitrogenous waste products.

Nutritional imbalances and disorders

Balanced diet : The diet which contain the various nutrients in such proportions as can satisfy all the various needs of our body, is called a "balanced diet".

Table : 5.1-14 Balanced diet for moderately active adult Indian

Name of food	Recommended amounts (*gms.* per day)	
	Adult man	Adult woman
(1) Cereals (Wheat/Rice)	520	440
(2) Pulses	50	45
(3) Milk	200	150
(4) Meat/Fish or Egg	30	30
(5) Fats (Oil, Butter, Ghee)	45	25
(6) Sugar/Molasses	35	20
(7) Root and Tubers (Raddish, Potato, etc.)	60	50
(8) Green leafy vegetables	40	100
(9) Other vegetables	70	40

The proportion of carbohydrates, proteins and fats into fulfill energy requirement is 4 : 1 : 1 *i.e.* 65% of energy is obtained from carbohydrates and 10–20% each from proteins and fats. This amount of energy is fulfilled by intake of 400–600 gm of carbohydrates, 80–100 gm of proteins and 50–60 gm of fats. The balanced diet must also contain sufficient amount of minerals and vitamins.

Metabolic rates

(1) **Basal metabolic rate :** Amount of energy required daily by a person to maintain its basal metabolism and is about 1600 *k cal*/day.

(2) **Routine metabolic rate :** Amount of energy required daily by a person to do his routine work. It is about 2800 k cal/day for males and 2300 k cal for female.

(3) **Active metabolic rate :** Amount of energy required daily by a person to maintain its high metabolic rate during heavy physical work and is about 4000 to 6000 k cal/day for males and 4500 k cal for females. It has been scientifically determined that a child of 4–6 years approximately requires 1500, a child of 13–15 years requires 2500 and a youth of 16–18 year requires 3000 k cal of energy per day.

Table : 5.1-15 Daily Dietary Requirements of Nutrients (Recommended by Indian Council of Medical Research)

Individual	Total *kcal*	Protein (*gms.*)	Calcium (*gms.*)	Iron (*mgs.*)	Vitamin *A* (*µg.*)	Thiamin (*mgs*)	Riboflavin (*mgs.*)	Niacin (*mgs.*)	Folacin (*µg.*)	Vitamin B_{12} (*µg.*)	Vitamin *C* (*mgs.*)	Vitamin *D* (IU)
(1) Man Moderately active	2800	55	0.4-0.5	24	750	1.4	1.7	19	100	1	40	
(2) Woman	2200	45	0.4-0.5	32	750	1.1	1.3	15	100	1	40	
(i) Moderately active	2700	59	1.0	40	750	1.3	1.5	17	300	1.5	40	
(ii) Pregnant	2750	70	1.0	32	1150	1.4	1.6	19	150	1.5	80	

(3) Boy (16-18 years)	2820	53	0.5-0.6	25	750	1.4	1.7	19	100	1	40	200
(4) Girl (16-18 years)	2200	44	0.5-0.6	35	750	1.1	1.3	15	100	1	40	200

Nutritional disorders : Every organism requires an adequate supply of nutrients in proper proportion in their diet for proper growth and development. There are two types of nutritional disorders

(1) **Diseases due to over nutrition**

(i) **Fluorosis** : Caused due to excess of fluorides. It results in tooth and bone decay.

(ii) **Obesity** : This is over-nutritional disorder. It is caused when "energy inputs exceeds energy output". It results in deposition of excess fat in the body.

(iii) **Constipation** : Slow movement of faeces down the large intestine causes accumulation of dry and hard stool is colon. It is generally caused by irregular bowel habits.

(iv) **Diarrhoea** : Rapid movement of faecal matter down the large intestine causes loose stools called diarrhoea. It may be also caused by viral or bacterial infections of intestinal tract, particularly of large intestine and by nervous tension.

(v) **Piles or haemmorhoids** : Enlargement of the anal veins. It may be either hereditary or may be caused due to rapid changes in the diet.

(vi) **Hypercholesterolemia** : Caused due to excess of saturated fats like butter, ghee, hydrogenated vegetable oils and eggs etc. It results in increased level of cholesterol in blood, arteriosclerosis, coronary thrombosis, heart attack etc.

(vii) **Hypervitaminosis** *A* : It results in loss of appetite, body hairs, painful swelling etc.

(viii) **Hypervitaminosis** *D* : It results in deposition of calcium ion in the soft tissues of the body.

(2) **Diseases due to deficiency of nutrition (malnutrition)**

Name of the Deficiency	Deficient Nutrient	Symptoms
Anaemia (microcytic)	*Fe*	Haemoglobin and number of erythrocytes gets reduced.
Megaloblastic anaemia	Folic acid and B_{12}	Presence of immature erythrocytes in blood.
Pernicious anaemia	Vitamin B_{12}	Immature RBC without Hb. This may be fatal unless treated with vitamin B_{12} injection.
Xerophthalmia	Vitamin *A*	Thickened, keratinised, opaque ulcerated cornea. Prime cause of blindness in India, especially among children.
Night Blindness	Vitamin *A*	Less rhodopsin in rod cells of retina. So no vision in dim light.
Rickets (in children)	Vitamin *D*	Weak, soft, thin bones due to poor deposition of Ca and P. Bent long bones and painful swelling on wrist, elbow and knee joints.
Osteomalacia (adults)	Vitamin *D*	Weak bones of vertebral column, pelvis gets bent and deformed by body weight.
Sprue	Folacin	Ulceration of mouth, inflammation of bowel, indigestion, diarrhoea, weakness.
Pigeons breast	Vit. – D	Incomplete ossification at the end of limb bone, deformed ribs leading to pigeons breast.
Beri – beri	Vitamin B_1 (Thiamine)	Reduces aerobic carbohydrate metabolism. So peripheral nerves are inflammed causing pain, numbness and weakness of limb muscles. Paralysis. Fluid accumulation in tissues or oedema of hands and legs. Cardiac oedema.
Scurvy	Vitamin *C*	Fragile blood vessels because of defective collagen fibres in their walls. Bleeding gums, teeth fall, bones fragile. Wound healing delayed, vitamin C is recommended in serious injury.
Bleeding disease (Hypoprothrombin anaemia)	Vitamin *K*	Delayed blood clotting (s) so profuse bleeding.
Marasmus	Protein / Malnutrition	Growth and replacement of tissue proteins imparted so emaciated body with thin limbs and prominent ribs, dry, thin and wrinkled skin, Diarrhoea. It affects infants under one year of age.
Kwashiorkor	Protein	Wasting muscles, thin limbs, Retarded growth of body and brain, Oedema, Diarrhoea. It commonly affects babies between 1-3 years of age.
Pellagra	Nicotinamide	Swollen lips, thick pigmented skin of hands and legs. Irritability.
Osteoporosis	*Ca*	Weakning of bones, tooth decay.
Goitre	I_2	Enlargement of thyroid gland.
Muscular cramps	*NaCl*	Pulling of muscles due to dehydration.
Dental cramps	Fluorine	Tooth decay.

Regulation of food intake

Hunger : Hunger is defined as the intrinsic (involuntary) desire or craving for food. Hunger is associated with a number of objective sensations. For instance, food deprival for many hours causes intense rhythmic hunger contractions in stomach, which even causes intense pain (hunger pangs) send sensory impulses to a "hunger or feeding centre", located in the lateral regions of hypothalamus.

When glucose levels fall in blood, hunger centre is stimulated. Hunger centre transmits impulses to wall of stomach and wall of empty stomach start contraction or hunger pangs. After taking meal satiety centre which is located in hypothalamus stimulates and feeding is stopped. During high fever person does not feel like taking meal because high temperature shuts off the appetite centre.

Thirst : Subconscious desire for water is called thirst. It is also induced by a hypothalamic "thirst centre". When amount of water decreases in body fluids (blood, lymph, tissue fluid, cerebrospinal fluid etc.) due to fever, exercise and sweating, copious urination, diarrhoea, etc. This induces the feeling of thirst. Presumably, a fall in glucose level in the blood also induces thirst.

Tips & Tricks

- Upper canine form tusk in walrus for digging mollusc and for locomotion.
- In carnivores, last premolars in upper jaw and first molars in lower jaw may have very sharp cusps for cracking bones and shearing tendons. These are called carnassial teeth.
- **Tonsillectomy** – Surgical removal of tonsil.
- **Cheek pouches** – In some rodents (squirrel, rat) certain old world monkey, the vestibule extends to form cheek pouches for temporary storage of masticated food.
- Elephant tusk is the upper incisors.
- Teeth of fishes are modified placoid scales.
- Pyorrhoea infected gums and tooth sockets.
- Maximum number of teeth present in opossum is $\frac{5134}{4134}\times 2 = 50$.
- The number of teeth that grows once and twice in humans life is 12 and 20 respectively.
- Lophodont : Cusps of premolars and molars fuse and form transverse ridges e.g. in elephant.
- Jacobson organ (Vomeronasal organs) – This organ serve to smell food and recognize its chemical nature. They also help enemy recognition, locating members to opposite sex, courtship etc. It is found in reptiles such as lizards, snakes and sphenodon.
- Taste of chilli is not real taste but it is burning sensation of nerves.
- Fangs of poisonous snake attached to maxillary bones, they are replaceable. Solenoglyphous, Proteroglyphus and Opisthoglyphus types of fang occurs in poisonous snake.
- Greenish faecal matter passed by infant in first two days of birth due to sterilized intestine is called meconium.
- National institute of nutrition is located in Hyderabad.
- Gastritis – Inflammation of stomach.
- Amount of rennin decreases with age, then the curdling of milk is done by pepsin and chymotrypsin.
- Removal of stomach causes dumping syndrome.
- Oesophagus does not secrete any enzyme.
- Stomach absent in labeo, lamprey and hag fish.
- The study of alimentary canal is called Gastro-Enterology.
- Digestion of cellulose is also found in termites (white ants). In which symbiotic flagellate Triconympha found in their intestine that secretes enzyme β-glucosidase which hydrolyse the cellulose to sugars which are used by both symbionts.
- Bursa fabricious is also called cloacal thymus, is a lymphoid mass in the cloaca of birds. It is site of differentiation of B-lymphocytes. So a part of immune system.
- Carnivores, cattles and other cud-chewing mammals lack ptyalin enzymes in their saliva.
- Pepsin hydrolyses the peptic bonds on c-terminus side of tyrosine, tryptophan and methionine amino acids.
- Trypsin is called universal enzyme as found from protozoans to mammals.
- Nucleases of pancreatic juice digest about 80% of nucleic acid.
- Pancreatic juice is called as "complete digestive juice" as it is protease enzymes can break all type of peptide bonds.
- Amylases act on glycoside linkages.
- Pepsin, trypsin and chymotrypsin are endopeptidases whereas carboxy peptidase is exopeptidase.
- Blood is digested by trypsin.
- Enterokinase is a non-digestive protease while bile is a non-enzymatic digestive juice.
- Galactosemia is a disease of children in which amount of galactose increases in blood. Such children are kept on milk free diet.
- Sphincter of boyden is absent in rabbit and frog.
- **Cholecystectomy** – Surgical removal of gall bladder.
- Liver produces biles, cholesterol and iron.
- Prussic acid formed during metabolism is rendered harmless by liver.
- Septicaemal anaemia causes destruction of liver.
- Bile is alkaline in man but acidic in cats and dogs.
- Choleretic are substance which increase bile secretion from liver e.g. bile salts.

- Cholagogues are substances which causes the contraction of the gall bladder.
- Obstructive jaundice is the condition when hepatic or common bile duct may be obstructed and failing to be excreted bile by the bile capillaries.
- World food day (W.F.D) is 16th october.
- **White revolution** – Increased milk production.
- **Blue revolution** – Increased fish production.
- **Yellow revolution** – Increased oil production.
- The foul & flatus odour of the faeces is due to presence of gases such as CH_4, NH_3, H_2S, CO_2 etc. and presence of indole, skatole and mercaptones amines formed due to decarboxylation of tryptophan amino acid.
- Villus is the unit of absorption of food.
- The enzymes that converts glucose to glucose 6-phosphate is hexokinase.
- Human insulin is known as Humulin.
- Fructose is the sweetest sugar found in fruits but not in grapes.
- Glycogen is also called as "animal starch".
- Zinc is necessary to maintain plasma concentration of vitamin A.
- Vertebrates cannot digest keratin protein of hair, nails, fibroin protein of silk fibers etc, but certain insects can digest these proteins so damages silken and woolen garments.
- Vitamin C was the first vitamin to be produced during fermentation process using wild bacteria.
- An alcoholic is always deficient of vitamin C.
- Vitamin B_{17} is a recently discovered vitamin with anti–cancer property.
- Most of the B-complex vitamins are coenzymes.
- Presently vitamin B_{12} is produced directly during the course of fermentation by propioni bacteria and certain strains of Pseudomonas.
- Vitamins, which are synthesized by the intestinal flora are vitamin K. Thiamine, Riboflavin, Pantothenic acid, Niacin, Pyridoxin, Biotin and Folic acid.
- Gama – linolenic acid and arachidonic acids are essential fatty acid in mammals.
- Phenyl alanine amino acid is denoted by symbol F.
- The overdosage of vitamin 'A' causes injury to lysosomes.
- Vitamin B_6 is essential for transmission.
- Frog tadpole is delayed in metamorphosis due to less amount of iodine in water.
- The most complex amino acid having double rings structure is tryptophan.
- The intestinal bacteria are able to synthesize both essential amino acids and vitamins in ruminants.
- Whiptail disease is caused due to the deficiency of molybdenum.

Ordinary Thinking

Objective Questions

Digestive System

1. In mammals the lower jaw is made up of **[MP PMT 1998; BVP 2001]**
(a) Dentary (b) Maxilla
(c) Premaxilla (d) Palatine

2. Dental formula of rabbit is **[CPMT 1994, 98, 2010; Bihar CECE 1995]**
(a) $\frac{1023}{1023}$ (b) $\frac{3023}{3023}$
(c) $\frac{1023}{2023}$ (d) $\frac{2103}{2304}$
(e) $\frac{2033}{1023}$

3. Which one has a developed canine **[MP PMT 1995]**
(a) Polar bear (b) Walrus
(c) Male elephant (d) Rhinoceros

4. The hardest substance of vertebrate body is **[NCERT; MP PMT 1995; RPMT 2006]**

Or

Crown of teeth is covered by **[AFMC 2005; MP PMT 2013]**
(a) Keratin (b) Enamel
(c) Dentine (d) Chondrin

5. On the tongue of rabbit which type of papillae are present but absent in human
(a) Circumvallate (b) Circumvallate and foliate
(c) Foliate (d) Fungiform

6. The layer lining the lumen of the human alimentary canal is **[Kerala PMT 2012]**
(a) Serosa (b) Sub-mucosa
(c) Muscularis (d) Pleura
(e) Mucosa

7. The back flow of faecal matter in the large intestine is prevented by the presence of **[NCERT; Kerala PMT 2011]**
(a) Epiglottis
(b) Sphincter of Oddi
(c) Ileo-Caecal valve
(d) Gastro-oesophagal sphincter
(e) Pyloric sphincter

8. In mammals the teeth are
(i) Of different types
(ii) Embedded in the cup-like socket of the jaw bones
(iii) Only two sets, present throughout life
These conditions are referred as **[Kerala PMT 2007, 09; Odisha JEE 2009]**

Or

Teeth of rabbits are **[CPMT 2004]**
(a) Heterodont, thecodont and diphyodont
(b) Thecodont, heterodont and diphyodont
(c) Diphyodont, thecodont and heterodont
(d) Heterodont, diphyodont and thecodont
(e) Thecodont, diphyodont and heterodont

9. It is a correct dental formula for the child falling under age group 5-6 yrs. **[GUJCET 2007, 09]**
(a) *I2/2, C1/1, P M2/2, M0/0* (b) *I2/2, C1/1, P M2/2, M3/3*
(c) *I1/1, C2/2, P M2/2, M3/3* (d) *I2/2, C2/2, P M1/1, M3/3*

10. The mucosal layer in the stomach form irregular folds known as **[NCERT; Kerala PMT 2011]**
(a) Villi (b) Lumen
(c) Rugae (d) Crypts of Lieberkuhn
(e) Lacteals

11. A pair of small lymphatic tissue present at the sides of root tongue is called as **[CBSE PMT 1993]**
(a) Thyroid (b) Tonsils
(c) Epiglottis (d) Adenoids

12. Vomerine teeth are present in
(a) Man (b) Reptiles
(c) Frogs (d) Rabbits

13. The function of tongue is to **[CBSE PMT 1993]**
(a) Help in the act of swallowing
(b) Help in mixing saliva with the food
(c) Help in speaking
(d) All the above

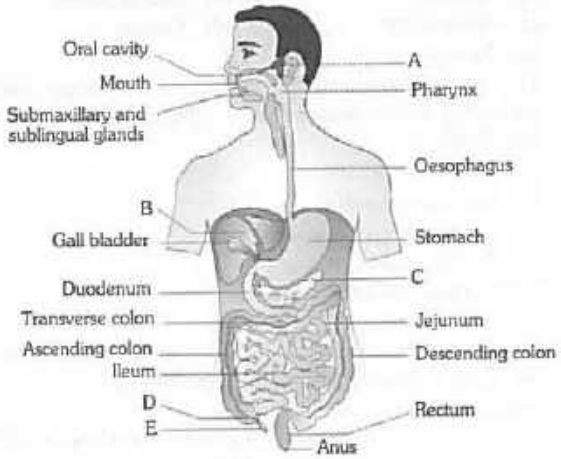
14. The primary dentition in human differs from permanent dentition is not having one of the following type of teeth **[AIPMT 2015]**

Or

A baby boy aged two years is admitted to play school and passes through a dental check-up. The dentist observed that boy had twenty teeth. Which teeth were absent **[NEET 2017]**
(a) Premolars (b) Molars
(c) Incisors (d) Canine

15. Taste buds for bitter taste are found on tongue at
(a) Tip (b) On basal surface
(c) Posterior part (d) Lateral sides

16. The given figure shows the human digestive system. Identify A, B, C, D and E respectively **[NCERT]**



(a) A - Parotid gland, B - Liver, C - Caecum, D - Pancreas, E - Vermiform appendix
(b) A - Parotid gland, B - Caecum, C - Pancreas, D - Liver, E - Vermiform appendix
(c) A - Parotid gland, B - Pancreas, C - Liver, D - Caecum, E - Vermiform appendix
(d) A - Parotid gland, B - Liver, C - Pancreas, D - Caecum, E - Vermiform appendix

17. Two friends are eating together on a dining table. One of them suddenly starts coughing while swallowing some food. This coughing would have been due to improper movement of **[NCERT; CBSE PMT (Pre.) 2011]**
(a) Tongue (b) Epiglottis
(c) Diaphragm (d) Neck

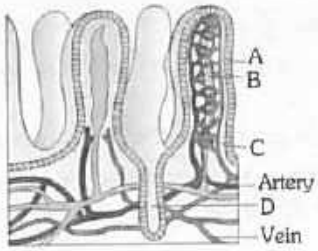
18. If for some reason our goblet cells are non-functional, this will adversely affect **[CBSE PMT (Pre.) 2010]**
(a) Smooth movement of food down the intestine
(b) Production of somatostatin
(c) Secretion of sebum from the sebaceous glands
(d) Maturation of sperms

19. In mammals, the digestion of starch starts from **[NCERT; CPMT 1995; BHU 2001; MHCET 2003; BCECE 2006]**
(a) Mouth (b) Stomach
(c) Oesophagus (d) Duodenum

20. If the dental formula of Rabbit is 2033/1023. What does it show **[CPMT 1993; Manipal 1995; RPMT 2001]**
(a) Total number of teeth in Rabbit is 15
(b) Number of total incisors in Rabbit is 3
(c) Diastema is present between incisors & premolars
(d) In the formula 2033 is for adult and 1023 is for young ones

21. Which of the following teeth are lophodont **[CPMT 1998; AIIMS 2002]**
(a) Incisor and canine (b) Premolar and molar
(c) Canine and premolar (d) Premolar and incisor

22. The given figure shows a section of small intestinal mucosa showing villi. Identify A to D **[NCERT]**



(a) A - Crypts, B - Lacteal, C - Capillaries, D - Villi
(b) A - Villi, B - Lacteal, C - Crypts, D - Capillaries
(c) A - Lacteal, B - Villi, C - Capillaries, D - Crypts
(d) A - Villi, B - Lacteal, C - Capillaries, D – Crypts

23. Tusk of an elephant is an enormously enlarged **[AFMC 2000; HP PMT 2005; Odisha JEE 2010]**
(a) Upper canine (b) Lower incisor
(c) Upper incisor (d) Lower canine

24. The type of muscle fibre present in the wall of alimentary canal is **[Odisha JEE 2010]**
(a) Smooth muscle fibre (b) Striped muscle fibre
(c) Cardiac muscle fibre (d) Both (a) and (b)

25. Which of the following is vestigial teeth found in human **[Pb. PMT 2000]**
(a) Incisors (b) Premolars
(c) Diphyodont (d) Wisdom tooth

26. Teeth in frog are **[BHU 2002]**
(a) Acrodont (b) Homodont
(c) Polyphyodont (d) All of these

27. Pulp cavity of teeth is lined by **[RPMT 2000, 06; CPMT 2002]**
(a) Odontoblast (b) Chondroblast
(c) Osteoblast (d) Amyloblast

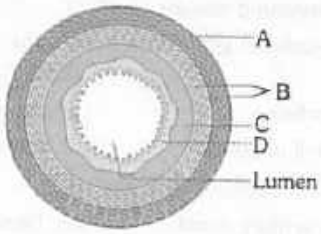
28. Lacteals are central lymph vessels which are found in **[NCERT; CPMT 1996]**
(a) Liver (b) Pancreas
(c) Villi (d) Spleen

29. In the wall of alimentary canal which are/ is true sequence from outer to inner **[NCERT; BHU 2003]**
(a) Serosa, longitudinal muscle, mucosa, sub mucosa
(b) Mucosa, serosa, long muscle
(c) Serosa, long muscle, circular, sub-mucosa, mucosa
(d) Serosa, long muscle, sub-mucosa, mucosa

30. Dental formula of human being is **[NCERT; Manipal 1995; MP PMT 2001, 03, 11; Odisha JEE 2004; BCECE 2005; DPMT 2006]**
(a) I_2, C_2, P_1, M_3 (b) I_2, C_1, P_2, M_3
(c) I_3, C_1, P_2, M_2 (d) I_2, C_2, P_3, M_1

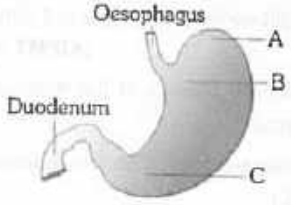
31. Some of the animals eat their feaces to digest the cellulose contents again, such animals are known as **[DPMT 2003; Odisha JEE 2004]**
(a) Sanguivorous (b) Frugivorous
(c) Coprophagous (d) Deteritivorous

32. The given diagram indicates the TS of Gut. Identify A , B, C and D **[NCERT]**



(a) A - Serosa; B - Submucosa; C - Muscularis; D - Mucosa
(b) A - Serosa; B - Muscularis; C - Mucosa; D - Submucosa
(c) A - Muscularis; B - Serosa; C - Submucosa; D - Mucosa
(d) A - Serosa; B - Muscularis; C - Submucosa; D - Mucosa

33. The given diagram represent anatomical regions of human stomach. Identify A, B and C **[NCERT]**



(a) A - Pyloric; B - Fundus; C - Cardiac
(b) A - Fundus; B - Cardiac; C - Pyloric
(c) A - Cardiac; B - Fundus; C - Pyloric
(d) A - Fundus; B - Pyloric; C - Cardiac

34. The muscular contraction in the alimentary canal is known as **[NCERT; MP PMT 1994; RPMT 1999]**
(a) Systole (b) Diastole
(c) Peristalsis (d) Metachronal

35. Fundic part of stomach is
(a) Present in rabbit but absent in frog
(b) Absent in rabbit but present in frog
(c) Absent in both rabbit and frog
(d) Present in both rabbit and frog

36. *HCl* is secreted by **[NCERT; MP PMT 1999, 2009; AFMC 2005; DPMT 2006; WB JEE 2010; Odisha JEE 2011; PET (Pharmacy) 2013]**
(a) Zymogen cells (b) Oxyntic cells
(c) Kupffer cells (d) Mucous cells

37. "Chief cells" or "Zymogen cells" secrete the enzymes of the gastric juice, are found in the **[CBSE PMT 1992]**
(a) Isthmus of the gland
(b) Neck of the tubular gland
(c) Base of the tubular region
(d) All the above

38. Inner lining of gut, stomach and liver is composed of **[AFMC 1997]**
(a) Simple squamous epithelium
(b) Simple columnar epithelium
(c) Simple cuboidal epithelium
(d) Compound epithelium

39. The mucosal lining of the oesophagus of mammals is made up of **[MP PMT 1997]**
(a) Simple columnar epithelium
(b) Squamous epithelium
(c) Stratified cuboidal epithelium
(d) Stratified columnar epithelium

40. Submucosa is thickest in **[MP PMT 1998]**
(a) Stomach (b) Oesophagus
(c) Intestine (d) Rectum

41. Which one of the following is the correct pairing of the site of action and the substrate of rennin **[CBSE PMT 1994]**
(a) Stomach–Casein
(b) Stomach–Fat
(c) Small intestine–Protein
(d) Mouth–Starch

42. The site of protein digestion is **[NCERT; KCET 1994; MP PMT 2012]**

Or

A rabbit eats a lot of gram. Then its digestion starts in **[RPMT 2001]**
(a) Gullet (b) Stomach
(c) Small intestine (d) Oral cavity

43. The stomach of ruminants is mainly divided into four parts, but in camel which one part is missing
(a) Abomasum (b) Omasum
(c) Recticulum (d) Rumen

44. Match column I with column II and choose the correct option

Column I		Column II	
A.	Goblet cells	1.	Antibacterial agent
B.	Lysozyme	2.	Mucus
C.	Saliva	3.	HCl
D.	Oxyntic cells	4.	Sublingual gland

[NCERT; MP PMT 2000; Kerala PMT 2010]

(a) A-3, B-1, C-4, D-2 (b) A-1, B-3, C-4, D-2
(c) A-2, B-3, C-1, D-4 (d) A-4, B-1, C-2, D-3
(e) A-2, B-1, C-4, D-3

45. During chain elongation peptide bond is formed between carboxyl group of 1st amino acid and amino group of 2nd amino acid by **[Odisha JEE 2010]**

(a) Aminoacyl transferase (b) Aminoacyl synthetase
(c) Peptidyl transferase (d) Chloramphenicol

46. Peyer's patches contain **[MP PMT 1996; Pb. PMT 2004]**

(a) Mucus (b) Sebum
(c) Lymphocytes (d) Red blood cells

47. Narrower distal end of stomach is called **[NCERT; MP PMT 1994, 95]**

(a) Cardiac (b) Duodenum
(c) Pharynx (d) Pylorus

48. Aggreagates of lymphoid tissue present in the distal portion of the small intestine are known as **[DUMET 2010]**

(a) Villi (b) Peyer's patches
(c) Rugae (d) Choroid plexus

49. Wisdom teeths are **[AFMC 2005]**

(a) Last molars (b) Last premolars
(c) Incisors (d) Canines

50. Peyer's patches are found on the ileum in **[CBSE PMT 1993]**

(a) Fishes (b) Reptiles
(c) Birds (d) Mammals

51. Water is largely absorbed in **[NCERT; CPMT 1999, 2005]**

(a) Stomach (b) Oesophagus
(c) Small intestine (d) Colon (Large Intestine)

52. Crypts of Lieberkuhn are found in between the villi. They secrete **[MP PMT 2003, 06]**

(a) Glucagon (b) Succus entericus
(c) Insulin (d) None

53. Both the crown and root of a tooth is covered by a layer of bony hard substance called **[J & K CET 2005]**

(a) Enamel (b) Dentine
(c) Bony socket (d) Cementum

54. Which of the following nerves innervates alimentary canal **[Odisha JEE 2010]**

(a) Oculomotor (b) Abducens
(c) Trigeminal (d) Vagus

55. Goblet cells are **[NCERT; MP PMT 2012]**

(a) Unicellular mucous gland
(b) Multicellular mucous gland of stomach
(c) Tubula–veolar gland
(d) All of the above

56. Which of the following is correct regarding diastema **[Odisha JEE 2010]**

(a) Gap between bones
(b) Gap between the teeth/Absence of certain teeth
(c) Gap between nerves
(d) Gap between cells

57. Brunner's gland are found in which of the following layers **[NCERT; CBSE PMT 1992, 99; CPMT 1993, 99; MP PMT 1998, 2001, 03; AFMC 2003, 08, 10; BHU 2012; WB JEE 2012, 16]**

(a) Submucosa of stomach
(b) Mucosa of ileum
(c) Submucosa of duodenum (intestine)
(d) Mucosa of oesophagus

58. Pepsinogen is secreted by **[NCERT; CPMT 1993; MP PMT 2003; DPMT 2007]**

(a) Chief cells (b) Parietal cells
(c) Gastric glands (d) Intestinal cells

59. Intestinal villi are mainly concerned with **[MP PMT 1994; MHCET 2001]**

Or

The process by which digested food of the alimentary canal passes through its mucous membrane into circulatory system is called as **[AIIMS 1992]**

(a) Assimilation (b) Secretion
(c) Ultrafilteration (d) Absorption

60. Crypt of Lieberkuhn is example for **[Kerala CET 2003]**

(a) Simple tubular gland
(b) Coiled tubular gland
(c) Compound alveolar gland
(d) Compound tubular gland

61. Brush bordered epithelium is found in **[CPMT 1999; JIPMER 2001]**

(a) Trachea (b) Stomach
(c) Small intestine (d) Fallopian tube

62. Vermiform appendix is a part of **[MP PMT 1994, 95]**

(a) Alimentary canal (b) Nervous system
(c) Vascular system (d) Reproductive system

Digestive glands

1. How many kinds of cells are found in islet of Langerhans **[MP PMT 1997]**

(a) 1 (b) 2
(c) 3 (d) 4

2. Which of the following statement is not correct **[AIPMT (Cancelled) 2015]**

(a) Goblet cells are present in the mucosa of intestine and secrete mucus
(b) Oxyntic cells are present in the mucosa of stomach and secrete HCl
(c) Acini are present in the pancreas and secrete carboxypeptidase
(d) Brunner's glands are present in the submucosa of stomach and secrete pepsinogen

3. Fat digestion is facilitated by [CPMT 1998]
(a) Bile juice (b) Pancreatic juice
(c) Gastric juice (d) None of these

4. The predominant antibody in saliva is [DUMET 2010]
(a) *IgG* (b) *IgA*
(c) *IgM* (d) *IgD*

5. In man, Glisson's capsule is associated with the [Kerala PMT 2012]
(a) Digestive system (b) Excretory system
(c) Nervous system (d) Reproductive system
(e) Endocrine system

6. Parotid salivary gland are present [NCERT; MP PMT 1993]
(a) Below the tongue
(b) Below the ear
(c) Below the eye orbit
(d) In the angle between two jaws

7. Pissiform cells loaded with zymogen granules can be seen in [MP PMT 1993]
(a) Liver (b) Pancreas
(c) Ovary (d) Kidney

8. Pancreatic juice contains [NCERT]
(a) Trypsin, lipase and maltase
(b) Pepsin, trypsin and maltase
(c) Trypsin, chymotrypsin, amylase and lipase
(d) Trypsin, pepsin and amylase

9. Gastric juice of infants contains [AIPMT (Cancelled) 2015]
(a) Nuclease, pepsinogen, lipase
(b) Pepsinogen, lipase, rennin
(c) Amylase, rennin, pepsinogen
(d) Maltase, pepsinogen, rennin

10. Ptyalin is [AFMC 1996]
(a) Strongly acidic (b) Slightly acidic
(c) Slightly neutral (d) Strongly alkaline

11. Liver in our body stores [AIIMS 1999]
(a) Vitamin A (b) Vitamin D
(c) Vitamin B_{12} (d) All of these

12. Argentaffin cells are found in [NCERT; BHU 1999; AMU (Med.) 2012]
(a) Pancreas (b) Internal ear
(c) Gastric glands (d) Liver

13. *pH* of gastric juice is [Odisha JEE 2008; MP PMT 2010]
(a) 2 (b) 4
(c) 6 (d) 8

14. Which of the following guards the opening of hepatopancreatic duct into the duodenum [NEET (Phase-I) 2016]
(a) Semilunar valve (b) Ileocaecal valve
(c) Pyloric sphincter (d) Sphincter of Oddi

15. In pancreas, pancreatic juice and hormones are secreted by [CBSE PMT 1990]
(a) Same cells
(b) Different cells
(c) Same cells at different times
(d) None of these

16. The *pH* of amylase present in saliva is [NCERT; CPMT 1996]
(a) 6 (b) 6.8
(c) 7.2 (d) 8

17. Characteristic of mammalian liver is [AFMC 2006]
(a) Kupffer's cells and leucocytes
(b) Leucocytes and canaliculae
(c) Glisson's capsules and Kupffer cells
(d) Glisson's capsules and leucocytes

18. The *pH* of succus entericus is [MP PMT 1996]
Or
In intenstine, *pH* value is
(a) 7.6 (b) 6.6
(c) 5.6 (d) 2.0

19. Succus entericus is the name given to [NCERT]
(a) Junction between ileum and large intestine
(b) Intestinal juice
(c) Swelling in the gut
(d) Appendix

20. Liver of rabbit is made up of
(a) 4 lobes (b) 6 lobes
(c) 5 lobes (d) 7 lobes

21. Which of the following statements is correct [CPMT 2010]
(a) Argentaffin cells produce serotonin
(b) Villikinin is secreted by large intestine
(c) In cheilosis, deficiency nutrient is nicotinamide
(d) Bleeding diseases occur due to deficiency of vitamin E

22. Which of the following is the symptom of Ulcerative colitis [GUJCET 2015]
(a) Watery stools containing blood and mucus
(b) Difficulty in swallowing
(c) Loss of appetite
(d) Eyes turn yellow

23. Which one of the following is not the reason for very high load of bilirubin in a newborn [KCET 2010]
(a) Excessive red blood corpuscles in the newborn burst, releasing the bilirubin
(b) The liver of the newborn is too young to cope up with the heavy load of bilirubin
(c) Mother's milk contain a high amount of bilirubin
(d) Insoluble bilirubin in the intestine is reabsorbed by the blood

24. Saliva is secreted from [NCERT; MP PMT 1998]
(a) Submaxillary and sublingual glands
(b) Gastric gland
(c) Pancreas
(d) Gall bladder

25. The number of salivary glands in man is [NCERT]
(a) Two pairs (b) Three pairs
(c) Four pairs (d) Five pairs

26. Ptyalin is an enzyme of **[CMC Vellore 1992; MP PMT 1994, 99; CPMT 2003; MH CET 2004; Odisha JEE 2011]**

(a) Salivary juice (b) Pancreatic juice
(c) Intestinal juice (d) None of these

27. The enzymes responsible for the digestion of starch in food of man is present in

(a) The salivary and gastric secretions
(b) The salivary and pancreatic secretions
(c) The gastric and pancreatic secretions
(d) The gastric and duodenal secretions

28. A lubricant, mucin in saliva is made up of **[Pb. PMT 2004]**

(a) Glycoprotein (b) Polysaccharides
(c) Phospholipids (d) Myosin

29. The toxic substance are detoxicated in the human body by **[AIIMS 2001]**

(a) Lungs (b) Kidneys
(c) Liver (d) Stomach

30. The trypsin enzyme is secreted by **[AFMC 2003]**

(a) Stomach (b) Duodenum
(c) Pancreas (d) Liver

31. Bilirubin and billverdin are found in **[NCERT; MP PMT 2001]**

(a) Blood (b) Bile
(c) Pancreatic juice (d) Saliva

32. Match the names of glands listed under column-I with the location given under column-II, choose the answer which gives correct combination of the alphabets of the two columns

Column-I (glands)		Column –II (location)	
A.	Crypts of Lieberkuhn	p.	Loop of duodenum
B.	Pancreas	q.	Stomach
C.	Adrenal gland	r.	Intestine
D.	Gastric gland	s.	Kidney

[KCET 2001; Kerala PMT 2008]

(a) A = r, B = p, C = q, D = s
(b) A = r, B = p, C = s, D = q
(c) A = q, B = s, C = r, D = p
(d) A = p, B = r, C = s, D = q

33. The bile secreted by the liver cells passes into the gall bladder through **[NCERT; DPMT 1993]**

(a) Hepato–pancreatic duct (b) Cystic duct
(c) Hepatic duct (d) Hepato–gall duct

34. Which of the following is not a human salivary gland **[NCERT; AIIMS 1993]**

(a) Parotid (b) Submaxillary
(c) Sublingual (d) Infra-orbital

35. Which is correct about the bile of rabbit **[NCERT; RPMT 2002]**

(a) It is synthesized by gall bladder & also stored there
(b) It is an enzyme which emulsify the fats
(c) It contain bile salts & bile pigments
(d) Bilirubin present in it decomposed fats

36. Which of the following digestive juices have the minimum *pH* **[AIIMS 2002]**

(a) Bile (b) Saliva
(c) Gastric juice (d) Pancreatic juice

37. In which of the following, putrefying bacteria is present **[BHU 2006]**

(a) Intestine (b) Colon
(c) Stomach (d) Liver

38. The glucose is converted into glycogen in liver and stored in **[MP PMT 1994, 95; CPMT 1995]**

(a) Liver (b) Liver and muscles
(c) Liver and spleen (d) Spleen and muscles

39. Gastric juice contains **[NCERT; CPMT 1993; Kerala PMT 2010; MP PMT 2011]**

(a) Pepsin, rennin, lipase (b) Pepsin, amylase, rennin
(c) Pepsin, amylase, trypsin (d) Lipase, rennin, trypsin

40. Enzyme arginase is found in **[CPMT 1994]**

(a) Mouth cavity (b) Stomach
(c) Intestine (d) Liver

41. A your infant may be feeding entirely on mother's milk which is white in colour but the stools which the infant passes out is quite yellowish. What is this yellow colour due to **[CBSE PMT 2009]**

(a) Intestinal juice
(b) Bile pigments passed through bile
(c) Undigested milk protein casein
(d) Pancreatic juice poured into duodenum

42. Kupffer cells of liver are **[JIPMER 2001; MP PMT 2001, 02; BVP 2002; CPMT 2003; BHU 2008; WB JEE 2011]**

(a) Loose connective tissue (b) Phagocytic cell
(c) Mast cell (d) Fat cell

43. Bile secretion is proportional to the concentration of **[MP PMT 2007]**

(a) Protein (b) Fat
(c) Carbohydrate (d) None of these

44. The special feature of bile juice is that it **[NCERT; Odisha JEE 2011]**

(a) Has no enzyme (b) Has amylase
(c) Contains lipase (d) Contains H_2O

45. Cells of the liver manufacture **[DPMT 1993]**

(a) Diastase (b) Amylase
(c) Lipase (d) Insulin

46. Succus entericus is secreted by **[KCET 2007, 10]**

(a) Islets of Langerhans
(b) Gastric gland
(c) Uterine crypt and endometrium
(d) Crypts of Leiberkuhn and Brunner's gland

47. In which of the following proteins are absent **[MP PMT 2000]**

(a) Pancreatic juice (b) Saliva
(c) Bile (d) Intestinal juice

48. Which word best describes the action of bile on fats **[CBSE PMT 1993; BHU 2003; DUMET 2010; Odisha JEE 2010]**

(a) Neutralises (b) Digests
(c) Emulsifies (d) Absorbs
(e) Dissolves

49. pH of the pancreatic juice is about
(a) 6.4 (b) 8.4
(c) 12.0 (d) 7.0

50. One of the following is specific function of the liver. Mark it **[WB JEE 2008]**

(a) Excretion (b) Glycogenolysis
(c) Digestion (d) Histolysis

51. Surgical removal of gall bladder in human beings would lead to **[AIIMS 1992; CBSE PMT 1992]**

(a) Impairment of the digestion of fat
(b) Increased acidity in the intestine
(c) Jaundice
(d) None of the above

52. Which one of the following does not produce any digestive enzyme **[NCERT; DPMT 1992]**

(a) Intestinal mucosa (b) Gastric mucosa
(c) Pancreas (d) Liver

53. Kupffer cells are found in **[CPMT 1999, 2003; Bihar MDAT 1995; JIPMER 2000, 01; MP PMT 2000, 01, 02; BHU 2006; WB JEE 2016]**

(a) Mouth (b) Liver
(c) Kidney (d) Stomach

54. Which one of the following pairs of the kind of cells and their secretion of correctly matched **[AIIMS 2008]**

(a) Oxyntic cells – A secretion with *pH* between 2.0 and 3.0
(b) Alpha cells of islets of Langerhans – Secretion that decreases blood sugar level
(c) Kupffer cells – A digestive enzyme that hydrolyses nucleic acids
(d) Sebaceous glands – A secretion that evaporates for cooling

55. Liver is called the reticular gland because **[DPMT 1993]**

(a) The shape is reticular
(b) It contains reticular tissue
(c) Lobules branches and anastomose with one another to form a network
(d) Hepatic duct and cystic duct unite to form the bile duct

56. Enterokinase and lactase are found in **[CPMT 2000; MP PMT 2000]**

(a) Saliva (b) Bile
(c) Pancreatic juice (d) Intestinal juice

57. The largest gland in the human body is **[NCERT; KCET 2000; CPMT 2000; BVP 2002; BHU 2006]**

(a) Liver (b) Brain
(c) Pancreas (d) Thyroid

58. Cholesterol is synthesised in **[MP PMT 1993, 2000]**

(a) Pancreas (b) Brunrer's gland
(c) Spleen (d) Liver

59. Match the types of cells listed under column I with the secretions given under column II. Choose the answer which gives the correct combination of the alphabets of the two columns

Column I (Types of cells)		Column II (Secretions)	
A.	Beta cells	p.	Lysozyme
B.	Mast cells	q.	Histamine
C.	Paneth cells	r.	Insulin
D.	Acinar cells	s.	Pancreatic enzymes

[KCET 2004]

(a) A = r; B = s; C = p; D = q (b) A = s; B = q; C = p; D = r
(c) A = r; B = q; C = p; D = s (d) A = q; B = r; C = p; D = s

60. Caudate is the part of

(a) Left lobe of liver (b) Right lobe of liver
(c) Spigelian lobe of liver (d) All of the above

61. Amount of saliva secreted daily in humans is **[NCERT; Odisha JEE 2004; AMU (Med.) 2012]**

(a) 250 *ml.* (b) 500 *ml.*
(c) 100 *ml.* (d) 1000 *ml.*

62. Lysozymes are found in **[MP PMT 2004; Odisha JEE 2010]**

(a) Saliva (b) Tears
(c) Saliva and tears both (d) Mitochondria

63. The amount of gastric juice secreted per day from man's stomach is about **[MP PMT 2003]**

(a) 5000 *ml* to 10000 *ml* (b) 2000 *ml* to 3000 *ml*
(c) 100 *ml* to 500 *ml* (d) 10 *ml* to 15 *ml*

64. Which cells of 'Crypts of Lieberkuhn' secrete antibacterial lysozyme **[NEET 2017]**

(a) Argentaffin cells (b) Paneth cells
(c) Zymogen cells (d) Kupffer cells

Physiology of digestion

1. Fructose is absorbed into the blood through mucosa cells of intestine by the process called **[NCERT; CBSE PMT 2014]**

(a) Simple diffusion (b) Co-transport mechanism
(c) Active transport (d) Facilitated transport

2. Which one of the following pairs of food components in humans reaches the stomach totally undigested **[CBSE PMT 2009]**

(a) Protein and starch (b) Fat and starch
(c) Fat and cellulose (d) Starch and cellulose

3. In vertebrates, lacteals are found in **[CBSE PMT 1998]**

(a) Ileum (b) Ischium
(c) Oesophagus (d) Ear

4. If pancreas is removed, the compound which remain undigested is **[CBSE PMT 1997]**

(a) Carbohydrates (b) Fats
(c) Proteins (d) All of these

5. Chylomicrons are **[NCERT; CPMT 1999]**

(a) Undigested proteins
(b) Undigested carbohydrates
(c) Fat droplets coated with glycerol and protein
(d) Fat droplets coated with phospholipids

6. Which enzymes are likely to act on the baked potatoes eaten by a man, starting from the mouth and as it moves down the alimentary canal **[NEET (Kamataka) 2013]**

(a) Pancreatic amylase → salivary amylase → lipases
(b) Disaccharidase like maltase → lipases → nucleases
(c) Salivary amylase → pancreatic amylase → disaccharidases
(d) Salivary maltase → carboxy peptidase → trypsinogen

7. Trypsin is a digestive enzyme which occurs in mammals and digests **[CPMT 1992, 93; MP PMT 1995]**

(a) Starch in buccal cavity in an alkaline medium
(b) Protein in stomach in an acidic medium
(c) Protein in duodenum in an acidic medium
(d) Protein in duodenum in an alkaline medium

8. The major site of protein breakdown to form free amino acids, is in the **[WB JEE 2009]**

(a) Kidney (b) Spleen
(c) Liver (d) Bone-marrow

9. The first phase in the breakdown of glucose in animal cell is **[CBSE PMT 1994]**

(a) Glycolysis (b) Electron transport system
(c) Fermentation (d) Kreb's cycle

10. Digestion of both starch and protein is done by **[NCERT; AFMC 1996]**

(a) Gastric juice (b) Gastric lipase
(c) Pancreatic juice (d) Ptylin

11. The end product of carbohydrate metabolism is **[AFMC 1993]**

(a) CO_2 and H_2O (b) NH_3 and CO_2
(c) NH_3 and H_2O (d) CO_2

12. Which one of the following statements about glycogen is correct **[CBSE PMT 1995]**

(a) It is a disaccharide stored in liver which can react with ammonia to form proteins
(b) It is synthesised in the liver and takes part in the formation of bile and lipase, besides being a source of energy
(c) It is a polysaccharide which is synthesised and stored in liver cells
(d) It is synthesised in blood and stored in liver and muscles to provide glucose in times of need

13. Which one of the following statements is true regarding digestion and absorption of food in humans **[CBSE PMT 2009]**

(a) Oxyntic cells in our stomach secrete the proenzyme pepsinogen
(b) Fructose and amino acids are absorded through intestinal mucosa with the help of carrier ions like Na^+
(c) Chylomicrons are small lipoprotein particles that are transported from intestine into blood capillaries
(d) About 60% of starch is hydrolysed by salivary amylase in our mouth

14. Fats and lipids are absorbed in **[AFMC 2008]**

(a) Lymph capillaries (b) Blood capillaries
(c) Hepatic portal vein (d) None of these

15. One of the following movements in our body is not completely involuntary. Identify it **[KCET 2012]**

(a) Deglutition (b) Peristalsis
(c) Systole of the ventricles (d) Dilation of pupil of the eye

16. In the gastrointestinal tract the Meissner's plexus and the Auerbach's plexus occur respectively in the **[NCERT; AMU (Med.) 2012]**

(a) Lamina propria and muscularis mucosa
(b) Submucosa and muscularis externa
(c) Submucosa and mucosa
(d) Mucosa and muscularis externa

17. Emulsified fat is digested by **[AFMC 1996]**

Or

Bile salts act as activator of which enzyme **[WB JEE 2010]**

(a) Lipase (b) Lipase and hydrolase
(c) Bile salts (d) Bile pigments

18. Lacteals are found in **[NCERT; MP PMT 1999; KCET 2004]**

(a) Liver (b) Lungs
(c) Kidney (d) Villus of intestine

19. Which one of the following is the correct matching of the site of action on the given substrate, the enzyme acting upon it and the end product **[NCERT; CBSE PMT 2008]**

(a) Small intestine : ⟶ Proteins Pepsin Amino acids
(b) Stomach : ⟶ Fats Lipase micelles
(c) Duodenum : ⟶ Triglycerides Trypsin monoglycerides
(d) Small intestine : ⟶ Starch ∝ Amylase Disaccharide (Maltose)

20. If for some reason the parietal cells of the gut epithelium become partially non-functional, what is likely to happen **[NCERT; CBSE PMT (Mains) 2010]**

(a) The pancreatic enzymes and specially the trypsin and lipase will not work efficiently
(b) The pH of stomach will fall abruptly
(c) Steapsin will be more effective
(d) Proteins will not be adequately hydrolysed by pepsin into proteoses and peptones

21. Which of the following is secreted by pancreas **[Odisha JEE 2012]**

(a) Dipeptidases (b) Amylase
(c) α – Dextrins (d) Pepsin

22. Most digestion and absorption of food takes place in **[NCERT; Odisha JEE 2009]**

(a) Stomach (b) Small intestine
(c) Large intestine (d) Caecum

23. Essentially the word 'digestion' means **[NCERT; CPMT 2005]**

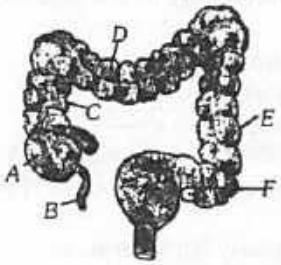
(a) Burning of food (b) Oxidation of food
(c) Hydrolysis of food (d) Breakdown of food

24. Emulsification of fats is brought about by **[NCERT; CBSE PMT 1990; Manipal 2005]**
(a) Bile pigments (b) Bile salts
(c) Pancreatic juice (d) *HCl*

25. Sacculus rotundus is present in **[CPMT 2010]**
(a) Duodenum of rabbit (b) Ileum of frog
(c) Ileum of rabbit (d) Colon of rabbit

26. Which one of the following will not take place when glucose is taken as food **[J & K CET 2002]**
(a) Ingestion (b) Digestion
(c) Absorption (d) Assimilation

27. The diagram of large intestine of man is given below. Identify the parts labelled A, B, C, D, E and F **[KCET 2010]**



	A	B	C	D	E	F
(a)	Sigmoid	Vermiform appendix	Ascending colon	Transverse colon	Descending colon	Caecum
(b)	Caecum	Vermiform appendix	Sigmoid	Ascending colon	Transverse colon	Descending colon
(c)	Caecum	Vermiform appendix	Ascending colon	Transverse colon	Descending colon	Sigmoid
(d)	Sigmoid	Vermiform appendix	Descending colon	Transverse colon	Ascending colon	Caecum

28. Some proteolytic enzymes are **[NCERT; Odisha JEE 2010]**
(a) Trypsin, Erepsin, pepsin
(b) Amylopsin, steapsin, ptyalin
(c) Amylase, lipase, zymase
(d) Urease, zymase, dehydrogenase

29. Choose the wrong statement **[Kerala PMT 2012]**
(a) Lipases and nucleases are not present in pancreatic juice
(b) Goblet cells secrete mucus
(c) Brunner's glands are sub-mucosal glands
(d) Carboxypeptidase catalyses conversion of proteins, peptones and proteoses to dipeptides
(e) Bile contains no enzymes

30. Rennin acts on milk proteins and converts **[JIPMER 2002]**
(a) Caseinogen into casein
(b) Casein into paracasein
(c) Caseinogen into paracasein
(d) Paracasein into caseinogen

31. Lacteals are associated with **[DPMT 1993; MP PMT 2013]**
(a) Secretion of lactic acid
(b) Absorption of long chain fatty acids
(c) Absorption of short chain fatty acids
(d) Production of lymph

32. In gluconeogenesis **[Pb. PMT 2000; DPMT 2003]**
(a) Glucose is polymerized into glycogen
(b) Glycogen is broken into glucose
(c) Carbohydrates are synthesized from amino acids/lipids
(d) Glucose is broken into pyruvic acid

33. Carrier ions like Na^+ facilitate the absorption of substances like **[CBSE PMT (Pre.) 2010]**
(a) Fructose and some amino acids
(b) Amino acids and glucose
(c) Glucose and fatty acids
(d) Fatty acids and glycerol

34. The *pH* of the digestive juices within the human small intestine is between 7.5 and 8.5. This environment is slightly **[AIIMS 2009]**
(a) Basic (b) Acidic
(c) Neutral (d) None of these

35. Trypsin differs from pepsin in that **[NCERT]**
(a) It digest protein in alkaline medium while pepsin does so in acidic medium
(b) It digest protein in acidic medium while pepsin does so in alkaline medium
(c) Both (a) and (b)
(d) None of these

36. Digestion of starch takes place in **[NCERT; Kerala CET 2003]**
(a) Stomach and duodenum
(b) Buccal cavity and duodenum
(c) Buccal cavity and oesophagus
(d) Duodenum only

37. Ptyalin is inactivated by a component of gastric juice known as **[WB JEE 2011]**
(a) Pepsin (b) Mucus
(c) Rennin (d) *HCl*

38. Function of *HCl* in stomach is to **[MP PMT 1994; CPMT 1995; Odisha JEE 2012]**
(a) Kill micro-organisms of food
(b) Facilitate absorption of food
(c) Dissolve enzymes
(d) Activate pepsinogen to pepsin

39. Lipids, which can be found in oil based salad dressings and ice cream, during digestion are splitted into **[NCERT; AIIMS 2009]**

Or

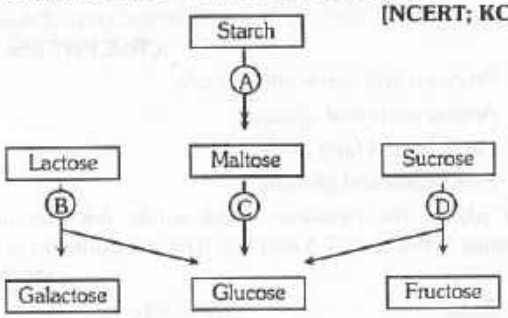
The main function of Lacteals in the human small intestine is the absorption of **[KCET 2006]**
(a) Fatty acids and glycerol (b) Glycerol and amino acids
(c) Glucose and fatty acids (d) Glucose and amino acids

40. In horses, rabbits, hares, the cellulose gets digested in the **[CPMT 1994, 95, 2010; MP PMT 2000; AFMC 2005; RPMT 2006]**
(a) Caecum (b) Stomach
(c) Appendix (d) Rumen

41. Part of the stomach which opens into the duodenum **[NCERT; BHU 2008; Odisha JEE 2010]**
(a) Cardiac (b) Pyloric
(c) Fundus (d) Body

42. Energy released by carbohydrate, fats, protein is **[NCERT; DPMT 2006]**
(a) 4.1, 9.45, 5.65 (b) 4.1, 5.65, 9.40
(c) 5.4, 6.5, 8.9 (d) 5.0, 7.8, 10.5

43. The following is a scheme showing the fate of carbohydrates during digestion in the human alimentary canal. Identify the enzymes acting at stages indicated as A, B, C and D. Choose the correct option from those given **[NCERT; KCET 2006]**



(a) A= amylase, B=maltase, C= lactase, D= invertase
(b) A= amylase, B= maltase, C= invertase, D= lactase
(c) A= amylase, B= invertase, C= maltase, D= lactase
(d) A= amylase, B= lactase, C= maltase, D= invertase

44. The food that enters intestine from stomach is called **[NCERT; AFMC 2008, 09]**
(a) Chyle (b) Chyme
(c) Fundus (d) None of these

45. End products of protein hydrolysis are **[RPMT 2002; HPMT 2005]**
(a) Mixture of amino acids (b) Sugars
(c) Peptides (d) 25 amino acids

46. The amount of bile released in proportion to the amount of **[CPMT 2004]**
(a) Fat in meal (b) Protein in meal
(c) Carbohydrate in meal (d) All of the above

47. Which one of the following is the matching pair of digestive enzyme and substrate **[MP PMT 1992]**
(a) Rennin–Protein (b) Amylase–Lactose
(c) Trypsin–Starch (d) Invertase–Maltose

48. Digestion of which component of the food is likely to be most adversely affected if the pH of stomach is made neutral **[MP PMT 1992]**
(a) Sucrose (b) Starch
(c) Protein (d) Fat

49. In man cellulose is digested in **[CBSE PMT 1992; CPMT 1995]**
(a) The caecum (b) The colon
(c) The appendix (d) Not digested at all

50. Milk protein is acted upon by a gastric enzyme **[NCERT; CBSE PMT 2000; AIIMS 2002; BCECE 2005]**
Or
Which one of the following enzyme carries on the initial step in the digestion of milk in humans **[CBSE PMT (Pre.) 2011; CBSE PMT 2014]**
(a) Casein (b) Rennin
(c) Pepsin (d) Caseinogen

51. Bile salt **[AMU (Med.) 2005]**
(a) Acts as emulsifying agent
(b) Helps in absorption of fatty acids, cholesterol etc.
(c) Stimulates the bile production in liver
(d) All of the above

52. Maltase converts **[Odisha JEE 2005]**
(a) Maltose to glucose at *pH* greater than 7
(b) Maltose to glucose at *pH* less than 7
(c) Maltose to alcohol
(d) Starch to maltose at higher *pH* than 7

53. Duodenum has characteristic Brunner's glands which secrete two hormones called **[CBSE PMT 2004, 05; KCET 2012]**
(a) Prolactin, parathormone (b) Estradiol, progesterone
(c) Kinase, estrogen (d) Secretin, cholecystokinin

54. The function of erepsin in the process of digestion is to convert
(a) Fats into amino acids
(b) Proteins in amino acids
(c) Polysaccharides into disaccharides
(d) Disaccharides into monosaccharides

55. Just as hydrochloric acid is to pepsinogen, so is **[MP PMT 2004]**
(a) Enterokinase to trypsinogen
(b) Haemoglobin to oxygen
(c) Bile juice to fat
(d) Glucagon to glycogen

56. In ileum which of the following is absorbed **[CPMT 2009]**
(a) Vitamin K (b) Bile salt
(c) Glucose (d) Fat

57. Bile salts are poured into the alimentary canal where they are necessary for the absorption of
(a) Na^+ and Ca^{++}
(b) Fat soluble vitamins
(c) Amino acids and monosaccharides
(d) All the nutrients contained in chyme

58. Fatty substances are emulsified by **[WB JEE 2016]**
(a) Lipase enzyme
(b) Bilirubin and biliverdin
(c) HCl
(d) Sodium salts of glycocholic and taurocholic acids

59. Which of the following option best represents the enzyme composition of pancreatic juice **[NEET 2017]**
(a) Amylase, peptidase, trypsinogen, rennin
(b) Amylase, pepsin, trypsinogen, maltase
(c) Peptidase, amylase, pepsin, rennin
(d) Lipase, amylase, trypsinogen, procarboxypeptidase

Gastro intestinal hormones/Digestive enzymes

1. What will happen if the secretion of parietal cells of gastric glands is blocked with an inhibitor **[CBSE PMT 2008]**
(a) In the absence of *HCl* secretion, inactive pepsinogen is not converted into the active enzyme pepsin
(b) Enterokinase will not be released from the duodenal mucosa and so trypsinogen is not converted to trypsin
(c) Gastric juice will be deficient in chymosin
(d) Gastric juice will be deficient in pepsinogen

2. Pancreatic secretion and gall bladder contraction are stimulated by **[AFMC 1993, 2005; CBSE PMT 1998; BHU 1999; AIIMS 2000; CPMT 2003; DPMT 2006; MP PMT 2010]**
(a) Gastrin
(b) Enterocrinin
(c) Enterogastrone
(d) Cholecystokinin pancreozymine

3. Digestion is brought about by **[Odisha JEE 2009]**
(a) Hormones (b) Neurotransmitters
(c) Growth factors (d) Enzymes

4. Salivary amylase, a digestive enzyme begins digestion of **[Odisha JEE 2009; MP PMT 2010]**
(a) Proteins (b) Fats
(c) Carbohydrates (d) All of these

5. One of the constituents of the pancreatic juice while poured into the duodenum in humans, is **[CBSE PMT (Mains) 2011]**
Or
Which is same as propepsin **[CPMT 1994]**
(a) Trypsin (b) Enterokinase
(c) Trypsinogen (d) Chymotrypsin

6. Match list I with list II and choose the correct option

List I	List II
(A) Salivary amylase	(1) Proteins
(B) Bile salts	(2) Milk proteins
(C) Rennin	(3) Starch
(D) Pepsin	(4) Lipids
(E) Steapsin	(5) Emulsification of fats

[NCERT; Kerala PMT 2009]
(a) (A) — (5), (B) — (4), (C) — (1), (D) — (2), (E) — (3)
(b) (A) — (2), (B) — (3), (C) — (4), (D) — (5), (E) — (1)
(c) (A) — (2), (B) — (4), (C) — (3), (D) — (1), (E) — (5)
(d) (A) — (3), (B) — (5), (C) — (2), (D) — (1), (E) — (4)
(e) (A) — (3), (B) — (5), (C) — (1), (D) — (2), (E) — (4)

7. Which of the following statement is correct **[AIIMS 1993]**
(a) Though secretin is an enzyme, it is not involved in digestion
(b) Secretin is an enzyme and so it helps digestion
(c) Secretin is a hormone but it plays a role in digestion
(d) Secretin is a hormone and hence it does not play any role in digestion

8. The enzyme added to the starch solution may have been **[CPMT 1992, 93]**
(a) Maltase (b) Invertase
(c) Lipase (d) Amylase

9. Enzymes which acts similarly are called as **[CPMT 1995]**
(a) Isoenzymes (b) Cofactor
(c) Coenzymes (d) All the above

10. Zymogen cells and chief cells secrete **[CBSE PMT 1990; CPMT 1994]**
(a) Hydrochloric acid (b) Mucus
(c) Pepsin (d) Trypsin

11. If this enzyme were to be absent in our small intestine, digestion of proteins in our body would be severely affected **[GUJCET 2007; KCET 2009, 12]**
(a) Pancreatic amylase (b) Maltase
(c) Lipase (d) Enterokinase

12. Prorennin is secreted by **[DPMT 2007]**
(a) Zymogene cells (b) Islet of langerhans
(c) Sertoli cells (d) Hepatocytes

13. Enzyme Rennin is secreted by **[MP PMT 2001]**
(a) Cells of stomach
(b) Cells of intestine
(c) The cortical cells of kidney
(d) The cells of juxtaglomerular apparatus of kidney

14. The digestive enzyme that is not found in human pancreatic juice is **[Kerala PMT 2006]**
(a) Nucleotidase (b) Nuclease
(c) Trypsin (d) Lipase
(e) Amylase

15. Deoxyribonuclease, ribonuclease and Carboxypeptidase are secreted by **[BHU 2003; Kerala PMT 2004]**
(a) Liver (b) Stomach
(c) Pancreas (d) Kidney

16. Bile synthesis occurs in **[NCERT; MP PMT 1994; J & K CET 2002; Bihar CECE 2006]**
(a) Liver (b) Duodenum
(c) Pancreas (d) Stomach

17. Which one of the following four secretions is correctly matched with its source, target and nature of action **[AIIMS 2005]**

	Secretion	Source	Target	Action
(a)	Gastrin	Stomach lining	Oxyntic cells	Production of *HCl*
(b)	Inhibin	Sertoli cells	Hypothalamus	Inhibition of secretion of gonadotropin releasing hormone
(c)	Enterokinase	Duodenum	Gall bladder	Release of bile juice
(d)	Atrial Natriuretic Factor (ANF)	Sinu atrial node (SAN) M-cells of Atria	Juxta-glomerular apparatus (JGA)	Inhibition of release of renin

18. Which one of the following enzymes initiates protein digestion **[MP PMT 1997; Bihar CECE 2006; GUJCET 2014]**
Or
Which of the following digest proteins and peptides **[HP PMT 2005]**
(a) Aminopeptidase (b) Carboxypeptidase
(c) Trypsin (d) Pepsin

19. Pepsin is produced by **[MP PMT 1995, 98, 2006]**
(a) Salivary glands (b) Stomach
(c) Duodenum (d) Small intestine

20. Which one of the following is the correct match of digestive enzyme and substrate **[CBSE PMT 1996]**
(a) Lactose–Renin (b) Starch–Maltose
(c) Fat–Steapsin (d) Casein–Trypsin

21. Glucagon secreted by the alpha-cells of the islets of Langerhans does this function **[CPMT 1993; KCET 1994; MP PMT 2000; GUJCET 2014]**
(a) Glucagon converts glucose into glycogen and increases the concentration of blood sugar
(b) Glucagon converts glycogen into glucose and increases the concentration of blood sugar
(c) Glucagon converts glucose into glycogen
(d) None of these

22. Match the following and choose the correct combination from the options given

Column I		Column II	
A.	Ptyalin	1.	Lipids
B.	Pepsin	2.	Starch
C.	Steapsin	3.	DNA
D.	Nuclease	4.	Proteins

[MP PMT 1994; Kerala PMT 2004]

(a) A-1, B-3, C-2, D-4 (b) A-1, B-4, C-3, D-2
(c) A-2, B-4, C-1, D-3 (d) A-2, B-3, C-1, D-4
(e) A-4, B-3, C-1, D-2

23. Cells of the pancreas is not digested by their own enzymes because **[MP PMT 2003]**

(a) Enzymes are secreted in inactive form
(b) Cells are not lined by mucous membrane
(c) Enzymes are released only when needed
(d) None of the above

24. When fat is in the stomach the secretion of gastrin is inhibited. This inhibition is due to **[CPMT 1992]**

(a) Presence of fat (b) Non-stimulation of vagus
(c) Slow digestion of fat (d) Release of enterogastron

25. Which of the following hormone stimulates the secretion of gastric juice **[CMC Vellore 1993; CPMT 2002; BHU 2003; WB JEE 2010]**

Or

Which of the following hormone helps in secretion of *HCl* from stomach **[WB JEE 2008, 11]**

(a) Secretin (b) Gastron
(c) Cholecystokinin (d) Gastrin

26. Cholecystokinin is a secretion of **[MP PMT 1992; WB JEE 2012]**

(a) Stomach which stimulates pancreas to release the pancreatic juice
(b) Liver synthesised from cholesterol and controls secondary sexual characters
(c) Duodenum and makes the gall bladder to contract and release bile
(d) Goblet cells of ileum and stimulates the secretion of succus entericus

27. In rabbit proteins are digested by **[CPMT 1995]**

(a) Pepsin and trypsin (b) Trypsin and steapsin
(c) Steapsin and pepsin (d) All the above

28. Which of the following is not a proteolytic enzyme **[Bihar MDAT 1995]**

Or

Which of the following belongs to the class of pepsin and trypsin

Or

Enzyme released from kidney is **[AFMC 2008]**

(a) Pepsin (b) Trypsin
(c) Erepsin (d) Renin

29. Identify the correct set which shows the name of the enzymes from where it is secreted and substrate upon which it acts **[Odisha PMT 2002]**

(a) Pepsin-stomach wall- casein
(b) Ptyalin- intestine-maltose
(c) Chymotrypsin- salivary gland-lactose
(d) Ptyalin – pancreas-lipid *CoA*

30. Trypsin converts **[MP PMT 1995]**

(a) Fats into fatty acids
(b) Starch and glycogen into maltose
(c) Proteins into peptones
(d) Sucrose into glucose and fructose

31. Islets of Langerhans produce **[MP PMT 1995]**

(a) Insulin (b) Rennin
(c) Ptyalin (d) *HCl*

32. Which of the following is a gastro–intestinal enzyme **[AFMC 1997; WB JEE 2011]**

(a) Cholinestrase (b) Enterokinase
(c) Secretin (d) Prolactin

33. Secretin **[AMU (Med.) 2009]**

(a) Stimulates enzyme secretion by pancreas, inhibits acid secretion in stomach, stimulates gall bladder
(b) Stimulates bicarbonate secretion by pancreas, inhibits acid secretion in stomach, stimulates bicarbonate secretion by liver
(c) Stimulates acid secretion in stomach, potentiates action of CCK, inhibits intestinal movement
(d) Stimulates gall bladder, inhibits acid secretion in stomach, stimulates bicarbonate secretion by pancreas

34. The gastrointestinal hormone which stimulates insulin secretion is **[AMU (Med.) 2012]**

(a) Gastrin (b) CCK
(c) Secretin (d) GIP

35. Gastric enzymes are **[CPMT 2009]**

(a) Pepsinogen (b) Prorennin
(c) Gastric lipase (d) All of these

36. Enzymes, vitamins and hormones can be classified into a single category of biological chemicals, because all of them **[AIIMS 1992; CBSE PMT 2005]**

(a) Are proteins
(b) Enhance the oxidative metabolism
(c) Aid the regulating mechanism
(d) Are synthesised within the body of an organism

37. The hormone 'secretin' stimulates secretion of **[CBSE PMT 1990; MP PMT 1996, 2002, 07, 12; Pb. PMT 1999, 2000; BHU 2000]**

(a) Pancreatic juice (b) Bile juice
(c) Salivary juice (d) Gastric juice

38. What is common among amylase, rennin and trypsin **[CBSE PMT 1997; Pb. PMT 1999, 2000; BHU 2001]**

(a) These all are proteins
(b) These all are proteolytic enzymes
(c) These are produced in stomach
(d) These act at a pH lower than 7

39. Cholecystokinin and duocrinin are secreted by **[CBSE PMT 1999; AIEEE Pharmacy 2003]**

(a) Intestine (b) Pancreas
(c) Adrenal cortex (d) Thyroid gland

40. Which part of body secretes the hormone secretin **[MP PMT 1994, 95; CBSE PMT 1999; AIEEE Pharmacy 2003]**

(a) Ileum (b) Stomach
(c) Duodenum (d) Oesophagus

41. What is the substrate for lipase enzyme **[WB JEE 2012]**

(a) Protein (b) Carbohydrate
(c) Lipid (d) Nucleic acid

42. Which of the following hormones induce secretion of succus entericus **[RPMT 2000]**

Or

Which hormones do stimulate the production of pancreatic juice and bicarbonate **[NEET (Phase-II) 2016; WB JEE 2016]**

(a) Insulin
(b) Secretin and cholecystokinin
(c) Glucagon
(d) Secretin

43. What is cholecystokinin **[Odisha PMT 2002]**

(a) Enzyme (b) Bile-pigment
(c) Gastro-intestinal hormone (d) Lipid

Nutrition and Nutritional requirement

1. When breast feeding is replaced by less nutritive food low in proteins and calories; the infants below the age of one year are likely to suffer from **[MP PMT 2001; CBSE PMT 2009; J & K CET 2010]**

(a) Marasmus (b) Rickets
(c) Kwashiorkor (d) Pellagra

2. Statements

A. The element which is very important for the production of thyroxine is iodine
B. Vitamin B_6 is otherwise known as niacin or nicotinic acid
C. Fructose is a monosaccharide and is a hexose sugar
D. Globulin is an example for a conjugated protein

Of the above statements **[Kerala PMT 2008]**

(a) A, B and C are correct but D is wrong
(b) A and C are correct but B and D are wrong
(c) A and B are correct but C and D are wrong
(d) A is correct while B, C and D are wrong
(e) A, C and D are correct but B is wrong

3. The number of essential amino acids in adult human is **[Odisha JEE 2009]**

(a) Nine (b) Eight
(c) Four (d) Seven

4. Which one of the following statements is not correct **[CBSE PMT 2014]**

(a) Retinal is a derivative of vitamin C
(b) Rhodopsin is the purplish red protein present in rods only
(c) Retinal is the light absorbing portion of visual photopigments
(d) In retina the rods have the photopigment rhodopsin while cones have three different photopigments

5. Inadequate protein intake leads to kwashiorkor. The subsequent edema is most closely related to inadequate synthesis of which protein **[DUMET 2009]**

(a) Gamma globulin (b) Glucagon
(c) Insulin (d) Albumin

6. Hypochromic microcytic anaemia and leucopenia are caused by the deficiency of ..... respectively **[EAMCET 2009]**

(a) Pyridoxine and riboflavin (b) Pyridoxine and folacin
(c) Biotin and folacin (d) Biotin and cyanocobalamin

7. Liver necrosis and muscular dystrophy are caused by the lack of this trace element **[AMU (Med.) 2009]**

(a) Arsenic (b) Molybdenum
(c) Zinc (d) Selenium

8. This trace element is needed for insulin to exert its maximal effect in glucose uptake **[AMU (Med.) 2010]**

(a) Vanadium (b) Chromium
(c) Molybdenum (d) Selenium

9. Which of the following is a reducing sugar **[CBSE PMT 2002; AFMC 2012]**

(a) Sucrose (b) Galactose
(c) Gluconic acid (d) β – methyl galactoside

10. What is the common between amino acids, fatty acids and glycerol

(a) These are all rich source of calories
(b) These are the builders of protoplasm
(c) These are the end products of digestion of two categories of food constituents
(d) These can be stored in the form of fat

11. The smallest structural units of proteins are called **[CPMT 1993; RPMT 1999]**

(a) Amino acids (b) Peptides
(c) Proteoses (d) Peptones

12. In human per cent of body weight of carbohydrates, lipids and proteins respectively is **[AMU (Med.) 2009]**

(a) 1, 15, 17 (b) 15, 17, 7
(c) 7, 17, 15 (d) 17, 15, 7

13. During prolonged fasting **[AFMC 1994; CBSE PMT 2003; CPMT 2005]**
(a) The first to be used up are carbohydrates, next fat is withdrawn and proteins are metabolised at the last
(b) The first to be used up are the fats, next carbohydrates are withdrawn from stored glycogen in the liver and muscles and proteins are withdrawn at the last
(c) First lipids are used up, then proteins and finally carbohydrate
(d) None of these

14. To get sufficient carbohydrates one should take **[CBSE PMT 2002]**
(a) Meat (b) Rice
(c) Carrots (d) Ground nuts

15. Glucose and amino acids are absorbed in the intestine by **[NCERT; JIPMER 2002]**
(a) Active transport (b) Passive transport
(c) Selective absorption (d) Osmosis

16. Milk protein is **[Manipal 1995]**
(a) Rennin (b) Casein
(c) Galactose (d) Glycine

17. Unsaturated fatty acids have **[Kerala CET 2002]**
(a) Palmitic acid
(b) Stearic acid
(c) Oleic acid
(d) One or more double bonds

18. Which one of the following set is a polysaccharide group **[CBSE PMT 1996; BHU 1999]**
(a) Glucose, fructose, lactose
(b) Starch, glycogen, cellulose
(c) Sucrose, maltose, glucose
(d) Galactose, starch, sucrose

19. Lactose is composed of **[CBSE PMT 1998; BHU 2000; DPMT 2006; WB JEE 2011]**
(a) Glucose + fructose (b) Glucose + glucose
(c) Glucose + galactose (d) Fructose + galactose

20. The anhydro bond of proteins are called **[Pb. PMT 2000]**
(a) Glycosidic (b) Peptide
(c) Ester (d) Diester

21. Role of carbohydrates is to function as **[NCERT; RPMT 1999]**
(a) Catalyst (b) Source of energy
(c) Enzyme (d) Building material

22. Digestion of protein takes place in **[NCERT; MP PMT 1996]**
(a) Duodenum and stomach
(b) Stomach and oesophagus
(c) Small and large intestine
(d) Intestine and rectum

23. Amino acids not synthesized in the body are called **[MP PMT 1996]**
(a) Non-essential (b) Active
(c) Essential (d) Inactive

24. Essential : non-essential amino acid is **[AMU (Med.) 2010]**
(a) Lysine : leucine (b) Methionine : threonine
(c) Valine : tyrosine (d) Alanine : cystine

25. Most abundant mineral of animal body is **[WB JEE 2010]**
(a) Iron (b) Sodium
(c) Potassium (d) Calcium

26. Which element is the cause of etai etai disease **[WB JEE 2009]**
(a) *Hg* (b) *Pb*
(c) *Cd* (d) *As*

27. Which of the following is not a vitamin deficiency disease **[CPMT 2010]**
(a) Addision's disease (b) Goitre
(c) Keratomalacia (d) Xerophthalmia

28. Choose the correct non-protein amino acid **[WB JEE 2009]**
(a) Hydroxyproline (b) Hydroxylysine
(c) Cystine (d) γamino butyric acid

29. Thiamine (B_1) deficiency results in **[AIIMS 2009, 13]**
(a) Wernickes' syndromes (b) Korsakoffs' syndromes
(c) Osteonecrosis (d) Tunnel vision

30. Vitamin *D* is synthesised by one of the following with the help of sunlight **[AIIMS 1992; RPMT 1999; WB JEE 2010]**
(a) Skin (b) Gall bladder
(c) Liver (d) Pancreas

31. Water soluble vitamins are **[AFMC 2001; Kerala PMT 2007]**
(a) Vitamin *A*, *B* and *C* (b) Vitamin *B* and *C*
(c) Vitamins *C* and *D* (d) None of these

32. Which of the following elements is a constituent of biotin **[NEET (Karnataka) 2013]**
(a) Magnesium (b) Calcium
(c) Phosphorus (d) Sulphur

33. Which of the following are required in minimum amount by human **[DPMT 2006; AIIMS 2011]**
(a) Iron, iodine, carbon, manganese, copper, O_2
(b) Iron, iodine, manganese, copper, zinc, fluorine
(c) Iron, iodine, manganese, zinc, hydrogen
(d) Nitrogen, oxygen, zinc, fluorine

34. Which is not used up in human body **[DPMT 2006]**
(a) Calcium (b) Phosphorus
(c) Zinc (d) Barium

35. Simple storage protein that coagulates upon heating but remains soluble in dilute salt solution is correctly exemplified by **[Kerala PMT 2004; WB JEE 2012]**
(a) Globulin (b) Albumin
(c) Histone (d) Collagen

36. Fat soluble vitamins are
(a) Vitamin *A*, *B* and *C* (b) Vitamin *A*, *B* and *D*
(c) Vitamin *A*, *D*, *E* and *K* (d) Vitamin *C* and *D*

37. Vitamin *C* is **[AFMC 2012]**
(a) Ascorbic acid (b) Nicotinic acid
(c) Lipoic acid (d) Aspartic acid

38. A pregnant female delivers a baby who suffers from stunted growth, mental retardation, low intelligence quotient and abnormal skin. This is the result of **[NEET 2013]**
(a) Over secretion of pars distalis
(b) Deficiency of iodine in diet
(c) Low secretion of growth hormone
(d) Cancer of the thyroid gland

39. Main difference between brown fat and white fat is that the cells of brown fat
(a) Are multicoloured (b) Have more mitochondria
(c) Are polygonal in shape (d) All the above

40. Collagen is a **[WB JEE 2009]**
(a) Phosphoprotein (b) Globulin
(c) Derived protein (d) Scleroprotein

41. Higher animals cannot synthesize few fatty acids which are very essential for their growth and development. These fatty acids are typically **[WB JEE 2012]**
(a) Saturated (b) Cycle
(c) Unsaturated (d) Branched

42. Which vitamin gets destroyed by heating
(a) Vitamin *A* (b) Vitamin *E*
(c) Vitamin *C* (d) Vitamin *K*

43. Continued consumption of a diet rich in butter, red meat and eggs for a long period may lead to **[AIIMS 2007]**
(a) Vitamin A toxicity
(b) Kidney stones
(c) Hypercholesterolemia
(d) Urine laden with ketone bodies

44. Term "*vitamin*" was given by **[CBSE PMT 1992]**
(a) James Lind (b) Sterling
(c) Funk (d) J.C. Drummond

45. In vertebrate's body mainly the food is stored in the form of **[BHU 2002]**
(a) Fat (b) Fat and glycogen
(c) Glycogen (d) Proteins

46. Which of the following vitamins is water soluble as well as an anti-oxidant **[BHU 2005; Bihar CECE 2006]**
(a) Vitamin B_1 (b) Vitamin *A*
(c) Vitamin *D* (d) Vitamin *C*

47. Zinc is associated with **[RPMT 2000]**
(a) Glycosylation (b) Immunization
(c) Sulfation (d) Transcription

48. Vitamin K is required for **[CPMT 2009; MP PMT 2013]**
(a) Converting prothrombin to thrombin
(b) Synthesis of prothrombin
(c) Calcium combination with prothrombin
(d) All of the above

49. Iron is present in which one of the following **[RPMT 2000]**
(a) Glycophorin (b) Nuclein
(c) Lectin (d) Catalase

50. A balanced diet does not include **[KCET 2011]**
(a) Carbohydrates and fats
(b) Nucleic acids and enzymes
(c) Proteins and vitamins
(d) Minerals and salts

51. Vitamin D is synthesized in skin, by the action of sunlight on **[CPMT 2000; BHU 2006]**
(a) Cholesterol (b) 7-hydroxy cholesterol
(c) Cephano-cholesterol (d) Ortho-phenoxy cholesterol

52. Which one is an amino acid **[WB JEE 2011]**
(a) Pepsin (b) Proline
(c) Cysteine (d) Renin

53. Cyanocobalamine is essential for the formation of **[JIPMER 2002; AFMC 2012]**
(a) *RBC* (b) *WBC*
(c) Lymph (d) Platelets

54. Salivary amylase is also known as **[Manipal 2005]**
(a) Ptyalin (b) Gastrin
(c) Glyoxylase (d) Pepsin

55. Beri-beri was discovered by
(a) Funk (b) G.E. Foxan
(c) Eijkman (d) Admiral Takaki

56. In a normal adult, ascending order of concentration of following molecules is **[AIIMS 2012]**
(a) K>Na>Fe>Cu (b) Na>K>Cu>Fe
(c) Fe>Na>K>Cu (d) Na>Fe>K>Cu

57. Megaloblastic anaemia of pregnancy is caused by the deficiency of
(a) Vitamin B_{12} (b) Vitamin B_{12} and folic acid
(c) Folic acid (d) Vitamin *D*

58. A non-essential amino acid is **[AFMC 2002]**
(a) Lysine (b) Methionine
(c) Alanine (d) Isoleucine

59. Which of the following is not an unsaturated fatty acid (essential) **[CPMT 2009]**
(a) Oleic acid (b) Linoleic acid
(c) Linolenic acid (d) Stearic acid

60. Fluorine helps in maintaining the
(a) Dentine to deposit normally in teeth
(b) Enamel deposition and prevents the dental carries
(c) Erythropoiesis
(d) Absorption of certain substances by the cell

61. Which one of the following is a fat-soluble vitamin and its related deficiency disease **[CBSE PMT 2007]**
(a) Ascorbic acid – Scurvy
(b) Retinol – Xerophthalmia
(c) Cobalamine – Beri-beri
(d) Calciferol – Pellagra

62. Cod and shark liver oil is a source of **[Kerala PMT 2007]**
(a) Energetic nutrients
(b) Constructive nutrients
(c) Energetic and constructive nutrients
(d) Protective nutrients
(e) Protective and constructive nutrients

63. Certain vitamin *B* acts as **[MP PMT 2002]**
(a) Enzymes (b) Coenzymes
(c) Digestive enzymes (d) Hormones

64. Which one of the following vitamins is manufactured in human liver **[BHU 2012]**

(a) Vitamin A (b) Vitamin D
(c) Vitamin C (d) Vitamin K

65. Deficiency of it, causes loss of appetite, mental confusion, fatigue and muscle depreciation **[GUJCET 2007]**

(a) Vitamin - *K* (b) Vitamin - *C*
(c) Thiamine (d) Riboflavin

66. The following are needed for blood-clotting in mammals **[MP PMT 1994, 97, 2001, 02; HPMT 2005; BHU 2006; VITEEE 2006; DPMT 2007; Kerala PMT 2009]**

(a) Ca^{++} and Vitamin *E* (b) Ca^{++} and Vitamin *K*
(c) Ca^{++} and Vitamin *A* (d) K^{+} and Vitamin *K*

67. Which of the following is mismatched **[CBSE PMT 1998, 99]**

(a) Vitamin *K* – Beri-beri (b) Vitamin *C* – Scurvy
(c) Vitamin *A*–Xerophthalmia (d) Vitamin *D* – Rickets

68. In beri–beri **[CBSE PMT 1993]**

(a) The coagulation time increases
(b) Dermatitis in organs exposed to sun rays
(c) The depigmentation of skin and hair starts
(d) The affect over peripheral nervous system, gastro-intestinal tract and cardiovascular is pronounced

69. Examination of blood of a person suspected of having anaemia, shows large, immature, nucleated erythrocytes without haemoglobin. Supplementing his diet with which of the following is likely to alleviate his symptoms **[AIEEE Pharmacy 2003; CBSE PMT 2006]**

(a) Riboflavin (b) Iron compounds
(c) Thiamine (d) Folic acid and cobalamine

70. In mammals vitamin synthesised by the intestinal bacteria is **[MP PMT 2006]**

(a) Pantothenic acid (b) B_{12} (Cyanocobalamine)
(c) Biotin (d) Choline

71. Which of the following helps in synthesis of DNA and cell division **[MP PMT 2001, 02; BHU 2002]**

(a) Nicotinamide (b) Biotin
(c) Folic acid (d) Pantothenic acid

72. Which one is the most abundant protein in the animal world **[CBSE PMT (Pre.) 2012]**

(a) Trypsin (b) Haemoglobin
(c) Collagen (d) Insulin

73. Defective red blood corpuscles can be seen when there is a deficiency of **[MP PMT 1993]**

(a) Retinol (b) Vitamin *K*
(c) Vitamin B_2 (Riboflavin) (d) Vitamin B_6 (Pyridoxine)

74. General metabolism of the body will be affected due to the deficiency of **[MP PMT 1993]**

Or

One of the following minerals is responsible to regulate your heart beats

(a) Sodium (b) Calcium
(c) Iodine (d) Cobalt

75. Infertility is believed to be due to the lack of vitamin **[AIIMS 1993; DPMT 1993; MP PMT 2012]**

(a) *A* (b) *B*
(c) *C* (d) *E*

76. Animals consuming only plant materials are referred as **[J & K CET 2005]**

(a) Herbivores (b) Carnivores
(c) Omnivores (d) Insectivores

77. A person suffers from beri–beri, rickets and scurvy if he is not taking adequate amounts of **[JIPMER 1993; MP PMT 1994, 95; Bihar MDAT 1995; CPMT 1995; BHU 1998, 99; Odisha JEE 2010; PET (Pharmacy) 2013]**

(a) Vitamin B_{12}, *A* and *C* (b) Vitamin B_1, *D* and *C*
(c) Vitamin *A*, *B* and *E* (d) Vitamin B_6, and *K*

78. Riboflavin (B_2 or *G*) is concerned with **[CMC Vellore 1993; MP PMT 2012]**

(a) Maintenance of epithelial cells of skin
(b) Iron porphyrin proteins
(c) Metal containing pigments
(d) Oxidation process and intermediate metabolism

79. A nutrient not required / has no function in plants except in Fabaceae, but essential nutrient of animals whose deficiency makes a person anemic as it is an integral part of vitamin B-12, and this nutrient is **[Kerala CET 2003; MP PMT 2013]**

(a) Iron (b) Calcium
(c) Cobalt (d) Cadmium

80. Rickets in children and osteomalacia in adults is caused by the deficiency of **[NCERT; MP PMT 1996, 99, 2000, 03, 10; BHU 1999; CPMT 2001; CBSE PMT 2001; Kerala CET 2002; DUMET 2009; WB JEE 2009, 11]**

Or

Weakening of limb bones may be due to deficiency of **[MP PMT 1993]**

(a) Vitamin *A* (b) Vitamin *B*
(c) Vitamin *C* (d) Vitamin *D* (calciferol)

81. Which one of the following is the best source for vitamin A (Antixerophthalmic) **[AFMC 1996, 99; AIEEE Pharmacy 2003]**

(a) Apples (b) Carrots
(c) Honey (d) Peanuts

82. Angiotensinogen is a protein produced and secreted by **[CBSE PMT 2006]**

(a) Liver cells
(b) Juxtaglomerular (JG) cells
(c) Macula densa cells
(d) Endothelial cells (cells lining the blood vessels)

83. Which one of the following is dominant intracellular cation **[RPMT 2000]**
(a) Potasium (b) Chloride
(c) Phosphate (d) Calcium

84. Vitamin B_{12} is available to ruminants by **[DPMT 2006]**
(a) Plants
(b) Micro-organisms in caecum
(c) Animals
(d) All of the above

85. A vitamin which is generally excreted in human urine is
Or
Earliest known vitamin is
(a) C (b) K
(c) A (d) D

86. The richest sources of vitamin B_{12} are **[CBSE PMT 2004]**
(a) Rice and hen's egg
(b) Carrot and chicken's breast
(c) Goat's liver and Spirulina
(d) Chocolate and green gram

87. To which of the following family do folic acid and pentothenic acid belong **[CBSE PMT 1998, 99]**
(a) Vitamin K (b) Vitamin A
(c) Vitamin C (d) Vitamin B complex

88. Which of the following is the correct match **[KCET 1994; CBSE PMT 2001]**
(a) Vitamin A–calciferol (b) Vitamin E–tocopherol
(c) Vitamin D–thiamine (d) Vitamin K–ascorbic acid

89. Pellagra is caused due to the deficiency of **[CBSE PMT 1994, 96; MP PMT 1998, 2011; BHU 2000, 01, 03; DPMT 2003; AMU (Med.) 2006; WB JEE 2009; DUMET 2009]**
(a) Thiamine
(b) Ascorbic acid
(c) Niacin (Nicotinic Acid) (B_5)
(d) Calciferol

90. One of the factors required for the maturation of erythrocytes is **[CBSE PMT 1998; AFMC 2000]**
(a) Vitamin D (b) Vitamin A
(c) Vitamin B_{12} (d) Vitamin C

91. Which is the best source for vitamin B_1
(a) Cod liver oil (b) Egg
(c) Whole wheat bread (d) Curd

92. Xerophthalmia in children and nyctalopia (Night blindness) in adults is caused by the deficiency of vitamin **[CBSE PMT 1992; MP PMT 1999, 2002; MH CET 2001; J & K CET 2002]**
(a) A (b) D
(c) E (d) K

93. Which one of the following is very rich in magnesium **[JIPMER 2002]**
(a) Meat (b) Egg
(c) Soybean (d) Milk

94. Which one of the following pairs is ***not*** correctly matched **[CBSE PMT 2004]**
(a) Vitamin B_1 – Beri-beri
(b) Vitamin B_5 – Pellagra
(c) Vitamin B_{12} – Pernicious anaemia
(d) Vitamin B_6 – Loss of appetite

95. Which one is correctly matched **[Kerala PMT 2006]**
(a) Vitamin E – Thiamine (b) Vitamin D – Riboflavin
(c) Vitamin B_1 – Tocopherol (d) Vitamin A – Calciferol
(e) Vitamin B_{12} – Cyanocobalamine

96. Which of the following is a fat soluble vitamin **[MP PMT 2003]**
(a) Thiamine (b) Folic acid
(c) Ascorbic acid (d) Tocopherol

97. Excessive intake of vitamin D leads to bone reabsorption and
(a) Beri-beri (b) Hypercalcemia
(c) Hyperkeratosis (d) Keratomalacia

98. Vitamin B_{12} is helpful
(a) In the absorption of fats
(b) To stimulate the liver
(c) To stimulate the bone marrow
(d) To increase life span of RBC

99. Starch is converted to maltose by the action of **[CPMT 1999; JIPMER 2001]**
(a) Invertase (b) Amylase
(c) Sucrase (d) Maltase

100. Recently discovered vitamin having anti–cancer properties is
(a) Vitamin B_5 (b) Vitamin B_{15}
(c) Vitamin B_{17} (d) Vitamin Q

101. How many of the twenty amino acids are essential amino acids for children **[HP PMT 2005; Kerala PMT 2006]**
(a) 6 (b) 8
(c) 10 (d) 7
(e) 11

102. The vitamin nicotinamide can be synthesized in our body from **[AIIMS 2002]**
(a) Tyrosine (b) Valine
(c) Tryptophan (d) Phenyl alanine

103. Rhodopsin is synthesised with the help of **[MP PMT 2000]**
(a) Vitamin A (b) Vitamin B_{12}
(c) Vitamin D (d) Vitamin B_6

104. For normal absorption and deposition of calcium and phosphate the vitamin that is very necessary **[MP PMT 1998; AIEEE Pharmacy 2003]**
Or
Calcium deficiency in the body occurs in the absence of **[CBSE PMT 1994]**
(a) B_1 (b) B_2
(c) A (d) D

105. Nutrition involving engulfment of the whole or part of a plant or an animal in solid or in liquid state is known **[J & K CET 2005; Kerala PMT 2009]**
(a) Holozoic (b) Saprozoic
(c) Parasitic (d) Symbiotic

106. Match the following nutrition/vitamin deficiences in column I with causes/deficiencies is column II and choose the correct option from the answer key

	Column I		Column II
(a)	Kwashiorkor	(p)	Iron
(b)	General Anaemia	(q)	Menadione
(c)	Dermatitis	(r)	Protein
(d)	Marasmus	(s)	Pyridoxin
(e)	Bleeding	(t)	Biotin

[Kerala CET 2005]

(a) (a) – (p), (b) – (t), (c) – (q), (d) – (r), (e) – (s)
(b) (a) – (t), (b) – (q), (c) – (r), (d) – (s), (e) – (p)
(c) (a) – (q), (b) – (r), (c) – (s), (d) – (p), (e) – (t)
(d) (a) – (r), (b) – (p), (c) – (t), (d) – (s), (e) – (q)
(e) (a) – (r), (b) – (s), (c) – (p), (d) – (t), (e) – (q)

107. Iodine test used to detect **[DPMT 2003]**

(a) Protein (b) Fat
(c) Carbohydrate (d) Chitin

108. Which one of the following is antioxidant vitamin **[DPMT 2003; BHU 2003]**

(a) Vitamin *C, E, A* (b) Vitamin B_1, B_4
(c) Vitamin *A, D, E* (d) Vitamin B_3, B_5

109. Vitamin-C is mainly helpful in **[MP PMT 2006]**

(a) Growth of bones
(b) Formation of connective tissue
(c) Treatment of anaemia
(d) Formation of visual pigment

110. Continuous bleeding from an injured part of body is due to deficiency of **[CBSE PMT 2002; MP PMT 2003]**

(a) Vitamin *A* (b) Vitamin *B*
(c) Vitamin *K* (d) Vitamin *E*

111. Which group of three of the following five statement (1-5) contain is all three correct statements regarding beri-beri

1. A crippling disease prevalent among the native population of sub-Saharan Africa
2. A deficiency disease caused by lack of thiamine (vitamin B_1)
3. A nutritional disorder in infants and young children when the diet is persistently deficient in essential protein
4. Occurs in those countries where the staple diet is polished rice
5. The symptoms are pain from neuritis, paralysis, muscle wasting, progressive oedema mental deterioration and finally heart failure. **[CBSE PMT 2005]**

(a) 2, 4 and 5 (b) 1, 2 and 4
(c) 1, 3 and 5 (d) 2, 3 and 5

112. 'Burning feet syndrome' is due to deficiency of

(a) Vitamin *D* (b) Vitamin *A*
(c) Vitamin B_3 (d) Vitamin B_5

113. A patient of diabetes mellitus excretes glucose in urine even when he is kept in a carbohydrate free diet. It is because **[Odisha JEE 2005]**

(a) Fats are catabolised to form glucose
(b) Amino acids are catabolised in liver
(c) Amino acids are discharged in blood stream from liver
(d) Glycogen from muscles is released in blood stream.

114. The disease due to inflammation of vermiform appendix of digestive system is known as **[CBSE PMT 1993]**

(a) Amoebic dysentery (b) Intestinal cancer
(c) Appendicitis (d) None of the above

115. Which of the following is related with vitamin B_2 **[AFMC 1997]**

Or

Riboflavin is essential in our diet, as it is required for the synthesis of

(a) *FMN / FAD* (b) *NAD*
(c) *NADH* (d) $NADH_2$

116. The method of intake of food in case of ciliate *Paramaecium*

(a) Holozoic (b) Saprozoic
(c) Saprophytic (d) Parasitic

117. Which one of the following is a matching pair of a certain body feature and its value/count in a normal human adult **[AIIMS 2003]**

(a) Urea 5-10 *mg*/100 *ml* of blood
(b) Blood sugar 80-100 *mg*/100 *ml*
(c) Total blood volume 3-4 litres
(d) *ESR* in Wintrobe method 9-15 *mm* per hour in males and 20-34 *mm* per hour in females

118. Average kilocalorie of energy needed by woman is **[NCERT; Odisha JEE 2005]**

(a) Less than man (b) More than man
(c) Equal to man (d) Cannot be predicted

119. An average man needs approximately **[NCERT; CBSE PMT 1999; MP PMT 2004]**

(a) 2900 *K cal.* energy/day (b) 500 *K cal.* energy/day
(c) 1000 *K cal.* energy/day (d) 2000 *K cal.* energy/day

120. The people dependent exclusively on maize diet, are more likely to suffer from **[AIEEE Pharmacy 2003]**

(a) Rickets (b) Pellagra
(c) Beri-beri (d) Dysentery

121. Vasco de Gama (1498) sailed to explore India with 180 companions but most of them died due to

(a) Rickets (b) Pellagra
(c) Scurvy (d) Xerophthalmia

122. Anti–infection vitamin is

(a) B_{12} (b) *A*
(c) *D* (d) *K*

123. Chemical formula of 'Retinol–1' is

(a) $C_6H_5NO_2$ (b) $C_3H_{10}O_3N$
(c) $C_{20}H_{30}O$ (d) $C_{28}H_{44}O$

124. Vitamin essential for formation of collagen is

(a) *A* (b) *E*
(c) B_{12} (d) *C*

125. Which one of the following is the correct matching of a vitamin, its nature and its deficiency disease **[CBSE PMT 2004; BCECE 2005]**

(a) Vitamin *A* – Fat-soluble – Beri-beri
(b) Vitamin *K* – water-soluble – Pellagra
(c) Vitamin *A* – Fat-soluble – Night blindness
(d) Vitamin *K* – Fat-soluble – Beri-beri

126. Vitamin E is also known as **[MP PMT 2002; Kerala CET 2003]**
(a) Decalcifying vitamin
(b) Antisterility vitamin
(c) Prothrombin vitamin
(d) Antihaemophilic vitamin

127. Vitamin A was discovered by
(a) McCollum and Davis (b) Funk
(c) Hopkin (d) Eijkmann

128. Organisms, which obtain energy by oxidation of reduced inorganic compounds, are **[CBSE PMT 2002]**
(a) Phototrophs (b) Saprozoic
(c) Copro-heterotrophs (d) Chemo-autotrophs

129. Which vitamin is destroyed by ultraviolet rays
(a) A (b) D
(c) E (d) K

130. *E. coli* in human colon behave as **[AFMC 2002]**
(a) Parasite (b) Commensal
(c) Saprophyte (d) Mutualism

131. Vitamin M is
(a) Nicotinic acid (b) Pantothenic acid
(c) Folic acid (d) Ascorbic acid

132. The vitamin isolated from egg yolk by *Kogl* and *Tonnis* in 1943 was
(a) Vitamin K (b) Vitamin M
(c) Vitamin H (d) Vitamin B_9

133. The vitamin which helps in carbohydrate metabolism during glycolysis and TCA cycle is
(a) Riboflavin (b) Thiamine
(c) Folic acid (d) Pantothenic acid

134. Which one of the following pairs is not correctly matched **[CBSE PMT 2003]**
(a) Vitamin B_6 – Beri–beri
(b) Vitamin C – Scurvy
(c) Vitamin B_5 – Pellagra
(d) Vitamin B_{12} – Pernicious anaemia

135. Which set includes neurotic vitamins
(a) Vitamin B_{12}, B_5, B_2 (b) Vitamin B_2, B_6, B_{12}
(c) Vitamin A, D, E (d) Vitamin B_6, B_{12}, K

136. Which one of the following vitamins can be synthesized by bacteria inside the gut **[CBSE PMT 1997]**
(a) B_1 (b) A
(c) D (d) K

137. Cow's milk is slightly yellowish in colour due to the presence of
(a) Carotene (b) Riboflavin
(c) Xanthophyll (d) Xanthophyll and carotene

138. The water soluble materials pass through the proteins called **[Kerala CET 2003]**
(a) Glycoprotein (b) Glycocalyx
(c) Extrinsic proteins (d) Channel proteins

139. Which combination is incorrect **[CPMT 1994]**
(a) Niacine – Pellagra
(b) Thiamine – Beri – beri
(c) Vitamin K – Sterility
(d) Vitamin D – Rickets

140. Vitamins, we must consume daily are **[AFMC 1995; CBSE PMT 2000]**
(a) Fat soluble (b) Water soluble
(c) Both (a) and (b) (d) None of these

141. Besides having C, H, O which of the following also contains N, S, P etc. **[AFMC 1995]**
(a) Protein (b) Fat
(c) Carbohydrate (d) Vitamin

142. Which of the following does not belong to vitamin B group **[MP PMT 2002]**
(a) Riboflavin (b) Nicotin
(c) Cyanocobalamine (d) Tocopherol

143. Milk sugar is **[Bihar MDAT 1995; KCET 2010]**
(a) Sucrose (b) Galactose
(c) Lactose (d) Glucose
(e) Fructose

144. Which of the following is not a source of vitamin A **[CPMT 2002; RPMT 2005, 06]**
(a) Carrot (b) Mango
(c) Apple (d) Yeast

145. What does the doctor advise to the patients suffering from high blood cholesterol **[CBSE PMT 1996]**
(a) Red mutton with fat layer
(b) Vegetable and margerin
(c) Vegetable oil such as ground–nut oil
(d) Pure deshi ghee or butter

146. Deficiency of copper causes **[MP PMT 1996]**
(a) Pellagra
(b) Anaemia and damage to *CNS*
(c) Influenza
(d) Xerophthalmia

147. The main cause of anaemia (Hypochromic or macrocytic) is **[MP PMT 1996, 99, 2006; AFMC 2006]**
(a) Deficiency of *Ca*
(b) Deficiency of *Fe*
(c) Deficiency of *Na*
(d) Deficiency of *Mg*

148. Mode of nutrition in Amoeba is **[HPMT 1993; MP PMT 2001]**
(a) Saprozoic (b) Holophytic
(c) Coprozic (d) Holozoic

149. Balanced diet should have approximately **[NCERT; AFMC 1994; CBSE PMT 2000]**
(a) 1/5 protein, 3/5 fat and 1/5 carbohydrate
(b) 3/5 protein, 1/5 fat and 1/5 carbohydrate
(c) 1/5 protein, 1/5 fat and 3/5 carbohydrate
(d) 1/2 protein, 1/4 fat and 3/5 carbohydrate

150. Holophytic nutrition is found in **[MP PMT 2000]**
(a) Amoeba (b) Giardia
(c) Entamoeba (d) Euglena

151. Fish–liver oils contain large amounts of
(a) Vitamin K
(b) Vitamin E
(c) Vitamins A and D
(d) Vitamins B_2 and C

NCERT Exemplar Questions

1. Select what is not true of intestinal villi among followings [NCERT]
   (a) They possess microvilli
   (b) They increase the surface area
   (c) They are supplied with capillaries and the lacteal vessels
   (d) They only participate in digestion of fats

2. Hepato-pancreatic duct opens into the duodenum and carries [NCERT]
   (a) Bile
   (b) Pancreatic juice
   (c) Both bile and pancreatic juice
   (d) Saliva

3. One of the following is not a common disorder associated with digestive system [NCERT]
   (a) Tetanus (b) Diarrhoea
   (c) Jaundice (d) Dysentery

4. A gland not associated with the alimentary canal is [NCERT]
   (a) Pancreas (b) Adrenal
   (c) Liver (d) Salivary glands

5. Match the two columns and select the correct among options given

Column I	Column II
A. Biomacromolecules of food	i. Alimentary canal and associated gland
B. Human digestive system	ii. Embedded in jawbones
C. Stomach	iii. Outer wall of visceral organs
D. Thecodont	iv. Converted into simple substances
E. Serosa	v. J-shaped bag like structure

Options [NCERT]
(a) A-ii, B-i, C-v, D-iii, E-iv
(b) A-iv, B-i, C-v, D-ii, E-iii
(c) A-i, B-ii, C-iii, D-iv, E-v
(d) A-i, B-iii, C-ii, D-iv, E-v

6. Match the two columns and select the right one among options given

Column I	Column II
A. Duodenum	i. A cartilaginous flap
B. Epiglottis	ii. Small blind sac
C. Glottis	iii. 'U' shaped structure emerging from the stomach
D. Caecum	iv. Opening of wind pipe

Options [NCERT]
(a) A-i, B-ii, C-iii, D-iv
(b) A-iv, B-iii, C-ii, D-i
(c) A-iii, B-i, C-iv, D-ii
(d) A-ii, B-iv, C-i, D-iii

7. Match the enzyme with their respective substrate and choose the right one among options given

A. Lipase	i. Dipeptides
B. Nuclease	ii. Fats
C. Carboxypeptidase	iii. Nucleic acids
D. Dipeptidases	iv. Proteins, peptones and proteoses

Options [NCERT]
(a) A-ii, B-iii, C-i, D-iv
(b) A-iii, B-iv, C-ii, D-i
(c) A-iii, B-i, C-iv, D-ii
(d) A-ii, B-iii, C-iv, D-i

8. Liver is the largest gland and is associated with various functions, choose one which is not correct [NCERT]
   (a) Metabolism of carbohydrate
   (b) Digestion of fat
   (c) Formation of bile
   (d) Secretion of hormone called gastric

9. Mark the right statement among the following [NCERT]
   (a) Trypsinogen is an inactive enzyme
   (b) Trypsinogen is secreted by intestinal mucosa
   (c) Enterokinase is secreted by pancrease
   (d) Bile contains trypsin

Critical Thinking Objective Questions

1. This is the common passage for bile and pancreatic juices [NCERT; AMU (Med.) 2010, 12]
   (a) Ampulla of Vater (b) Ductus Choledochus
   (c) Duct of Wirsung (d) Duct of Santorini

2. Digestion in *Hydra* takes place within [Odisha JEE 2009]
   (a) Pelvic cavity (b) Abdominal cavity
   (c) Pericardial cavity (d) Gastrovascular cavity

3. Which is the characteristic lining of stomach of mammals [MP PMT 1993]
   (a) Paneth cells (b) Deiter cells
   (c) Oxyntic cells (d) Kupffer cells

4. Fatty acid and glycerol are first taken up from alimentary canal by [AFMC 1994]
   (a) Villi (b) Blood capillaries
   (c) Hepatic portal vein (d) Lymph vessels

5. Erythropoiesis starts in [DUMET 2009; AIPMT (Cancelled) 2015]
   (a) Kidney (b) Liver
   (c) Spleen (d) Red bone marrow

6. In rabbit the colour of bile juice is
   (a) Colourless due to the presence of sodium and potassium taurocholate
   (b) Green due to the accumulation of biliverdin
   (c) Red due to the accumulation of haemoglobin
   (d) Yellow due to the presence of bilirubin

7. During absorption of carbohydrates in the blood the most rapidly transported monosaccharide is [BHU 2012]
   (a) Glucose (b) Galactose
   (c) Fructose (d) Sucrose

8. The wall of the stomach is protected against the action of *HCl* by **[J & K CET 2010]**
(a) Epidermal layer (b) Mesodermal layer
(c) Mucous layer (d) Muscular layer

9. Column I contains names of the sphincter muscles of the alimentary canal and column II contains their locations. Match them properly and choose the correct answer

	Column I		Column II
A.	Sphincter of ani internus	1.	Opening of hepatopancreatic duct into duodenum
B.	Cardiac sphincter	2.	Between duodenum and posterior stomach
C.	Sphincter of Oddi	3.	Guarding the terminal part of alimentary canal
D.	Ileocaecal sphincter	4.	Between oesophagus and anterior stomach
E.	Pyloric sphincter	5.	Between small intestine and bowel

[NCERT; KCET 2011]
(a) $A-3, B-2, C-4, D-1, E-5$
(b) $A-2, B-5, C-1, D-4, E-3$
(c) $A-3, B-4, C-1, D-5, E-2$
(d) $A-4, B-3, C-1, D-2, E-5$

10. The pungent odour of faeces is due to presence of **[MP PMT 1997]**
(a) Indole (b) Skatole
(c) Various gases (d) All the above

11. Maximum percentage of lipoprotein is present in **[DPMT 2007]**
(a) Chylomicron (b) HDL
(c) VDL (d) VLDL

12. Where do certain symbiotic microorganisms normally occur in human body **[NCERT; CBSE PMT (Mains) 2012]**
(a) Caecum
(b) Oral lining and tongue surface
(c) Vermiform appendix and rectum
(d) Duodenum

13. For the enzyme action **[BHU 1995]**
(a) Value of *Km* is unchange (b) Value of *Km* is low
(c) Value of *Km* is constant (d) Value of *Km* is high

14. Inhibition of gastric secretion is brought about by **[CMC Vellore 1993; CBSE PMT 1994; MP PMT 2003; CPMT 2005]**

Or

Which of these is not an enzyme of digestive system
(a) Cholecystokinin (b) Pancreozymin
(c) Gastrin (d) Enterogastron

15. A principal gastrointestinal hormone is
(a) Prolactin (b) Choline esterase
(c) Secretin (d) Acetyl

16. The activator of intestinal juice is **[JIPMER 1993]**

Or

Mechanical stimulation of villi by the food produces a hormone which is known as **[RPMT 2005]**
(a) Succus entericus (b) Secretin
(c) Enterocrinin (d) Enterozymase

17. Anxiety and eating spicy food together in an otherwise normal human, may lead to **[NCERT; CBSE PMT (Pre.) 2012]**
(a) Indigestion (b) Jaundice
(c) Diarrhoea (d) Vomiting

18. Wisdom teeth in human is **[CPMT 2002; RPMT 2005]**
(a) 3rd molar & 4 in number (b) 3rd molar & 2 in number
(c) 2nd molar & 4 in number (d) 2nd molar & 2 in number

19. In the stomach, gastric acid is secreted by the **[NEET (Phase-I) 2016]**
(a) Gastrin secreting cells (b) Parietal cells
(c) Peptic cells (d) Acidic cells

20. Which of the following can be called 'animal starch' **[AIIMS 1993]**
(a) Hemicellulose (b) Glucose
(c) Glycogen (d) Chitin

21. One of the following is needed for the conversion of trypsinogen into trypsin **[NCERT; CBSE PMT 1995, 99; AFMC 1996; BHU 2000; Kerala PMT 2008]**

Or

Trypsinogen is an inactive enzyme secreted by the pancreas. It is activated by **[WB JEE 2016]**
(a) *HCl* (b) Enterokinase
(c) Lipase (d) Zymase

22. Leison in ventromedial hypothalmus **[MP PMT 2004]**
(a) Increases hunger (b) Decreases hunger
(c) Do not change hunger (d) Stop eating

23. Antihaemorrhagic vitamin is **[BHU 2008]**
(a) Vitamin *A* (b) Vitamin *B*
(c) Vitamin *C* (d) Vitamin *K*

24. The mine workers are most likely to suffer from
(a) Beri-beri (b) Osteomalacia
(c) Scurvy (d) Xeropthalmia

25. Write proper option by matching column I, II and III

Column I (Name)		Column II (Enzyme)		Column III (Function)	
(i)	Gastric Juice	(P)	Chymo-trypsinogen	(A)	Dipeptide convert into amino acid
(ii)	Intestinal Juice	(Q)	Ptyalin	(B)	Proteoses convert into small polypeptides
(iii)	Saliva	(R)	Renin	(C)	Casein convert into paracasein
(iv)	Pancreat ic juice	(S)	Erepsin	(D)	Conversion of starch into maltose

[GUJCET 2015]
(a) (i - R – C) (ii - S – A) (iii - Q – B) (iv - P – D)
(b) (i - R – C) (ii - S – A) (iii - Q – D) (iv - P – B)
(c) (i - S – D) (ii - R – C) (iii - P – B) (iv - Q – A)
(d) (i - Q – A) (ii - P – C) (iii - R – B) (iv - S – D)

26. Wound healing is enhanced by a vitamin **[MP PMT 2002]**
(a) *A* (b) *C*
(c) *D* (d) *E*

27. Which of the following pair is characterised by swollen lips, thick pigmented skin of hands and legs and irritability **[CPMT 2004]**
(a) Iodine – Goitre
(b) Protein – Kwashiorkor
(c) Thiamine – Beri-Beri
(d) Nicotinamide – Pellagra

28. Select the mismatch between a vitamin and its deficiency disease, among the following **[AIEEE Pharmacy 2004]**
(a) Riboflavin-slow clotting of blood
(b) Niacin-damage to skin and lining of intestine
(c) Ascorbic acid-scurvy
(d) Thiamine-damage to nerves and heart.

29. The delicious food generally makes mouth watery. It is due to **[J & K CET 2002]**
(a) Hormonal response (b) Neural response
(c) Olfactory response (d) Optic response

30. A triglyceride molecule has or A typical fat molecule is made up of **[Kerala CET 2003; NEET (Phase-I) 2016]**
(a) Three fattyacids with one glycerol molecule
(b) Three fattyacids with two glycerol molecule
(c) Two fattyacids with two glycerol molecules
(d) One fattyacid with one glycerol molecule

31. Excessive stimulation of vagus nerve in humans may lead to **[AIIMS 2003]**
(a) Hoarse voice
(b) Peptic ulcers
(c) Efficient digestion of proteins
(d) Irregular contractions of diaphragm

32. Protein deficiency in children is called **[KCET 1994; CBSE PMT 1998; BHU 2003; DPMT 2007; AFMC 2008; CPMT 2008]**

Or

In Africa and South-east Asia, people like to have much bread and butter than pulses. They suffer
(a) Obesity (b) Marasmus
(c) Diabetes (d) Kwashiorkor

33. The intestine is different from the stomach by the presence of **[NCERT; AIIMS 1993]**
(a) Digestive gland (b) Villi
(c) Sub-mucosa (d) Serosa

34. In the empty stomach, mucosal folds appear. They are called **[MP PMT 2002]**
(a) Fiveoles (b) Ancinura angularis
(c) Rugae (d) None

35. Which of the following controls the peristaltic movement of the intestine **[BHU 2002]**
(a) Sacral plexus (b) Brachial plexus
(c) Discoidal plexus (d) Auerbach's plexus

36. Secretin hormone is secreted by **[CBSE PMT 2002]**
(a) Liver (b) Pancreas
(c) Intestine (d) Brunner's glands

37. Consider the following statements
A. The anti pellagra vitamin is nicotinamide present in milk, yeast, meat and leafy vegetables
B. Crypts of Leiberkuhn are present in the liver
C. Steapsin is the pancreatic amylase **[Kerala PMT 2007]**
(a) *A* and *B* correct (b) *B* and *C* correct
(c) *A* and *C* incorrect (d) *A* and *C* correct
(e) *B* and *C* incorrect

38. Digestion process in humans is **[BHU 2002]**
(a) Extracellular (b) Intracellular
(c) Intercellular (d) Both (a) and (c)

39. Mumps are caused due to
(a) Excessive cold
(b) Viral infection in tonsils
(c) Viral infection of parotid salivary glands
(d) Viral infection of zygomatic glands

40. The folds of Kerkring are developed in
(a) Duodenum (b) Jejunum
(c) Ileum (d) Large intestine

41. Meckel's diverticulum is found in **[JIPMER 2002]**
(a) Ileum (b) Appendix
(c) Pylorus (d) Rectum

42. Which of the following carries glucose from digestive tract to liver **[CBSE PMT 1999; Pb. PMT 2000; BHU 2001]**
(a) Hepatic artery (b) Pulmonary vein
(c) Hepatic portal vein (d) Renal portal system

43. Which of the following sugars is absorbed from the small intestine by facilitated diffusion **[CBSE PMT 2001]**
(a) Fructose (b) Glucose
(c) Sucrose (d) Lactose

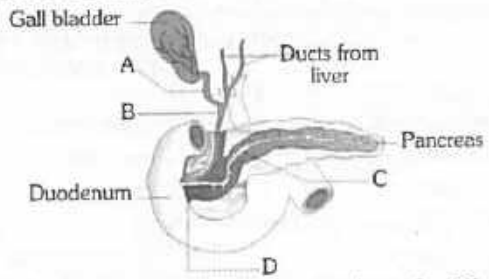
44. Mammals drink water and also obtain it from **[MP PMT 2013]**
(a) Break down of glycogen into glucose
(b) Secretion of saliva
(c) Conversion of oxyhaemoglobin to haemoglobin
(d) Oxidation of glucose

45. Select the correct match of the digested products in humans given in Column I with their absorption site and mechanism in Column II **[NEET 2013]**

	Column I	Column II
(a)	Cholesterol, maltose	Large intestine, active absorption
(b)	Glycine, glucose	Small intestine, active absorption
(c)	Fructose, Na^+	Small intestine, passive absorption
(d)	Glycerol, fatty acids	Duodenum, move as chilomicrons

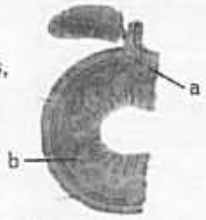
46. A healthy person eats the following diet-5gm raw sugar, 4 gm albumin, 10 gm pure buffalo ghee adulterated with 2gm vegetable ghee (hydrogenated vegetable oil) and 5 gm lignin. How many calories he is likely to get **[NEET (Karnataka) 2013]**
(a) 126 (b) 164
(c) 112 (d) 144

47. The given figure is a duct system of liver, gall bladder and pancreas. Identify the names of ducts from A to D **[NCERT]**



(a) A - Cystic duct, B - Pancreatic duct, C - Bile duct, D - Hepato - pancreatic duct
(b) A - Cystic duct, B - Bile duct, C - Hepato - pancreatic duct, D - Pancreatic duct
(c) A - Bile duct, B - Cystic duct, C - Pancreatic duct, D - Hepato - pancreatic duct
(d) A - Cystic duct, B - Bile duct, C - Pancreatic duct, D - Hepato - pancreatic duct

48. Which option is correct for the region labelled as 'a' and 'b' in the given diagram of transverse section of gut **[GUJCET 2014]**



(a) a = Nerve, b = Circular muscle
(b) a = Sub mucosal plexus of vessels, b = Mucosal gland
(c) a = Villi, b = Mucosal gland
(d) a = Longitudinal muscle, b = Muscularis mucosa

49. Pituitary gland is located in 'a', which is a 'b' and 'c' bone **[GUJCET 2014]**
(a) a = Sella turcica, b = Raised surface, c = Ethmoid
(b) a = Reketh's pauch, b = Depression, c = Nasal
(c) a = Sella turcica, b = Depression, c = Sphenoid
(d) a = Reketh's pauch, b = Depression, c = Sphenoid

50. The enzyme that is not present in succus entericus is **[AIPMT 2015]**
(a) Nucleases (b) Nucleosidase
(c) Lipase (d) Maltase

51. Good vision depends on adequate intake of carotene rich food
Select the best option from the following statements
(A) Vitamin A derivatives are formed from carotene
(B) The photopigments are embedded in the membrane discs of the inner segment
(C) Retinal is a derivative of Vitamin A
(D) Retinal is a light absorbing part of all the visual photopigments
Options **[NEET 2017]**
(a) (A) and (B) (b) (A), (C) and (D)
(c) (A) and (C) (d) (B), (C) and (D)

A R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Blood sugar level falls rapidly after hepatectomy.
Reason : The glycogen of the liver is the principal source of blood sugar. **[KCET 2009]**

2. Assertion : Arachidic acid is an unsaturated fatty acid
Reason : There are present one or more double bonds between carbon atoms in unsaturated fatty acids **[AIIMS 2007]**

3. Assertion : Rumen of alimentary canal of ruminant animals harbour numerous bacteria and protozoa.
Reason : Bacteria and protozoa help in the secretion of gastric juice in the rumen.

4. Assertion : Many tube like glands are present in the wall of small intestine.
Reason : These glands secrete enzymes DNAse and RNAse into the intestinal juice.

5. Assertion : Minerals are not biologically active substances.
Reason : Some individuals suffer anaemia due to deficiency of copper. **[AIIMS 2009]**

6. Assertion : Thick layers of muscles are present in the wall of alimentary canal.
Reason : These muscles help in the mixing of food materials with the enzymes coming from different glands in the alimentary canal. **[AIIMS 2007, 10]**

7. Assertion : In alcoholic fermentation, the hexose molecule is converted into glucose and fructose.
Reason : Alcoholic fermentation is anaerobic respiration brough about by enzyme zymase. **[AIIMS 1996]**

8. Assertion : Insulin is secreted by α-cells of islets of langerhans of pancreas.
Reason : Insulin promotes conversion of glucose to glycogen. **[AIIMS 1996]**

9. Assertion : Carbohydrates are more suitable for the production of energy in the body than proteins and fats.
Reason : Carbohydrates can be stored in the tissues as glycogen for use in the production of energy, whenever necessary.

10. Assertion : The amino acid glycine comes under the category of nonessential amino acids.
Reason : This is due to the fact that it can not be synthesised in the body. **[AIIMS 2010]**

11. Assertion : Scurvy is caused by deficiency of vitamin.
Reason : Deficiency of ascorbic acid causes scurvy. **[AIIMS 2001]**

12. Assertion : The main part of carbohydrate digestion takes place in small intestine.
Reason : Here pancreatic amylase converts carbohydrates into lactose. **[AIIMS 1995]**

13. Assertion : In alcoholic drink, the alcohol is converted into glucose in the liver.
Reason : Liver cells are able to produce glucose from alcohol by back fermentation. **[AIIMS 1996]**

14. Assertion : Adult human being is not perfect in digestion of milk.
Reason : With age, man produces little or no lactase in the intestinal juice.

15. Assertion : Trypsin helps in blood digestion of predator animals.
Reason : Trypsin hydrolyses fibrinogen.

16. Assertion : Volume and fluidity of intestinal contents have increased in a person.
Reason : The person drank sea water.

17. Assertion : Sea-faring fishermen sometimes eat raw fish.
Reason : They can be deficient of Vitamin B_1. **[AIIMS 2001]**

18. Assertion : Starch is hydrolysed by ptyalin to maltose.
Reason : Sucrase hydrolyses sucrose to lactose. **[AIIMS 2001]**

19. Assertion : Cold blooded animals have no fat layer.
Reason : Cold blooded animals use their fat for metabolic process during hibernation. **[AIIMS 1997]**

20. Assertion : Absorption of digested food mainly occurs in the stomach.
Reason : Stomach produces the hormone gastrin and the intrinsic factor and it liquifies ingested food. **[AIIMS 1996]**

Answers

Digestive system

1	a	2	e	3	b	4	b	5	c
6	e	7	c	8	a	9	a	10	c
11	b	12	c	13	d	14	a	15	c
16	d	17	b	18	a	19	a	20	c
21	b	22	d	23	c	24	a	25	d
26	d	27	a	28	c	29	c	30	b
31	c	32	d	33	b	34	c	35	a
36	b	37	c	38	b	39	b	40	b
41	a	42	b	43	b	44	e	45	c
46	c	47	d	48	b	49	a	50	d
51	d	52	b	53	b	54	d	55	a
56	b	57	c	58	a	59	d	60	a
61	c	62	a						

Digestive glands

1	d	2	d	3	a	4	b	5	a
6	b	7	b	8	c	9	b	10	b
11	d	12	c	13	a	14	d	15	b
16	b	17	c	18	a	19	b	20	c
21	a	22	a	23	c	24	a	25	b
26	a	27	b	28	a	29	c	30	c
31	b	32	b	33	b	34	d	35	c
36	c	37	b	38	b	39	a	40	d
41	b	42	b	43	b	44	a	45	a
46	d	47	c	48	c	49	b	50	b
51	a	52	d	53	b	54	a	55	c
56	d	57	a	58	d	59	c	60	b
61	d	62	c	63	b	64	b		

Physiology of digestion

1	d	2	c	3	a	4	d	5	c
6	c	7	d	8	c	9	a	10	c
11	a	12	c	13	b	14	a	15	a
16	b	17	a	18	d	19	d	20	d
21	b	22	b	23	d	24	b	25	c
26	b	27	c	28	a	29	a	30	b
31	b	32	c	33	a	34	a	35	a
36	b	37	d	38	d	39	a	40	a
41	b	42	a	43	d	44	b	45	a
46	a	47	a	48	c	49	d	50	b
51	d	52	a	53	d	54	b	55	a
56	c	57	b	58	d	59	d		

Gastro intestinal hormones/Digestive enzymes

1	a	2	d	3	d	4	c	5	c
6	d	7	c	8	d	9	a	10	c
11	d	12	a	13	a	14	a	15	c
16	a	17	d	18	d	19	b	20	c
21	b	22	c	23	a	24	c	25	d
26	c	27	a	28	d	29	a	30	c
31	a	32	b	33	d	34	d	35	d
36	c	37	a	38	a	39	a	40	c
41	c	42	b	43	c				

Nutrition and Nutritional requirement

1	a	2	b	3	b	4	a	5	d
6	b	7	d	8	b	9	b	10	c
11	a	12	a	13	a	14	b	15	a
16	b	17	d	18	b	19	c	20	b
21	b	22	a	23	c	24	c	25	d
26	c	27	b	28	d	29	a	30	a
31	b	32	d	33	b	34	d	35	b
36	c	37	a	38	b	39	b	40	d
41	c	42	c	43	c	44	c	45	b
46	d	47	b	48	b	49	d	50	b
51	b	52	b	53	a	54	a	55	c
56	a	57	b	58	c	59	d	60	b
61	b	62	d	63	b	64	a	65	c
66	b	67	a	68	d	69	d	70	b
71	c	72	c	73	d	74	a	75	d
76	a	77	b	78	a	79	c	80	d
81	b	82	a	83	a	84	b	85	a

86	c	87	d	88	b	89	c	90	c
91	c	92	a	93	c	94	d	95	e
96	d	97	b	98	c	99	b	100	c
101	c	102	c	103	a	104	d	105	a
106	d	107	c	108	a	109	b	110	c
111	a	112	c	113	a	114	c	115	a
116	a	117	b	118	a	119	a	120	b
121	c	122	b	123	c	124	d	125	c
126	b	127	a	128	d	129	c	130	d
131	c	132	c	133	b	134	a	135	b
136	a	137	b	138	d	139	c	140	b
141	a	142	d	143	c	144	d	145	c
146	b	147	b	148	d	149	c	150	d
151	c								

NCERT Exemplar Questions

1	d	2	c	3	a	4	b	5	b
6	c	7	d	8	d	9	a		

Critical Thinking Questions

1	a	2	d	3	c	4	d	5	b
6	b	7	b	8	c	9	c	10	d
11	a	12	a	13	b	14	d	15	c
16	c	17	a	18	a	19	b	20	c
21	b	22	b	23	d	24	b	25	b
26	b	27	d	28	a	29	b	30	a
31	b	32	d	33	b	34	c	35	d
36	d	37	e	38	d	39	c	40	b
41	a	42	c	43	a	44	d	45	b
46	d	47	d	48	b	49	c	50	a
51	b								

Assertion and Reason

1	a	2	d	3	c	4	c	5	d
6	a	7	e	8	e	9	b	10	c
11	a	12	c	13	d	14	a	15	a
16	a	17	a	18	d	19	b	20	e

Answers and Solutions

Digestive system

1. (a) The lower Jaw of man is formed by the fusion of dentary bone only.

2. (e) Dental formula of Rabbit is $\frac{2,0,3,3}{1,0,2,3}\times 2=\frac{16}{12}=28$

3. (b) Upper canines are most developed in Walrus.

4. (b) Crown of the teeth is covered by the hardest substance of the body called enamel.

5. (c) Foliate papillae are present only on tongue of rabbit.

12. (c) In frog teeth are pre maxillary, maxillary and vomerine.

13. (d) Tongue forms the floor of the oral cavity and it helps in the act of swallowing, help in mixing saliva with the food, help in speaking etc.

14. (a) Dental formula for milk teeth is $\frac{2102}{2102}$ so premolars are absent.

15. (c) Taste buds for bitter taste are found on tongue at posterior part while anterior tip for sweetness and lateral sides are responsible for sour.

17. (b) If a person suddenly starts coughing while swallowing food, it is due to improper movement of epiglottis. If the glottis is not properly closed some food can enter respiratory tract.

19. (a) In mammals, the digestion starts from mouth. Mouth contain 3-pair salivary gland which secretes saliva. Saliva contains a starch splitting enzyme ptyalin which acts on cooked starch changing them into a sugar maltose, isomaltose and limit dextrin.

20. (c) The dental formula of Rabbit is $\frac{2033}{1023}=\frac{8}{6}\times 2=28$, so 28 teeth occur in rabbit, canines are absent and Diastema is present between incisor and premolar.

21. (b) Premolar and molar teeth with transverse ridges called lophos, so, premolar and molar are lophodont occurs in rabbit and elephant.

23. (c) Upper incisor of an elephant is an enormously enlarged, called tusk teeth.

25. (d) The third molar appear very late and are called wisdom teeth. From evolutionary point of view it is vestigeal structure.

26. (d) Teeth of frog are homodont, acrodont and polyphyodont. They are small, sharp and backwardly directed which are not meant for mastication but for preventing escape of prey.

27. (a) Dentine forming cells, the odontoblasts line the pulp cavity of teeth.

28. (c) Lacteals are central lymph vessel found in villi of intestine. It is related to absorption of fats.

29. (c) The wall of alimentary canal is made up of four basic layers. First of all there is serosa which is a thin membranous covering around oesophagus. Then there is muscle layer-outer layer of longitudinal muscles and inner layer of circular muscles. Last there is submucosa which contains a few oesophageal glands. Then comes mucosa which have several layers of flattened cells.

30. (b) Dental formula of human is $\frac{2,1,2,3}{2,1,2,3}=\frac{8}{8}\times 2=32$. It shows the number of incisor 2, canine 1, premolar 2 molar 3 in each half upper and half lower jaw with 32 teeth in buccal cavity.

31. (c) Animals which eat their own faeces are called pseudo ruminants or coprophagus and phenomenon is known as pseudo rumination or coprophagy. e.g., Rabbit, Guinea pig.

34. (c) The muscular contraction in alimentary canal is known as peristalsis due to which the food passes from front to backward direction in the lumen of alimentary canal.

35. (a) Its large broader anterior part is called cardiac stomach, while the short narrower posterior part the pyloric stomach. So fundic part is absent in Stomach of frog.

36. (b) The fundic part of stomach consist 2 type of cells, chief or zymogenic cell secrets pepsin and oxyntic or parietal cell secretes *HCl*.

38. (b) Inner lining of gut, stomach and liver is composed of simple columnar epithellium, single layer of non ciliated rectangular cells contains goblet cells, nuclei at basis of cell.

39. (b) The mucosal lining of the oesophagus of mammals is made of squamous epithelium, several layers of cell deep layers, deep layers are cuboidal to columnar surface layers flat and scale like.

41. (a) Casein is a phosphoprotein found in milk. It is digested by rennin enzyme.

42. (b) The site of protein digestion is stomach where pepsin enzyme occur which changes protein to peptones + proteases.

43. (b) Stomach of ruminants is divided in 4 chamber, Rumen, Reticulum, omasum and abomasum. Some ruminants like camel and deer do not have omasum.

46. (c) In the wall of intestine, lymphatic tissue are present called peyer's patches. Peyer's patches are a group of lymph nodules that are most numerous in the ileum and produce lymphocyte.

50. (d) Peyer's patches are found in the ileum of mammals.

51. (d) Water is mostly absorbed in colon. Colon is a part of large intestine.

52. (b) The intestinal juice or succus entericus is secreted by crypts of lieberkuhn.

55. (a) Goblet cells are specialized unicellular cells that secrete mucus and form glands of the epithelium the stomach, intestine and part of the respiratory tract.

57. (c) Brunner's gland are found in submucosa of duodenum.

58. (a) Chief cells or pepsinogenic or zymogenic cells secretes pepsinogen and prorennin. These cells are situated in fundic part of stomach.

59. (d) Intestinal villi are mainly concerned with the absorption, the main function of intestinal villi is to provide large surface area for absorption.

60. (a) Crypt of lieberkuhn is a type of simple tubular glands in which secretory portion is straight and tubular.

62. (a) Vermiform appendix is vestigeal organ of man which is found in alimentary canal.

Digestive glands

1. (d) The endocrine part of pancreas is known as islets of Langerhans which contains 4 type of cell α-cell, β-cells, γ-cells and Δ-cell.

2. (d) Brunner's glands are present in the submucosa of duodenum and secrete HCO_3^-.

3. (a) Bile salts emulsify the fats and later on digested by enzyme lipase.

6. (b) Parotid glands are one pair largest salivary gland which is situated below ear (pinna).

8. (c) Pancreatic juice is also called as complete digestive juice. It contains trypsin, chymotrypsin, amylase, and lipase, which digest all types of food materials.

9. (b) Gastric juice of infants contains pepsinogen, lipase and rennin.

10. (b) Ptyalin is slightly acidic because its pH value is 6.8.

11. (d) Liver cell synthesize vitamin A from carotene and store vitamines A, D and B_{12}.

12. (c) Argentaffin cells are generally located at the base of gastric glands and secrete serotonin.

15. (b) Pancreas is a mixed gland its exocrine part release enzyme and endocrine part release hormones so, pancreatic juice and hormones are secreted by different cell.

16. (b) Amylase is present in saliva it is slightly acidic nature because its *pH* value is 6.8.

18. (a) Intestinal juice is a clear yellow fluid with slightly alkaline nature *pH* of 7.6, contains water, mucus and enzymes.

19. (b) Intestinal juice or succus entericus is mainly secreted by crypts of lieberkuhn.

20. (c) Liver of rabbit is partly divided into 5 lobes; three lobes on left side are a small spigelian, left lateral and left central, while two lobes on the right side are caudate and right central or cystic.

24. (a) Sub maxillary and sub lingual glands are salivary gland secretes saliva, which participates in digestion of starch.

25. (b) Human beings have 3 pairs of salivary glands parotid, submandibular and sublingual.

26. (a) Ptyalin is an enzyme of salivary juice.

27. (b) Ptyalin (salivary amylase) and pancreatic amylase are the starch spliting enzyme released by salivary gland and pancreas.

28. (a) A lubricant mucin in saliva is made up of glycoprotein.

29. (c) Liver detoxifies and neutralises harmful substances.

30. (c) The trypsin enzyme is present in pancreatic juice which is secreted by pancreas.

31. (b) Bilirubin and biliverdin are bile pigments and are present in the bile juice.

33. (b) By cystic duct bile juice passes into gall-bladder from liver.

34. (d) Infra orbital salivary gland is absent in man while in other mammals such as rabbit it is found.

35. (c) Bile juice contains bile salts and bile pigments.

36. (c) Gastric juices have *pH* 2-3.7.

37. (b) The bacteria are found in the colon which infact are the main source of vitamin-B_{12} as vitamin-B_{12} is not found in plants. Few micro-organisms of the rumen of stomach of ruminant mammals also synthesize large quantity of vitamin-B_{12}.

38. (b) In human body glycogen is stored in liver and muscles both total 400 gm. glycogen stored, 100 gm. in Liver and 300 gm. in muscles.

39. (a) Gastric juice is secreted by gastric glands. It consist pepsin, rennin, lipase.

40. (d) Arginase is found in liver. It is very important enzyme for ornithine cycle.

47. (c) Bile has no digestive enzymes and hence, no chemical action on food.

48. (c) The chief function of bile is emulsification of fats and make easy digestion of fats.

49. (b) Pancreatic juice is secreted from pancreas its *pH* about 8.4.

50. (b) Glycogenesis and glycogenolysis both process found in liver.

52. (d) Bile juice synthesis in liver helps in digestion of fats but it does not contains any digestive juice so liver is a organ which does not produce any digestive enzyme.

56. (d) Intestinal juice contains many enzymes like maltase, sucrase, lactase etc.

57. (a) The largest gland in human body is liver.

60. (b) Caudate is the part of right lobe of liver.

61. (d) Daily secretion of saliva in man is about 1-1.5 lit.

62. (c) Lysozymes are found in saliva and tears both.

Physiology of digestion

1. (d) Fructose is absorbed with the help of the carrier ions like Na^+. This mechanism is called facilitated transport.

3. (a) Lacteals are related with the absorbtion of fats are found in ileum.

4. (d) Pancreas is a digestive gland that secretes pancreatic juice. This juice acts on all type of food *i.e.*, protein, starch, fat and nucleic acid. If pancreas is removed from the body, the digestion does not occur.

5. (c) Chylomicron's are fat droplets coated with glycerol and protein.

7. (d) Trypsin is a protein digesting enzyme occur in pancreatic juice.

9. (a) Glycolysis is the first phase in the breakdown of glucose change in pyruvic acid occur in animal cell.

10. (c) A good source of lipase is pancreatic juice which is converted to fat into fatty acid + Glycerol.

11. (a) The end product of carbohydrate metabolism is CO_2 and H_2O.

12. (c) Glycogen is a polysaccharide which is synthesized and stored in liver cell.

17. (a) Emulsified fat is digested by lipase enzyme which is secreated by pancreatic juice, and intestinal juice.

20. (d) Parietal or oxyntic cells release HCL required for the activation of pepsin.

23. (d) Digestion is defined as the conversion of non-diffusable food particle in diffusable food particle.

24. (b) Breaking of large fat droplets into fine emulsion by bile salt (Bile juice contain bile pigment and bile salt) of the liver.

26. (b) Because glucose is directly absorbed by the blood.

28. (a) Those enzyme who digest protein called proteolytic enzyme, these are trypsin, peptidase, pepsin.

30. (b) Rennin hydrolyses the milk protein casein into paracasein.

32. (c) Gluconeogenesis is the process in which glucose is formed from substance other than the carbohydrates.

35. (a) Trypsin and pepsin both are endopeptidase enzyme. Trypsin digest proteins in alkaline medium while pepsin digest protein in acidic medium.

39. (a) All lipid digestion takes place in the small intestine. Fatty acids and glycerol are the digestion products of lipids.

40. (a) Caecum is a small, pouch-like structure which ends into a tubular structure called vermiform appendix.

42. (a) Carbohydrate and fats (lipids) are chief energy source although proteins can also gives energy.

Macronutrient	Gross Caloric Value Kcal/g	Physiologic Value kcal/g
Carbohydrate	4.1	4
Protein	5.65	4
Fat	9.45	9

47. (a) Rennin enzyme is found in gastric juice. It is a milk coagulating proteinase. Rennin acts on casein (milk protein) and convert into calcium paracasinate. It is known as curdling of milk.

48. (c) Because protein is primarily digested in the acidic media.

49. (d) Because human alimentary canal lacks cellulase enzyme and symbiotic micro-organisms.

54. (b) Enzyme erepsin is found in intestinal juice. It converts peptones to amino-acids.

57. (b) Bile salts help in the absorption of fats and fat soluble vitamin such as A, D, E and K in intestine.

58. (d) Fatty substance are emulsified by bile salts secreted by liver.

Gastro intestinal hormones/Digestive enzymes

2. (d) Cholecystokinin-pancreozymine hormone is secreted by the epithelium of entire small intestine. It stimulates the gall bladder to release bile and pancreas to secrete and release digestive enzymes in the pancreatic juice.

5. (c) Most of proteases are secreted in inactive forms called proenzyme. Propepsin and trypsinogen both are inactive form of proteolytic enzyme.

7. (c) Secretin is secreted by the mucosa of duodenum and it stimulates the secretion of pancreatic juice and increase the duodenal movements. Thus it plays important role in digestion.

8. (d) Amylase is a starch splitting enzyme similar to ptyalin, hydrolysing starch and glycogen to maltose, isomaltose and limit dextrin.

9. (a) Isoenzymes are those enzymes which are found in more than one form having similar functions.

10. (c) Gastric glands are lined with three kinds of secreting cells zymogen (main, peptic or chief) cells, parietal cells and mucous cells. The main peptic or zymogen cells secrete digestive proenzyme namely pepsinogen and prorennin. *HCl* convert pepsinogen and prorennin into pepsin and rennin.

11. (d) Enteropeptidase or enterokinase is an enzyme involved in human digestion.
Trypsin has an important role in the digestion of proteins in the anterior portion of the small intestine. It also activates other proteases in the pancreatic juice. Therefore in the absence of enterokinase the process of conversion of dipeptides to amino acids will be affected.

13. (a) Rennin is secreted by the cells of stomach in inactive form as prorennin and then activated to Rennin by *HCl*.

16. (a) Bile is secreted by liver and stored in gall bladder.

18. (d) Pepsin initiates the digestion of protein in stomach producing proteoses and peptones.

20. (c) Pancreatic lipase (formely called steapsin) hydrolyses fats into glycerol and fatty acids.

21. (b) Stored glycogen is broken down to glucose under the effect of glucagons secreted by alpha cells of Islets of Langerhans.

25. (d) Gastrin is a polypeptide hormone secreted by the pyloric mucosa which stimulates the stomach to release gastric juice.

26. (c) Cholecystokinin is a polypeptide hormone produced by the mucosa of the upper intestine which stimulates contraction of gall bladder.

28. (d) Renin is the hormone secreted by JGA in kidney. It is released due to hypotention (low BP).

30. (c) Trypsin an enzyme or enzyme complex is a part of pancreatic juice and is able to digest proteins in alkaline medium.

31. (a) Insulin is produced by β – cells of islets of Langerhans.

32. (b) Enterokinase is a gastro-intestinal enzyme secreted by small intestine of vertebrate, which converts trypsinogen to trypsin.

37. (a) Secretin hormone produced by duodenal mucosa which causes a copious secretion of pancreatic juice.

38. (a) Since amylase, rennin and trypsin are enzymes, therefore these all are proteins.

40. (c) The duodenal epithelium is stimulated to secrete secretin by the entry of acidic chyme into the duodenum.

42. (b) Succus entericus is the intestinal juice stimulated by secretin and cholecystokinin from the intestinal glands.

43. (c) It is a hormone secreted by the mucosa of small intestine.

Nutrition and Nutritional requirement

1. (a) Marasmus occurs due to prolonged malnutrition and deficiency of proteins and calories.

4. (a) Retinal pigment is an aldehyde of vitamin A.

10. (c) Proteins are broken down into amino acids during the process of digestion and finally all fats are converted into fatty acid, glycerol and monoglycerides.

11. (a) Proteins are made up of amino acid molecules, hence on hydrolysis they form amino acids.

14. (b) Carbohydrates are chief source of energy in the food of most of the animals. Main source of carbohydrates are cereals, fruits, milk rice, and potato.

16. (b) Casein is protein which form the part of food for the young animal. Best source of casein is milk.

18. (b) Carbohydrate are classified as :

Monosaccharides (e.g., glucose, fructose, galactose), disaccharides (e.g., sucrose, maltose, lactose) and polysaccharides (e.g., starches, glycogen, cellulose, dextrins).

19. (c) Lactose ($C_{12}H_{22}O_{11}$) is milk sugar. It is a diasaccharide composed of glucose and galactose unit.

20. (b) The anhydrobonds of protein are called peptide bonds. A peptide bond is formed between carboxyl group of one amino acid and amino group of adjacent.

21. (b) Carbohydrates are more suitable for the production of energy in the body then proteins and fats. Carbohydrate are also stored in the body cells as glycogen and are used for the production of energy whenever required.

23. (c) Essential amino acids are those which are taken from food, not synthesized in the body.

25. (d) Primary component of bones and also present in muscles and blood.

29. (a) Thiamine (B_1) deficiency is common in alcoholics. It leads to decreased mental function, double vision and reduced muscular contraction and the resulting disorder is known as Wernicke's syndrome.

30. (a) Steen Hoeck described that vitamin D is synthesized in presence of UV rays of sunlight in the skin.

31. (b) The vitamins are generally divided into Two major groups : Fat soluble (A, D, E and K) and water soluble (B – complex and C)

32. (d) Biotin or nicotinic acid consists of sulphur. It acts as coenzyme needed for protein and fatty acid synthesis, CO_2 fixation and transamination.

33. (b) On the basis of their requirement in body the inorganic elements are of two types :

(i) **Macroelements :** C, H, N_2 and O_2 are called big four elements of living body because they are required in maximum amount in the body.

(ii) **Microelements** : Iron, iodine, manganese, copper, zinc, fluorine etc, are required in minimum amount in the body.

34. (d) Barium is not used in human body.

Calcium is useful in formation of bone teeth and helps in blood clotting. It keeps muscle and nerve activity normal.

Phosphorus is important for formation of bone teeth and biomembranes. It keeps muscle and nerve activity normal. It is a part of energy carriers (ATP, ADP, AMT) nucleic acid (DNA and RNA) and coenzymes.

Zinc is a component of atleast 70 enzymes. It is also essential for vitamin A metabolism, healing of wounds and protein synthesis.

37. (a) Vitamin C is also called anti scorbutic factor and Ascorbic acid.

42. (c) Vitamin C is heat labile.

44. (c) The term vitamin was given by Funk.

47. (b) Zinc takes part in immune reactions.

55. (c) Deficiency of vitamin B_1 causes beri-beri disease. Beri-beri disease was discovered by Eijkman in 1897.

60. (b) Fluorine maintains normal dental enamel and prevents dental caries.

64. (a) Vitamin A is synthesized in liver from yellow and red carotenoid pigments.

65. (c) The given symptoms occur due to deficiency of thiamine (*vit.* B_1). Thiamine is a precursor of the coenzyme thiamine pyrophosphate which functions in carbohydrate metabolism. Deficiency leads to beriberi in humans and to polyneuritis in birds. Good sources include brewer's yeast, wheat germ, beans, peas and green vegetables.

66. (b) Because vitamin K helps in maintenance of normal prothrombin and factor VII in the blood and thus takes part in normal coagulation.

69. (d) As both vitamin B_{12} and folic acid are involved in maturation of erythrocytes in bone marrow.

75. (d) Vitamin E maintains normal functioning of reproductive organs hence it is called fertility vitamin. Sterility (impotence) and muscular atrophy is common deficiency disease of vitamin E.

79. (c) Vitamin B_{12} is a dark red compound containing cobalt.

80. (d) Vitamin D also known as calciferol. The deficiency of calciferol causes, the children suffer from rickets and adult from osteomalacia.

81. (b) Vitamin A occurs in yellow vegetables and fruits like carrots, tomatoes, papaya and mango, green leafy vegetables as spinach.

84. (b) Vitamin B_{12} is not found in plants. However it is considered that *spirulina* (an algae) contain B_{12}. Vitamin B_{12} is synthesized by intestinal bacteria which infact are main source of vitamin B_{12}. Many micro-organisms (bacteria) of the stomach of ruminant mammals also synthesize large quantities of vitamin B_{12}.

88. (b) Vitamin E is also called as tocopherol or antifertility vitamin.

89. (c) Nicotinic acid or vitamin B_5 is a pellagra preventing factor or PP factor. Pellagra caused due to the deficiency of vitamin B_5 is characterized by dermatitis (thick, pigmented skin), muscle atrophy and severe inflammation of mucous membrane of mouth.

90. (c) Vitamin B_{12} is also called cyanocobalamine. It is essential for the formation and maturation of erythrocytes.

98. (c) It increases the RBC count and the platelets through its action on the bone marrow. It promotes haemopoeisis.

100. (c) Vitamin B_{17} has been recently explained to be found in water melon. It is supposed to have anti cancer property.

109. (b) Vitamin-C (Ascorbic acid) play an important role in certain metabolic reactions. This vitamin activates an enzyme that is involved in synthesis of hydroxy proline which is an integral part of collagen. Obviously it is essential for formation and growth of connective tissues cartilage, bone, teeth etc.

110. (c) Since vitamin K helps in blood clotting, its deficiency will lead to excessive bleeding.

112. (c) Paralysis of muscle fatigue and burning feet syndrome is related with deficieny of pantothenic acid (vitamin B_3).

114. (c) In man, attached to caecum is a twisted, coiled tube, measuring about 3 inches in length, called the vermiform appendix. Inflamation of the vermiform appendix is called appendicitis.

115. (a) It takes part in the formation of coenzyme FMN and FAD.

116. (a) *Nutrition or food intake in paramecium of nutrition in amoeba is holozoic that is, amoeba is heterotrophic.*

119. (a) A young man requires approximately 3000K. cal. per day while a child of about 15 years requires 2500 and infant of 4-6 years requires about 1500 Kcal per day.

122. (b) It also maintains the integrity of epithelial tissue and prevents the infection.

124. (d) Vitamin C is necessary for formation of collagen fiber, in this way vitamin C helps for healing to the wound.

127. (a) Vitamin A was discovered by Mc collum and Davis (1915) from butter and egg yolk.

129. (c) The activity of vitamin E is destroyed by U.V. rays and oxidation.

130. (d) E.coli lives in mutual association in human colon as it obtains food from the intestine and in turn help to produce vitamin B_{12}.

133. (b) It acts as the coenzyme of pyruvate carboxylase. Its active factor is thymine pyrophosphate. It causes decarboxylation of pyruvic acid.

134. (a) Beri-beri is caused by deficiency of vitamin B_1 (thiamine)

136. (a) The chemical name of vitamin B_1 is thiamine. It can be systhesized by bacteria inside the gut.

137. (b) Because riboflavin is an orange-yellow compound, so cow's milk appears slightly yellowish.

139. (c) Vitamin K (phylloquinone) is required for the formation of clotting factors by liver, thereby its deficiency leads to delay in coagulation *i.e.* haemorrhage.

141. (a) Proteins are large molecules of high molecular weight containing C, H, O and nitrogen (N). The presence of N distinguishes them from carbohydrate and fat. Iron, copper, iodine, sulphur and phosphorus may also be present in a very low proportion. Proteins are found in fish, meat, egg, wheat, bean, ground-nut and pulses.

143. (c) Lactose or milk sugar is a disaccharide formed by the union of one molecule of galactose and one molecule of glucose. Besides milk it is found in flowers of some plants

145. (c) Vegetable oil contains low molecular weight lipids.

146. (b) Copper takes part in haemoglobin synthesis.

147. (b) Primary anaemia is due to deficiency of Fe

148. (d) Amoeba takes solid food and digests it intracellularly.

150. (d) Euglena carries on both autotrophic and hetrotrophic modes of nutrition.

Critical Thinking Questions

3. (c) The mucosa is highly folded and the single-layered mucous membrane of the infoldings forms tubular and often branched gastric gland in the lamina propria. Each gland has three types of secretory cells – neck cells, oxyntic cells, zymogen cells.

4. (d) Generally, fatty acids upto a chain length of 10 carbon atom are primarily absorbed through the blood capillaries, but those with higher chain length through lymphatic route (lymph vessels).

6. (b) The bile is a complex greenish and alkaline fluid. Containing bile salt and bile pigment. Most important bile pigment is bilirubin which is a breakdown product of hemoglobin, biliverdin is absent.

10. (d) Odour of faeces is due to presence of toxic amines indole and skatole derived from action of bacteria on amino acid. Gases also causes odour in faeces. They are produced by fermentation of carbohydrate.

11. (a) A lipoprotein is a biochemical assembly that contains both proteins and lipids. There are several types of lipoproteins, each having different functions, but all essentially are transport vehicles. Lipoproteins are categorized and named mainly accordingly to their density which varies with the ratio of lipids to proteins from largest and highest to smallest and heaviest, the four major classes of lipoproteins are chylomicrone, VLDL, LDL and HDLs.

12. (a) Caecum is small blind sac which host some symbiotic micro-organism.

14. (d) Enterogastrone is secreted by the duodenal epithelium. It inhibits gastric secretion and motality.

15. (c) Well established gastrointestinal hormones are – i. secretin, ii. CCK , iii. Gastrin, iv. GIP, v. Motilin.

16. (c) Enterocrinin is secreted by the epithelium of entire small intestine. It stimulates the crypts of lieberkuhn to release enzymes it to the intestinal juice.

18. (a) Third molars in human being are called wisdom teeth. Number of 3rd molar in both jaw is four.

20. (c) Glycogen is a branched polymer of glucose. It is stored mostly in muscles and liver of animal and it is also called animal starch.

21. (b) In the presence of enterokinase, inactive trypsinogen is converted into active trypsin.

23. (d) Vitamin K is also known as antihaemorrhagic vitamin.

26. (b) Vitamin C promote wound healing.

27. (d) Pellagra is a disease caused by the deficiency of nicotinamide or nicotinic acid or niacin or vitamin B_5. It is frequent among people eating food with low tryptophan content. The symptoms of pellagra are inflammation of skin, diarrhoea and dementia.

28. (a) Riboflavin (vitamin B_2) causes cheilosis, which is characterized by inflammation and cracking at the angles of the mouth.

30. (a) Triglyceride molecule is completely hydrolyzed into three molecules of fatty acid + one molecule of glycerol.

32. (d) Kwashiorkor is caused by the deficiency of proteins in diet this disease occurs in children of age group 1 to 5 years.

33. (b) Intestinal villi are mainly concerned with absorption. Villi are absent in stomach.

34. (c) Empty stomach is lined with folds called rugae.

35. (d) Auerbach's plexus is a part of autonomic nervous system in vertebrates lying between the two main muscular layers of intestine and controlling its peristaltic movements.

38. (d) Digestion in human is extracellular (intercellular).

40. (b) The entire small intestine has circular folds of the mucous membrane, the 'valves' of kerkring. These folds are more prominent in the jejunum.

42. (c) The blood carries from digestive tract to liver through hepatic portal vein the blood which comes from the digestive tract contains absorbed food like glucose and amino acids.

43. (a) Glucose and galactose are absorbed by active transport. Fructose is absorbed by facilitated diffusion.

46. (d) Physiological value of carbohydrates is 4.0 *kcal/g* of proteins 4.0 *kcal/g* and of fats is 9.0 *kcal/g*

Hence

5 g raw sugar will yield $5 \times 4.0 = 20.0$ *kcal*

4 g albumin (protein) will yield $4 \times 4.0 = 16.0$ *kcal*

$10 + 2$ g of fat will yield $12 \times 9.0 = 108.0$ *kcal*

Total yield $= 144$ *kcal.*

49. (c) Pituitary gland is located in bony depression called sella turcica in sphenoid bone of cranium.

Assertion and Reason

1. (a) In liver, glycogen a reserve food material is changed into glucose (glycogenolysis) and released into blood. Under abnormal conditions, liver can convert proteins and fats into glucose by complex chemical reactions *i.e.*, called gluconeogenesis. Thus, due to hepatectomy blood sugar level falls rapidly.

2. (d) Fatty acids which lack any double or triple bond in their hydrocarbon chain are known as saturated fatty acids. Example lauric acid, arachidic acid, myristic acid, palmitic acid, stearic acid etc in contrast to saturated fatty acids, unsaturated fatty acids have one or more double bonds between carbon atoms at fixed place along the hydrocarbon chain. Example palmitoleic acid, oleic acid, linoleic acid, linolenic acid, arachidonic acid etc.

3. (c) Ruminant animals such as cattle, buffalo, sheep, goat and camel have a compound stomach, which consists of four chamber, *viz*, rumen, reticulum, omasum and abomasum. Rumen is the first and the largest of the four chambers. Rumen and reticulum harbour numerous bacteria and protozoa, which carry out extensive fermentation of cellulose. So, these two chambers function as sites for cellulose digestion in ruminants. The gastric juice containing enzymes and *HCl* is secreted only by the fourth chamber i.e., Abomasum.

4. (c) Numerous tube like glands are present in the wall of small intestine which secrete intestinal juice into the intestinal lumen. This juice contains a number of enzymes like enterokinase, aminopeptidases, dipeptidases, maltase, lactase, lipase etc. for digesting various types of food. On the other hand, the enzymes RNAse and DNAse are present in the pancreatic juice. These enzymes are secreted by the pancreas and are drained into the small intestine via Hepato pancreatic duct.

5. (d) Minerals take part in biological reactions and are thus biologically active. Anaemia is caused by deficiency of iron.

6. (a) Thick layer of muscles are present in the alimentary canal. These muscles facilitate the movement of food particles through alimentary canal. Large food particles are broken down into small, semi liquid particles by the action of these muscles. Later also help in the forward flow of food materials and mixing of enzymes coming from different glands related to alimentary canal.

7. (e) Alcoholic fermentation is the respiration in absence of O_2. In this process, hexose molecule is changed to ethyl alcohol and CO_2. In presence of zymase enzyme. In this less amount of energy is released as compared to aerobic respiration.

8. (e) Insulin is secreted by β-cells of islets of Langerhans. It helps in conversion of glucose into glycogen decreasing blood sugar level. This is called glycogenesis.

9. (b) Carbohydrates are more suitable for the production of energy in the body than proteins and fats, because carbohydrate molecules contain relatively more oxygen than the others, and consequently, requires less molecules of oxygen for their oxidation. In other words, for each litre of oxygen consumed, carbohydrates yield far more energy than proteins or fats. Carbohydrates are also stored in the tissue as glycogen for use in the production of energy, when necessary. Glycogen is the stored fuel particularly in such tissues as skeletal muscles which then have to work with a supply of oxygen far lower than their immediate need.

10. (c) Non essential amino acids are those amino acids which need not be supplied in the diet because they can be synthesised by the body, particularly from carbohydrate metabolites, Glycine is one such non essential amino acid. On the contrary, essential amino acids are those amino acids which can not be synthesised in the animal body and must be supplied with food in adequate amounts. Out of twenty amino acids, eight are considered essential in human diet.

11. (a) Ascorbic acid is called vitamin C. The deficiency of this vitamin causes scurvy.

12. (c) In small intestine Pancreatic amylase converts starch and dextrins into maltoses and small intestine is main site for digestion of carbohydrates.

13. (d) In liver, alcohol is oxidised into acetaldehyde which is further oxidised into acetate. The latter is converted to acetyl coenzyme A which is used in Krebs' cycle.

Ethyl alcohol → Acetaldehyde → Acetate → Acetyl Co A → $CO_2 + H_2O$

14. (a) The human being is the only mammal who ingests significant amount of lactose in milk. Curiously, many human adults can not digest milk, because with age they produce little or no lactose in the intestinal juice. In such persons, the lactose of milk remains undigested and is fermented in the intestine producing gases and acids. This results in flatulence, intestinal cramps and diarrhoea.

Adult human
↓
Less or no lactase
↓
Lactose remains undigested
↓
Undigested substances fermented
↓
Produce gas, acids, intestinal cramps, diarrhoea

15. (a) Trypsin is protein digesting enzyme present in the intestine of animals. Though it cannot digest casein (a milk protein), in predator animals drinking the blood of their prey, trypsin hydrolyses fibrinogen of blood into fibrin, leading to blood coagulation thus help in blood digestion. It also activates other pancreatic proteases.

16. (a) If sea water is drunk, its Mg^{2+} ions increase the solute concentration in the intestinal lumen because Mg^{2+} is absorbed very slowly. On the contrary, Mg^{2+} draws water from the blood to the intestinal lumen by osmosis. So, water is not gained, but is lost from the blood on drinking sea water. Thus, there occurs increase in the fluidity and volume of intestinal contents, in the same way this consequently stimulates intestinal peristalsis and evacuation of fluid faeces.

17. (a) Sea faring fisherman suffer from paralysis because raw fish muscles contain an enzyme which destroys Vitamin B_1.

18. (d) Starch is hydrolysed by pancreatic amylase to maltose, isomaltose and dextrins sucrose $\xrightarrow{\text{sucrase}}$ glucose and fructose.

19. (b) The body temperature in cold blooded varies with that of the environment as there is no fat deposition. On the other hand, cold blooded animals use fat during hibernation to carry out their metabolic processes.

20. (e) Absorption takes place in small intestine as it offers large surface area for absorption. Stomach produces the hormone gastrin and intrinsic factor.

Digestion and Absorption

SET Self Evaluation Test

1. Find out the correctly matched pair **[Kerala PMT 2007]**
   (a) Pepsinogen - Zymogenic cells
   (b) *HCl* - Globlet cells
   (c) Mucous - Oxyntic cells
   (d) Pancreatic juice - Salivary glands
   (e) Ptyalin - Acinar cells

2. A dental disease characterized by mottling of teeth is due to the excess of a certain chemical element in drinking water. Which of the following is that element **[BHU 2000]**
   (a) Mercury (b) Chlorine
   (c) Fluorine (d) Boron

3. Spot the salivary gland among the following **[KCET 1999]**
   (a) Sublingual (b) Adrenal
   (c) Brunner (d) Lacrymal

4. Excess carbohydrates and proteins are stored in the body as **[DUMET 2010]**
   (a) Amino acids (b) Fats
   (c) Starch (d) Monosaccharide

5. The colour of the faeces is due to the
   (a) Urochrome (b) Stercobilin
   (c) Biliverdin (d) Bacteria

6. Which one is detritus feeder **[RPMT 2000]**
   (a) Parrot (b) Sheep
   (c) Unio (d) Dung beetle

7. Lamina propria is related with
   (a) Human intestine (b) Liver of human being
   (c) Graafian follicle (d) Acinus of pancreas

8. How many teeth in man grows twice in life **[JIPMER 2001; AFMC 2002, 04]**
   (a) 32 (b) 28
   (c) 20 (d) 12

9. Find out the correct match

	Column – I		Column – II
A.	Hepatic lobule	1.	Sub mucosal glands
B.	Brunner's glands	2.	Base of villi
C.	Crypts of Lieberkuhn	3.	Glisson's capsule
D.	Sphincter of Oddi	4.	Gallbladder
E.	Cystic duct	5.	Hepato-pancreatic duct
		6.	Serous glands

[NCERT; Kerala PMT 2007; J & K CET 2008]
   (a) A–3, B–6, C–2, D–5, E–4
   (b) A–5, B–2, C–3, D–6, E–1
   (c) A–3, B–1, C–2, D–5, E–4
   (d) A–4, B–6, C–5, D–2, E–1
   (e) A–4, B–2, C–6, D–5, E–3

10. By the mechanical stimulation on the wall of stomach, a hormone is released. This is
    (a) Gastrin (b) Progesterone
    (c) Secretin (d) Pancreozymin

11. Insulin, epinephrine, glucagon collectively influence
    (a) Glyconeogenesis
    (b) Glycerophosphate shuttle
    (c) Glycolysis
    (d) Glycogenolysis and glycogenesis

12. Match the item in Column I (vitamins) with those in Column II (deficiency diseases)

Column I (Vitamins)	Column II (Diseases)
I. *K*	A. Beri-beri
II. *D*	B. Haemorrhagic disease in new born
III. B_1	C. Night blindness
IV. A_1	D. Rickets

Which one of the following is the correct matching of all the four vitamins **[CBSE PMT 1995; MP PMT 1999, 2002; DPMT 2006]**
    (a) I–C, II–B, III–D, IV–A (b) I–A, II–B, III–D, IV–C
    (c) I–C, II–A, III–D, IV–B (d) I–B, II–D, III–A, IV–C

13. Pernicious anaemia is caused due to the deficiency of **[MP PMT 2009; WB JEE 2009]**

Or

This vitamin is also known as "Castle's extrinsic factor"
    (a) Folic acid (b) Vitamin B_6
    (c) Vitamin B_{12} (d) Appendix

14. Exclusive holozoic nutrition is seen in **[Odisha JEE 2011]**
    (a) Spider (b) Man
    (c) Housefly (d) Shark

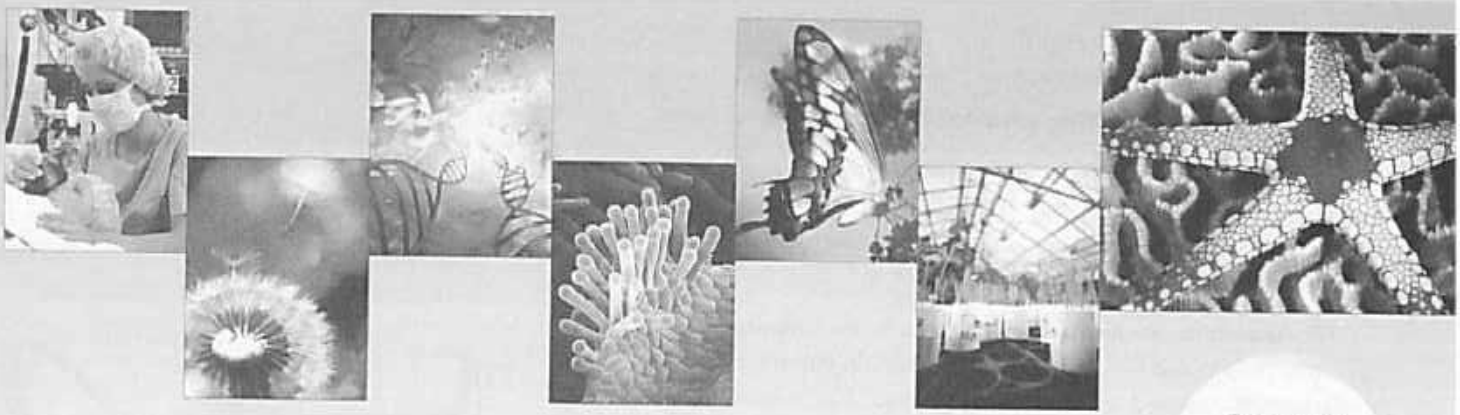
15. Symbiotic bacteria present in intestine of most primates, which synthesize certain vitamins are
    (a) *Entamoeba histolytica*
    (b) *Entamoeba coli*
    (c) *Entamoeba gingivalis*
    (d) None of these

AS Answers and Solutions

1	a	2	c	3	a	4	b	5	b
6	c	7	a	8	c	9	c	10	a
11	d	12	d	13	c	14	b	15	b

2. (c) Excess intake of fluorine causes fluorosis, which is manifested in its mild state by mottled teeth and in a more severe state by enlarged bones.
3. (a) In human, 3 pairs of salivary glands are present. They are sublingual, parotid and submaxillary.
5. (b) It is an oxidation product of bile pigment.
6. (c) Animal which feeds upon organic matter mixed with the soil e.g. earthworm and unio.
8. (c) In man, 20 teeth are diphyodont, i.e., grow twice in life.
11. (d) Epinephrine and glucagon cause glycogenolysis while insulin causes glycogenesis.
13. (c) Pernicious anaemia marked by a decrease in the number of red blood cells which is caused by a reduced ability to absorb vitamin B_{12}.
15. (b) *Escherichia coli* is common colon bacteria found in human beings and many vertebrates. This bacteria is normally not harmful but is mostly helpful in digestion through synthesis of vitamin.

* * *



Chapter

5.2

Breathing and Exchange of Gases

Cells continually use oxygen (O_2) for the metabolic reactions that release energy from nutrient molecules and produce ATP (Adenosine Tri Phosphate). At the same time, these reactions release carbon dioxide. Since an exce amount of CO_2 produces acidity that is toxic to cells, the excess CO_2 must be eliminated quickly and efficiently. The two systems that cooperate to supply O_2 and eliminate CO_2 are the cardiovascular system and the respiratory system. The respiratory system provides for gas exchange, intake of O_2 and elimination of CO_2, whereas the cardiovascular system transports the gases in the blood between the lungs and body cells.

Respiration

Respiration is a process which involves intake of oxygen from environment and deliver it to the cells. It include stepwise oxidation of food in cells with incoming oxygen, elimination of CO_2 produced in oxidation, *release of energy during* oxidation and storing it in the form of ATP. It takes place in three basic steps –

(1) **Pulmonary ventilation :** The first process, pulmonary (*pulmo* = lung) ventilation, or breathing, is the inspiration (inflow) and expiration (outflow) of air between the atmosphere and the lungs.

(2) **External (pulmonary) respiration :** This is the exchange of gases between the air spaces of the lungs and blood in pulmonary capillaries. The blood gains O_2 and loses CO_2.

(3) **Internal (tissue) respiration :** The exchange of gases between blood in systemic capillaries and tissue cells is known as internal (tissue) respiration. The blood loses O_2 and gains CO_2. Within cells, the metabolic reactions that consume O_2 and give off CO_2 during production of ATP are termed cellular respiration.

Respiratory surface

The surface at which exchange of gases (CO_2 and O_2) takes place is called respiratory surface. Respiratory surface must be vascular and have enough area for gas exchange. For example – plasma membrane in protozoa, body wall (skin) in annelids, alveocapillary membrane in men.

Respiratory medium

Oxygen is dissolved in air and water. Thus water and air are source of oxygen for animals and called respiratory medium. Water and air are external respiratory medium. Inside the body an internal respiratory medium is also found. This internal respiratory medium is tissue fluid.

Types of respiration : It is of two types

(1) **Aerobic respiration :** It occurs in the presence of molecular oxygen. The oxygen completely oxidizes the food into carbon dioxide and water, releasing large amount of energy. The organisms showing aerobic respiration, are called aerobes. It is found in most of animals and plants. Aerobic respiration is of two main types direct and indirect.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \rightarrow \underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \underset{\text{Energy}}{2830\,kJ}$$

(i) **Direct respiration :** It is the exchange of environmental oxygen with the carbon dioxide of the body cells without special respiratory organs and without the aid of blood. It is found in aerobic bacteria, protists, plants, sponges, coelenterates, flatworms, roundworms and most arthropods.

(ii) **Indirect respiration :** It involves special respiratory organs, such as skin, buccopharyngeal lining, gills and lungs, and needs the help of blood. The respiration in the skin, buccopharyngeal lining, gills and lungs is respectively called cutaneous buccopharyngeal, bronchial and pulmonary respiration. Cutaneous respiration takes place in annelids, some crustaceans, eel fish, amphibians and marine snakes. It occurs both in water and in air. Buccopharyngeal respiration is found in certain amphibians such as frog and toad. It occurs in the air. Bronchial respiration is found in many annelids, most crustaceans and

molluscs, some insect larvae, echinoderms, all fishes and some amphibians. It occurs in water only. Pulmonary respiration is found in snails, pila, some amphibians and in all reptiles, birds and mammals. It takes place in air only.

(2) **Anaerobic respiration :** It occurs in the absence of molecular oxygen and is also called fermentation. In this, the food is only partially oxidised so only a part of energy (5%) is released and of energy remains trapped in the intermediate compounds. It is found in lower organisms like bacteria and yeast. It is also found in certain parasitic worms (*Ascaris, Taenia*) which live in deficient medium. The organism showing anaerobic respiration, are called anaerobes. These involve one of following reactions.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{(Fermentation of sugars)}]{\text{In yeasts}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2 + 118\,kJ$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{In intestinal worms}} \underset{\text{Lactic acid}}{2CH_3CHOHCOOH} + \text{Energy}$$

Certain body tissues of even aerobes also show anaerobic metabolism *e.g.*, during the vigorous contraction of skeletal muscle fibres. In this, the glucose is metabolised into the lactic acid in anaerobic conditions. The rapid formation and accumulation of lactic acid are responsible for muscle-fatigue. The mammalian RBCs shows anaerobic respiration as these lack the mitochondria. In lens of eye and cornea of eye respiration is anaerobic because these structures are non vascular. Anaerobic respiration appeared first in primitive organisms because there was absence of O_2 in primitive atmosphere.

Respiratory organs

(1) **Skin :** Respiration by skin is called cutaneous respiration. Skin is the only respiratory organ in most annelids (earthworm and leeches) and an additional respiratory organ in amphibians (Toads and frogs). Skin should be thin, moist, naked, permeable and well vascular for respiration. For cutaneous respiration animal should have large surface area then its volume and should have relatively inactive life to minimize the use of oxygen. Some marine annelids such as sandworms (nereis) have parapodia (locomotory appendages) for respiration. In frog 100% cutaneous respiration during hibernation. In all marine snakes 20% respiration by skin.

(2) **Tracheae :** In insects, peripatus centipedes and millipedes tracheae are found for respiration. Tracheae are complex system of whitish, shining, intercommunicating air tubules. Tracheae are ectodermal air tubes. In cockroaches, three pairs of longitudinal tracheal trunks are present all along the length of body which are further connected with each other with the help of transverse branches. The main tracheae give off smaller tracheae whose branch repeatedly form a network of trachioles throughout the body. Trachea internally lined by chitinous cuticle called intima, which spirally thickened to form taenidae. Trachioles without taenidae, trachioles lined by trachein protein. From each tracheal trunk three branches come out. The dorsal branch is supplied to the dorsal muscles where as ventral one to nerve cord and ventral muscles and middle one to the alimentary canal.

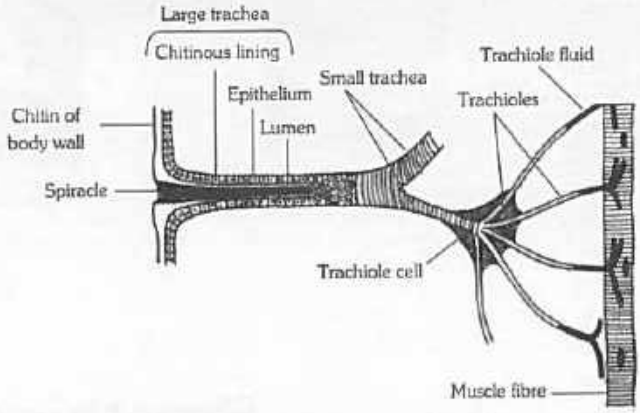


Fig : 5.2-1 Trachea of cockroach

(3) **Book lungs and book gills :** Spiders ticks, mites and scorpion (belongs to class arachnida) have book lungs for respiration. In scorpion 4 pairs of book lungs are present. A book lung is a chamber containing a series of thin vascular, parallel lamellae arranged like the pages of book. Book gills are found in marine king crab or horse shoe crab.

(4) **Gills :** Aquatic animals such as prawn, unio, fishes, sea stars and tadpoles respire by gills. Respiration by gills called bronchial respiration. Gills are of two types –

(i) **External gills :** External gills are found in arenicola (lug worm), larvae of certain insects *e.g.* damsel fly and some amphibians *e.g.* necturus, siren, proteus, frog tadpole first develop external gills which are replaced by internal gills later.

(ii) **Internal gills :** The internal gills may be phyllobranch (prawn), monopectinata (pila) eulamellibrach (unio), lamellibranch, fillibranch (pisces). In all fishes, gills are hemibranch or demibranch and holobranch. In gills, gill lamellae are found which have capillary network. Water is drawn into gills → blood flowing in the capillaries of gill lamellae absorb oxygen from water and release CO_2 → water containing CO_2 is thrown out from gills. The 80% of O_2 of incoming water is absorbed.

Table : 5.2-1 Oxygen content of respiratory media

Respiratory media	Oxygen content
Air	209.5 *ml./l.*
Fresh water at 25°C	5.8 *ml./l.*
Fresh water at 5°C	9.0 *ml./l.*
Sea water at 5°C	6.4 *ml./l.*

(5) **Buccopharyngeal lining :** Frog breathes by buccopharyngeal lining of buccopharyngeal cavity. This is called buccopharyngeal respiration.

Table : 5.2-2 Respiratory organs of animals

Animals	Respiratory organs
Protists, Bacteria	Direct respiration through plasma membrane
Porifera	Plasma membrane of each cell
Coelenterates	General body surface
Platyhelminthes (*Fasciola hepatica*, tapeworm)	Anaerobic
Nematodes (*Ascaris*)	Anaerobic
Annelids (Earthworm and Leeches)	Skin
Nereis	Parapodia
Insects	Trachea
Centipedes	Trachea
Millipedes	Trachea
Spider and Scorpion, ticks, mites	Book lungs
Marine king crab	Book gills
Prawns, Unio and Pila	Gills
Echinodermata	Dermal branchiae, Tube feet, Respiratory tree, Bursae
Fishes, Tadpoles	Gills
Frogs, Toads	Buccopharyngeal lining, Lungs, Skin
Reptiles, Mammals	Lungs
Birds	Air sacs/Lungs
Lung fish	Air bladder.
Urochordata (*Herdmania*)	Test
Marine turtle	Clocal respiration
Mollusca (Unio)	Mental

Respiratory system of human

Human respiratory system is derived from endoderm. Human respiratory system may be divided into two components –

(1) Respiratory tract or conducting portion

(2) Respiratory organs

(1) **Respiratory tract or conducting portion :** It is the passage for the air. In this part gaseous exchange does not takes place. It is also called dead air space. It is divided in following parts –

(i) **Nose** (Latin-*Nasa*) (Greek-*Rhine*) : Cavity of nose is called nasal cavity. Nasal cavity is divided into two parts by nasal septum called mesethmoid. Each part is called nasal chamber. Each nasal chamber opens out side by external nares. Nasal septum has two part. First part is small and is made of cartilage (hyaline). Second part is major and it is bony. Vomer is the main bone. Each nasal chamber has three region.

(a) **Vestibular region :** Vestibular region also known as vestibule is lined by non keratinized squamous epithelium, it is ectodermal in origin and have sebaceous gland, sweat gland and hair. Vestibule is also found in inner air larynx, mouth and vagina. It acts like a seive to check the entry of large dust particles and other things.

(b) **Respiratory region :** Middle region lined by respiratory epithelium which is ciliated pseudostratified columnar epithelium. It contains mucus and serous cells. Mucus cells produce mucus and serous cells produce watery fluid. Respiratory epithelium is highly vascular and appears pink or reddish. Respiratory region acts as a air conditioner and makes the temperature of in going air nearly equal to body. It also acts as a filter not give entry to dust particles, flies or mosquitoes.

(c) **Olfactory region :** It is upper region. It is lined by olfactory epithelium. This is also called Schneiderian epithelium. Olfactory region is the organ of smell and detect the odour of inspired air. Inspiration is stopped if odour of air is foul or offensive. According to new researches pheromone receptors are found in nasal cavities.

(ii) **Nasal conchae :** Lateral wall of nasal cavity have three shelves like structures called conchae or turbinate. 3 pairs of nasal conchae are found. Nasal conchae are covered with mucus membrane. They increase the surface of nasal chamber. Both the chambers of nasal cavity open into nasopharynx by their apertures called internal nostrils or conchae. Adjacent to internal nostril there are opening of eustachian tube. Names of these three conchae and names of the bones that form them are given below.

(a) **Superior conchae** : The dorsal most chochae is supported mainly by nasal bone called nasoturbinate. It is the smallest conchae.

(b) **Middle conchae** : Ethmoid bone called ethmoturbinate.

(c) **Inferior conchae** : The ventral most conchae supported by maxilla bone called maxilloturbinate. It is a separate bone itself.

(iii) **Pharynx :** It is the short vertical about 12 *cm* long tube. The food and air passages cross here. It can be divided in 3 parts –

(a) **Nasopharynx :** Nasopharynx is only respiratory upper part in which internal nares open. There are 5 opening in its wall; two internal nares, two eustachian tube opening and one opening into oropharynx.

(b) **Oropharynx :** Middle part is called oropharynx. In this part oral cavity open known as fauces. Two pair tonsils the palatine and lingual tonsils are found in the oropharynx.

(c) **Laryngopharynx or hypopharynx :** Lowest part is called laryngopharynx. It leads into two tubes. One at the front is wind pipe or trachea and one at the back is food pipe or oesophagus. Both oro and laryngo pharynx is both a respiratory and a digestive pathway.

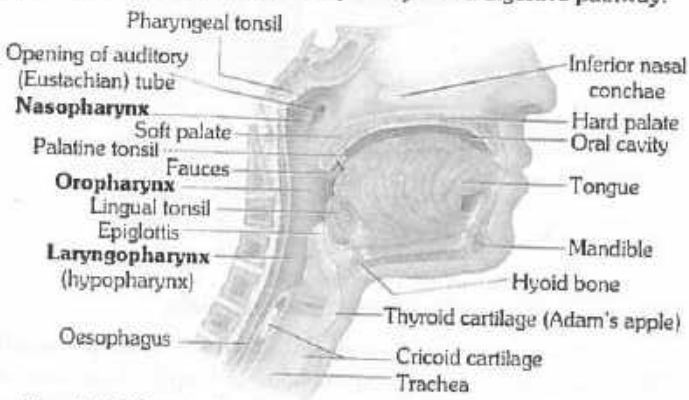


Fig : 5.2-2 Sagittal section showing the regions of the pharynx

Nasopharynx is lined by ciliated pseudostratified epithelia, oropharynx and laryngopharynx are lined by non keratinized epithelium. Pharynx is lined by non keratinized stratified squamus epithelium. This epithelium is cillieted in nasopharynx. Mouth serves as an alternate route for air when nasal chambers are blocked. Foramen by which pharynx opens into larynx called

glottis. In general it remains open. During swallowing it is closed. It provides passage for air. Pharynx leads into the oesophagus through an aperture called gullet. In general condition it remains closed and opens at the time of swallowing. During swallowing epiglottis closes the glottis.

(iv) **Larynx or Voice box :** It is found both in frogs and rabbits. Larynx does not help in respiration. It is present on tip of trachea and is made up of 9 cartilages such as thyroid (single) has a prominence called pomum admi or adam's apple, cricoid (single), arytenoid (paired), are piece of hyaline cartilage. While epiglottis (single), carniculate (paired), cuneiform (paired), santorini are piece of elastic cartilage. Clinically, the cricoid cartilage is the landmark for making an emergency air way.

Larynx is a short tubular chamber and opens into the laryngopharynx by a slit like aperture called glottis. Glottis always remains open except during swallowing. Larynx is more prominent in men than women due to male hormone. Before puberty, the larynx is inconspicuous and similar in both sexes. Larynx is a voice producing instrument. For this purpose larynx have two types of vocal cord. In birds voice producing organ is syrinx, found at lower end of tracheae.

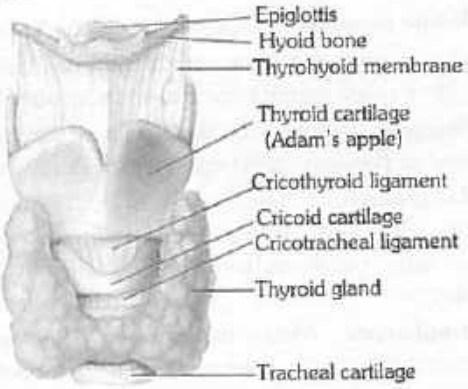


Fig : 5.2-3 Larynx (Anterior view)

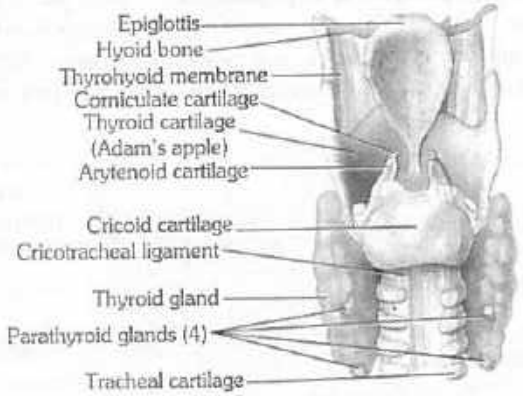


Fig : 5.2-4 Larynx (Posterior view)

(a) **False vocal cord or vibrating fold or anterior vocal cord :** These are folds of mucus membrane. Gap between them is called rema vestibuli. These are not responsible for sound production. In elephants only true vocal cords are present and are responsible for this trumpet sound.

(b) **True vocal cord or posterior vocal cords :** They are made up of yellow elastic fibres. Gap between them is called rema glottides or peep hole. In males the length of true vocal cord is 2.25 *cm* and in female is 1.75 *cm*. Sound produced by rabbit is called quaking. Hippopotamus lacks true vocal cords. Pitch is controlled by the tension of vocal folds.

Fig : 5.2-5 Movement of vocal folds apart (abduction)

Fig : 5.2-6 Movement of vocal folds together (adduction)

(v) **Trachea :** It is a tubular structure of about 12 *cm.* in length and 2.5 *cm* in diameter. The wall of trachea is made of fibres, cartilage muscles and the mucus membrane. In middle of thorax at the level of 4th and 5th thoracic vertebra divides it into two branches called right and left primary bronchi. Further division of primary bronchi is given in form of arrow diagram.

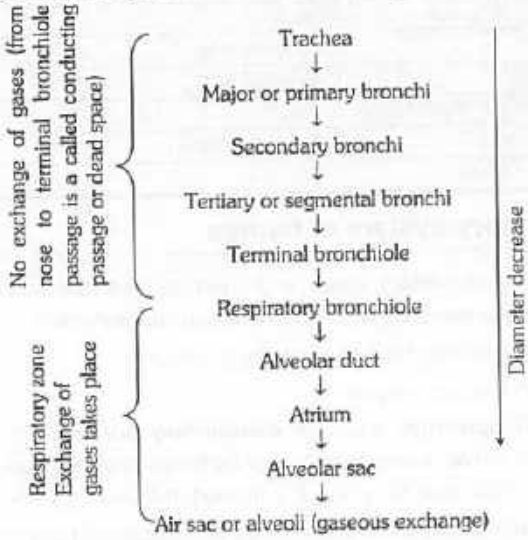


Table : 5.2-3 Different epithelium lining in respiratory tract

Vestibular region of nose	Skin having hair
Respiratory region of nose	Ciliated pseudostratified
Olfactory region of nose	Olfactory (Schneiderian) epithelium
Pharynx (Oropharynx, Laryngopharynx)	Non-keratinised stratified squamous
Trachea and bronchi (Upper)	Pseudostratified ciliated columnar epithelium with mucus cells
Lower bronchi (Secondary / Tertiary)	Lined by simple ciliated columnar epithelia
Terminal bronchioles and beginning of respiratory bronchiole	Simple ciliated columnar epithelium without mucus cells
Rest of respiratory bronchioles, alveolar duct	Non ciliated cuboidal epithelium
Alveoli	Non ciliated squamous
Alveoli of frog's lungs	Columnar ciliated epithelium

Three special types cell are found in Bronchioles epithelium :

(a) **Kultchitsky cells or argentaffin cells :** They secrete serotonin and histamine. Histamine dilate while serotonin constrict the bronchioles.

(b) **Clara cells :** They secrete a phospholipid named diapalmityl lecithin which acts as a surfactant. This surfactant prevents the collapse of bronchioles lacking cartilagenous rings. Collapsing of lungs is called atelectesis. Pottle in 1956 proved the existence of surfactant. Surfactant is formed by clara cells only at later stage of foetal life. Some times at birth some infants are devoid of surfactant so there is great respiratory difficulty because lungs refuse to expand. In this condition death may occur. This is called respiratory distress syndrome (RDS) or hyaline membrane disease (HMD) or glassy lung disease.

(c) **Dust cells :** They are phagocytes which eat foreign particles (dust).

Respiratory organs

In men the respiratory organ are a pair of lung. Some snakes have unpaired lungs. Respiration by lungs is called pulmonary respiration. Lungs are found in all vertebrates except fishes. In fishes such as protopterus, neoceratodus and lepidosiren air bladder is found, which is modified lung. Respiration in men and rabbit is pulmonary.

Lungs : Lungs lie in thoracic cavity on both side of heart in mediasternum space. Base of lung is attached to diaphragm. Right lung is divided into 3 lobes viz. Superior, Middle, Inferior and left lung is divided into two lobes Superior and Inferior. In rabbit, the left lung is divided into two lobes left anterior and left posterior where as the right lung has four lobes anterior azygous, right anterior, right posterior and posterior azygous. Lungs of reptiles are more complex than those of amphibians. In birds lungs are supplemented by elastic air sacs which increase respiratory efficiency. The narrow superior portion of lung is termed the apex or cupula.

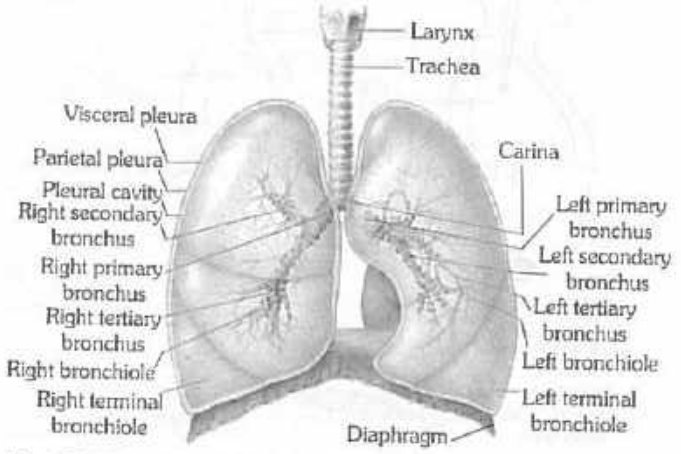


Fig : 5.2-7 Branching of airway from the trachea : the bronchial tree (Anterior view)

Each lung is enclosed in two membrane called pleura. Pleura are layers of peritoneum of thorax. Inner membrane is called the visceral pleuron. It is firmly bound to surface of lungs. The outer membrane is called parietal pleuron. It is attached to chest wall or wall of thoracic cavity. A narrow space exists between the two pleura. It is called pleural cavity. In pleural cavity a watery fluid is found called pleural fluid. Pleural fluid is glycoprotein in nature and secreted by pleura. Pleural fluid lubricate the pleura so that they may slide over each other without friction. This fluids reduces friction between the membrane. When the lungs expand and contract in respiration. Pressure inside pleural cavity is negative – 5 mm Hg. Pleurisy is inflamation of pleura and cause collection of fluid in pleural cavity. It results painful breathing (dyspnea). The surface of lung lying against the ribs, known as coastal surface. The mediastinal (medial) surface of each lung contains a region – the hilus, through which bronchi, pulmonary blood vessels, lymphatic vessels and nerve enter and exit.

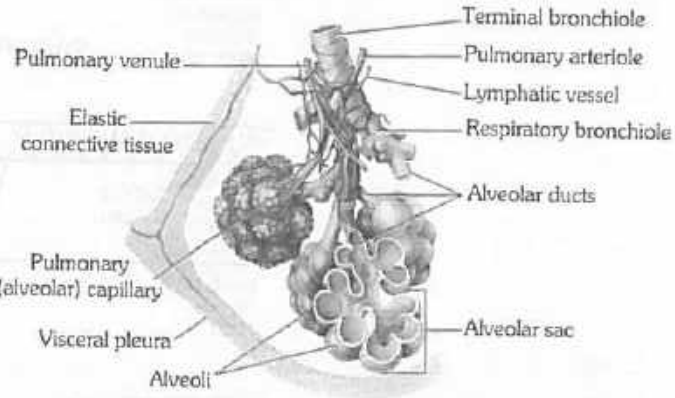


Fig : 5.2-8 Diagram of a portion of a lobule of the lung

Pulmonary volumes and capacities

The apparatus commonly used to measure the volume of air exchanged during breathing and the rate of ventilation is a spirometer (*spiro*=breathe) or respirometer. The record is called a spirogram. There are 4 respiratory volumes and capacity.

Respiratory volumes

(1) **Tidal volume (TV) :** Volume of air inspired or expired in relaxed or resting position – 500 *ml*. It consists of 150 *ml* of dead space volume and 350 *ml* of alveolar volume.

(2) **Inspiratory reserve volume (IRV) :** By taking a very deep breath, you can inspire a good deal more than 500 ml. This additional inhaled air, called IRV is about 3000 ml.

(3) **Expiratory reserve volume (ERV) :** If you inhale normally & then exhale as forcibly as possible, you should be able to push out 1100 ml. of air in addition to 500 ml. of T.V. The extra 1100 ml. is called ERV.

(4) **Residual volume (RV) :** Even after expiratory reserve volume is expelled, considerable air remains in the lung, this volume, which can not be measured by spirometry, it is called residual volume is about 1200 ml.

(5) **Dead space** : Portion of tracheobronchial tree where gaseous exchange does not occur called dead space. It is also called conductive zone. Dead space is 150 ml.

(6) **Functional residual capacity (FRC) :** It is the amount of air that remains in the lungs after a normal expiration. It is about 2300 ml.

$$FRC = ERV + RV$$
$$= 1100 + 1200 = 2300 \text{ ml.}$$

(7) **Vital capacity (VC) :** This is the maximum amount of air that can be expired forcefully from his lungs after first filling these with a maximum deep inspiration. It is about 4600 ml.

$$VC = IRV + TV + ERV$$
$$= 3000+500+1100 = 4600 \text{ ml.}$$

(8) **Total lung capacity (TLC) :** TLC is the sum of vital capacity (VC) and residual volume (RV). It is about 5800 ml.

$$TLC = VC + RV$$
$$= 4600 + 1200 = 5800 \text{ ml.}$$

(9) **Inspiratory capacity (IC) :** It is the total amount of air a person can inspire by maximum distension of his lungs.

$$IC = TV + IRV$$
$$= 500 + 3000 = 3500 \text{ ml.}$$

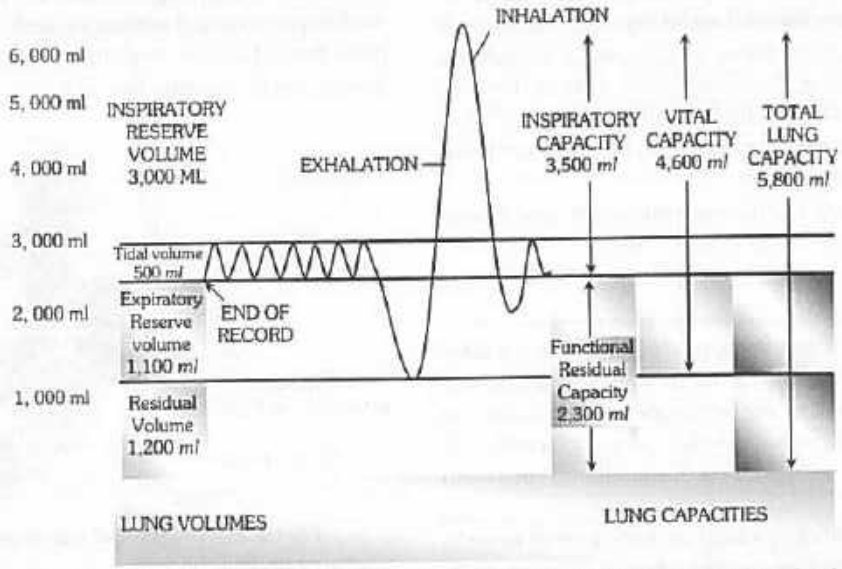


Fig : 5.2-9 Spirogram of lung volumes and capacities (average values for a healthy adult)

Process of Respiration

The process of respiration is completed in 4 steps –

(1) Breathing or ventilation

(2) Exchange of gases or External respiration

(3) Transport of gases

(4) Cellular respiration

(1) **Breathing or ventilation :** Movement of thorax, expansion (inflation) and deflation of lungs and flow of air into the lungs and from the lungs. It is extracellular, energy consuming and physical process. Sum of inspiration and expiration is called respiratory movement. There are two steps of breathing –

(i) **Inspiration :** Intake of fresh air in lungs from outside. It is an active process. Blood pressure increases during later part of respiration. Following muscles are involved in inspiration.

(a) **Diaphragm :** Principle muscles of inspiration. It is a skeletal muscles attached to the sternum, vertebral column and ribs. It is formed by radial muscles fibres.

In relaxed condition it is dome shaped, convex towards thoracic cavity and concave towards abdominal cavity. During inspiration it contracts and become straight and descends down. This causes an increase in vertical diameter of thoracic cavity. Descent of diaphragm can explain about 75% of tidal air volume. 70% muscles fibres of diaphragm have some resistance to fatigue. Nerve which supply to diaphragm is phrenic nerve. Contribution of diaphragm in breathing of full term pregnant lady is 0%. Most important function of diaphragm in mammals is to aid in inspiration. If diaphragm is punctured, respiration will stop and patient will die.

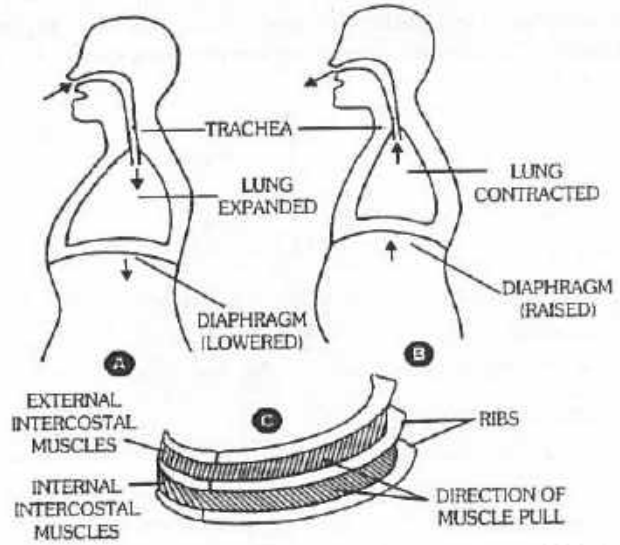


Fig : 5.2-10 Mechanism of breathing. A – Inspiration (Chest cavity enlarged) B – Expiration (Chest cavity reduced) C – Intercostal muscles

(b) **External intercostal muscles :** Gaps between the ribs are called intercostal spaces. They are filled by intercostal muscles. Intercostal muscles are of two types external intercostal muscles and internal intercostal muscles.

External intercostal muscles are related to inspiration and internal intercostal muscles are related to expiration. Here we are concerned with external intercostal muscles. External intercostal muscles start from lower border of upper rib and comes to end outer lip of upper border of lower rib. Thus direction of external intercostal muscles fibres is downward forward. Contraction of external intercostal muscles causes increase in anteroposterior diameter of thoracic cavity and transverse diameter of thoracic cavity.

This two dimensional increase in diameter (i.e. anteroposterior and transverse) of thoracic cavity is due to special arrangement of ribs. This increase in thoracic cavity is assisted by diaphragm the most important muscle of inspiration. Contraction of diaphragm causes it to flatten lowering its dome. For simplification we can assume that each rib is attached anteriorly to sternum by its anterior end and posteriorly to vertebral column by its posterior end. Note these two points carefully –

- Anterior end of rib is lower than the posterior end.
- Middle portion of rib which is called shaft lies at lower level than the two end of rib (i.e. anterior and posterior)

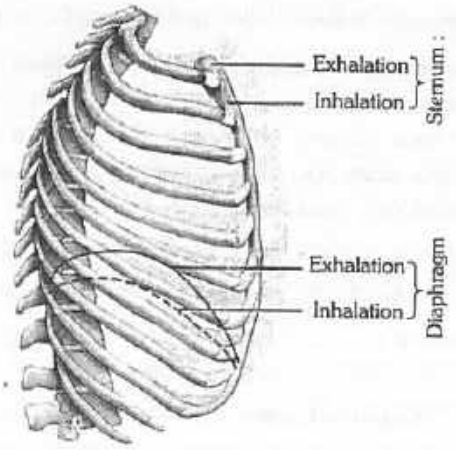


Fig : 5.2-11 Changes in size of thoracic cavity during inhalation and exhalation

(c) **Accessory muscles of inspiration :** These muscles normally are not called into action but in forced inspiration they come into action. Accessory muscles are scaleni, sternomastoid and alae nasi.

(ii) **Expiration :** Out flow of the air from the lungs is called expiration. When the inspiratory muscles relax, the external intercostal relax, ribs move inferiorly and as the diaphragm relaxes, its dome moves superiorly owing to its elasticity. These movements decrese vertical and anterior-posterior dimentions of thoracic cavity.

(a) **Internal intercostal muscles :** Direction of fibres is backward and downward. Action is just opposite to external intercostal muscles. These muscles by their action reduces antero-posterior and transverse diameter of thoracic cavity.

(b) **Abdominal muscles :** Muscles of anterior abdominal wall. These muscles push the diaphragm up.

(iii) **Mechanism of ventilation/breathing**

Inspiration

Enlargement of thoracic cavity due to action of muscles of inspiration.
↓
Lungs follow the enlargement of thoracic cavity and expand.
↓
Expansion of lungs leads to reduction of air pressure within the lungs than the atmospheric pressure.
↓
Air from the outside, where pressure of air is high, comes inside the lungs.
↓
At the top point of inspiration contraction of inspiratory muscles suddenly stops. ← Impulses from CNS
↓

Expiration

Inspiratory muscles relax and also due to the elastic recoil, lungs shrink.
↓
Air pressure within lungs exceeds atmospheric air pressure.
↓
Air is expelled out into the atmosphere.

(2) **Exchange of gases**

(i) **Exchange of gases in lungs :** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2, comes to alveoli from pulmonary capillary. In order to exchange the gases have to pass through alveolocapillary membrane or respiratory membrane. Composition of alveolocapillary membrane is epithelium lining of alveolar wall, epithelial basement membrane, a thin interstitial space, capillary basement membrane and capillary endothelial membrane.

Thickness of respiratory membrane is 0.5 μm. Respiratory membrane has a limit of gaseous exchange between alveoli and pulmonary blood. It is called diffusion capacity. Diffusion capacity is defined as volume of gas that diffuse through membrane per minute for a pressure difference of 1 *mm Hg*. Exchange of gases through alveolocapillary membrane is a purely physical diffusion phenomenon. No chemical reaction is involved. Diffusion of a gas depends upon pressure gradient across the membrane and solubility of gas.

Partial pressure : Partial pressure of a gas is the pressure it exerts in a mixture of gases, and is equal to the total pressure of the mixture divided by percentage of that gas in the mixture. For instance, if the pressure of atmospheric air at sea level is 760 *mm.* of mercury (*Hg*) and oxygen forms 21% of the air, the partial pressure of oxygen will be 21% of 760, or 159 *mm. Hg*. In other words, the partial pressure of a gas is proportional to its concentration in the mixture. Only about 0.3 *ml.* of O_2 can dissolve in 100 *ml.* of plasma, about 20 *ml.* of O_2 is carried by haemoglobin in 100 *ml.* of blood. In atmospheric air except these gases some traces of helium, argon and neon are also found.

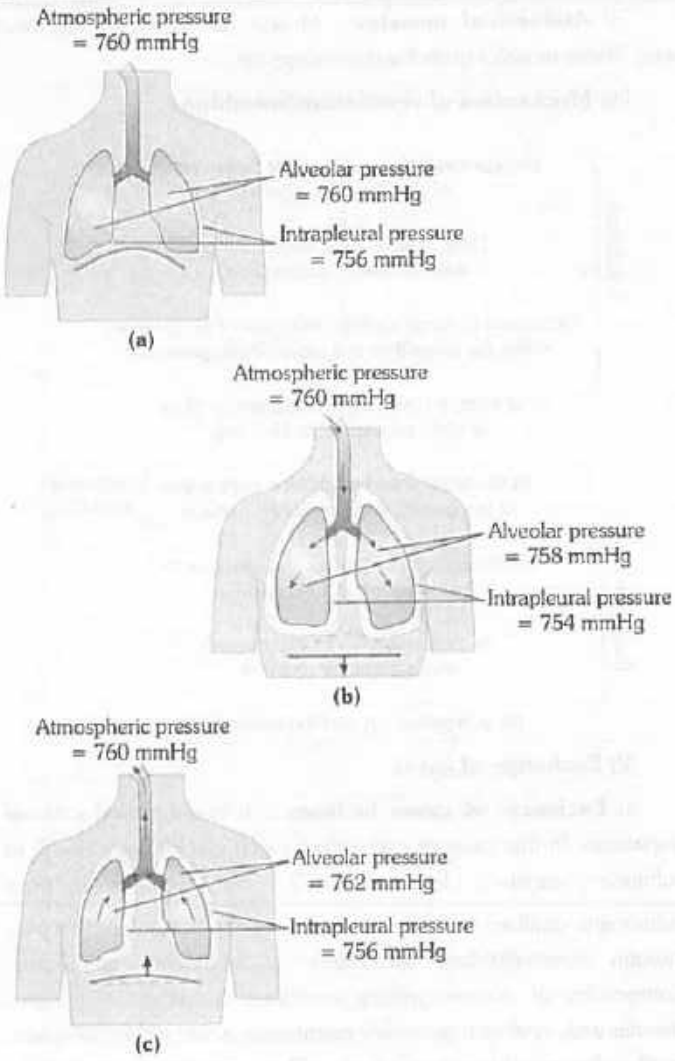


Fig : 5.2-12 Pressure changes in pulmonary ventilation ; (a) At rest (diaphragm relaxed) (b) During inhalation (diaphragm contracting) (c) During exhalation (diaphragm relaxing)

Table : 5.2-4 Partial pressures of respiratory gases in *mm. Hg*

Gas	Oxygen	Carbon dioxide	Nitrogen
Inspired air	158	0.3	596
Alveolar air	100-105	40	573
Venous blood	40	46	573
Arterial blood	95-100	40	573
Expired air	116	32	565
Tissue cells	20-40	45-52	–

Table : 5.2-5 Composition of three samples of air

Gas	Oxygen	Carbon dioxide	Nitrogen	Water
Inspired air	20.84%	0.04%	78.62%	0.5%
Expired air	15.70%	4.00%	74.50%	6.2%
Alveolar air	13.6%	5.3%	74.9%	6.2%
Gain/loss %	Gain 5.14%	Loss 3.96%	Gain 4.12%	Loss 5.7%

Exchange of gases in lungs can be divided into two steps –

Uptake of O_2 by blood in lung : The PO_2 (partial pressure of oxygen) of the alveolar air is higher than the PO_2 of blood in alveolar capillaries. Due to a PO_2 difference between air and blood, oxygen diffuses rapidly from the alveolar air into the blood of alveolar capillaries.

Release of CO_2 by the blood : The PCO_2 (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the PCO_2 of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.

(ii) **Exchange of gases in tissues :** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs *via* tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has PO_2 higher than that in the tissue cells and PCO_2 lower than that in the tissue cells. The tissue cells constantly use oxygen in oxidation that produces carbon dioxide. Therefore, they always have lower PO_2 and higher PCO_2 than the blood coming to them. Because of PO_2 and P_{CO_2} differences between blood and tissue cells, oxygen separates from oxyhaemoglobin and diffuses from the blood into the tissue fluid and hence into the tissue cells; and carbon dioxide diffuses from the tissue cells into the tissue fluid and thence into the blood in the tissue capillaries. Gases mostly diffuse through the tissue fluid as such, only small amounts dissolve in it.

Exchange of gases in the tissues that lowers the PO_2 of the blood and raises its PCO_2 is called internal respiration. The blood deoxygenated by this respiration returns to the right side of the heart that sends it to the lungs for reoxygenation.

(3) **Transport of gases :** Blood carries O_2 from respiratory organs to the tissue cells for oxidation and CO_2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O_2 and CO_2 properly.

(i) **Transport of oxygen :** Lung contains atmospheric air. From the lung O_2 diffuses into the blood. The blood transport O_2 from the lung to the cells. This is called oxygen transport. O_2 is carried in the blood in three forms –

(a) **In physical solution :** 100 *ml.* oxygenated blood contains 20 *ml* (0.3 *ml* dissolved in plasma and 19.7 *ml* bound to *Hb*) of oxygen. 2-3% oxygen is transported in form of physical solution. Thus 0.3 *ml* to 0.6 *ml.* O_2 is in physical solution form in 100 *ml* of blood.

(b) **As oxyhaemoglobin (HbO_2) :** Most of O_2 is transported in the form of oxyhaemoglobin. 98.5% in the form of HbO_2 and 1.5% is carried in the dissolved state in watery blood plasma.

Oxygen-haemoglobin dissociation curve

When a graph is plotted between percent saturation of haemoglobin and oxygen tension, a curve is obtained termed as O_2 - *Hb* dissociation curve. Oxygen-*Hb* dissociation curve is sigmoid shaped-or *S* shaped. This *sigmoid shaped* curve is characteristic for *Hb*.

Body tissue obtain oxygen from oxyhaemoglobin because of its dissociation caused by low O_2 and high CO_2 concentration. Under a given oxygen concentration in blood, dissociation of oxyhaemoglobin will increase if pH of blood falls. When partial pressure of CO_2 rises (blood pH decreases), dissociation curve of oxyhaemoglobin at 37°C shift to right. Effect of high temperature and low pH (high PCO_2) are similar. P_{50} indicates the oxygen concentration at which 50% haemoglobin of blood is saturated with O_2.

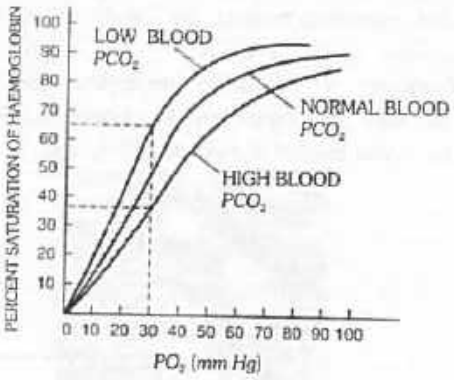


Fig : 5.2-13 Effect of PCO_2 on affinity of hemoglobin for oxygen

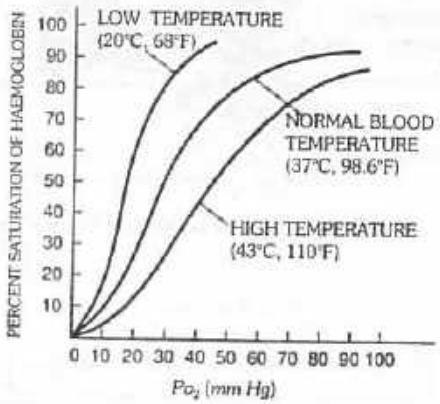


Fig : 5.2-14 Oxygen-hemoglobin dissociation curve showing the relationship between temperature and hemoglobin saturation with O_2

Bohr's effect : *Hb*- O_2 dissociation curve shifts to right when CO_2 tension in blood is high. Bohr discovered this effect in 1904. Bohr effect is the effect of CO_2 on oxyhaemoglobin. Deoxygenation of oxygaemoglobin is directly proportional to blood pCO_2. Extent of Bohr's effect depends upon the tension of CO_2 in blood only. CO_2 of tissue fluid and alveoli does not exert Bohr's effect. During exercise muscles need more O_2 and want to remove CO_2 which has high production. Because of pressure gradient CO_2 moves from tissues fluid to capillary blood → Exert Bohr's effect → O_2 release is hastened from *Hb*-O_2 *i.e.* *Hb*-O_2 curve shifts to right.

Haemoglobin : Oxygen carrier or respiratory pigment in vertebrates blood is haemoglobin. *Hb* molecule is made of two components haem and globin. Globin part is globulin protein which is made of four polypeptide chain, two α chains (141 amino acid) and two β chains (146 amino acid). Thus total no. of amino acid in *Hb* 574. Haem is iron containing compound and belongs to the class of compound called protoporphyrins. *Hb* in RBC synthesized before loss of nucleus. Iron of *Hb* is in ferrous state (Fe^{++}) and even after the combination with O_2 it remains ferrous. One *Hb* molecule has 4 haem molecules. Each haem is associated without polypeptide chain. Each *Hb* molecule can combine with one molecule (2 atoms) of oxygen. Thus each molecule of *Hb* combines *4* molecules of O_2.

Myoglobin : It is chemically and functionally similar to *Hb*. It is made up of one polypeptide chain (153 amino acids) attached with on haem group. P_{50} value for myoglobin is 5 *mm Hg*. This indicates that myoglobin release oxygen less readily than *Hb*. It is found in muscles. It acts as a store house for O_2. An average man can store about 1.5 *litre* oxygen in myoglobin. *Hb*-O_2 dissociation curve for myoglobin is hyperbola.

(ii) **Transport of CO_2 :** Transportation of CO_2 by blood is much easier due to its high (20 times that of O_2) solubility in water. Blood can carry upto 50% or 60% of CO_2 by volume, but normally about 4 ml of CO_2 on an average is transported from tissue to the lungs in each 100 ml of blood in man. With 5 litres of cardiac output per minute, the blood thus transports about 200 to 220 ml of CO_2 each minute. Obviously, this is the rate at which CO_2 is produced and released into tissue fluids by cells, and at which it diffuses out into alveolar air from pulmonary arterial blood. The blood transports this CO_2 in three ways.

(a) **In dissolved state :** Deoxygenated (PCO_2 is 45 to 46 mm Hg) and oxygenated (PCO_2 is 40 mm Hg) bloods respectively carry about 2.7 and 2.4 ml of CO_2 per 100 ml of blood in dissolved state in plasma (= in solution with plasma). Thus, about 0.3 (2.7 minus 2.4) ml of CO_2 is transported by each 100 ml. of blood in dissolved state in plasma. This is about 7% of all the CO_2 transported by blood from tissues to the lungs.

(b) **In the form of bicarbonate ions :** Most of the CO_2 that dissolved in blood plasma reacts with water, forming carbonic acid – $CO_2 + H_2O = H_2CO_3$ (carbonic acid)

This reaction is very slow in plasma, but occurs very rapidly inside RBCs, because an enzyme, carbonic anhydrase, present in RBCs, accelerates its rate about 5000 times. That is why, about 70% of the CO_2 (about 2.5 ml per 100 ml of blood), received by blood from the tissues, immediately enters into RBCs and hydrated to carbonic acid. Almost as rapidly as formed, all carbonic acid of RBCs dissociates into hydrogen and bicarbonate ions (H^+ and HCO^-_3). The hydrogen ions mostly combine with heamoglobin for

keeping the pH of blood. (7.4) in steady state, because haemoglobin is a powerful acid base buffer. Being quite diffusible, the bicarbonate ions, on the other hand, diffuse from RBCs into the plasma. To maintain electrostatic neutrality of plasma, many chloride ions, in turn, diffuse from plasma into the RBCs. Obviously, the chloride contents of RBCs increase when oxygenated blood becomes deoxygenated. This is termed "chloride or Hamburger shift".

Sequence of events : From tissues CO_2 enters in plasma → a small fraction of CO_2 is dissolved in plasma → rest of CO_2 enters into the RBC → within RBC CO_2 combines with H_2O in presence of enzyme carbonic anhydrase and forms H_2CO_3 → H_2CO_3 splits into H^+ and HCO_3^- → most of the HCO_3^- comes out of RBC and enters in plasma and form $NaHCO_3$, small fraction stays back within the RBC to form $KHCO_3$ and H^+ combine with Hb to form reduced haemoglobin $H.Hb$.

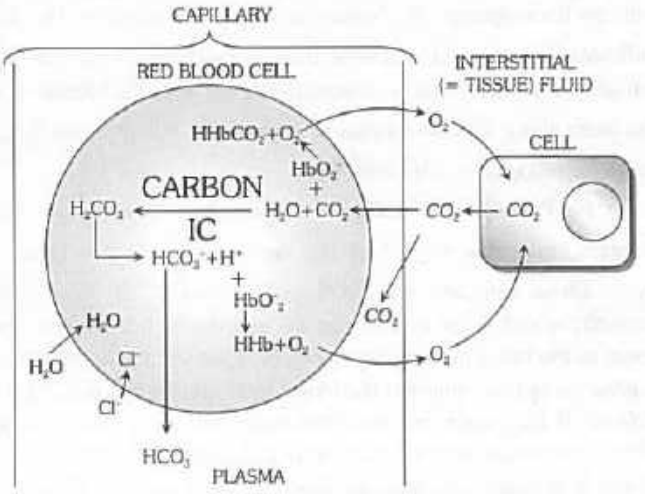


Fig : 5.2-15 Transportation of CO_2 by blood

(c) **In the form of carbamino compounds :** In addition to reacting with water, CO_2 also directly and reversibly reacts with haemoglobin, loosely binding with it and forming an unstable compound, called carbaminohaemoglobin (CO_2HHb). It also similarly forms loose bonds with some plasma proteins. It is estimated that about 23% of the CO_2 (1 ml per 100 ml of blood), collected from cells through tissue fluids, is transported by blood in this form.

Table : 5.2-6 Transformation of CO_2 in various forms

Transformation forms of CO_2	Transported quantity
CO_2	7 % (0.3 ml/100ml of blood)
$HHbCO_2$	23% (1ml/100 ml of blood)
HCO_3^-	70% (2.5 ml/100 ml of blood)

Haldane effect and CO_2 diffusion into the alveoli : Whereas the Bohr effect promotes O_2 transport, the Haldane effect is important in promoting CO_2 transport. The Haldane effect results from the simple fact that oxyhaemoglobin behaves as a strong acid. This in turn, displaces CO_2 from the blood in two ways.

(1) Due to its increased acidity, the haemoglobin loses its capacity to combine with CO_2. Hence all carbamino haemoglobin dissociates to release its CO_2.

(2) Secondly, the highly acidic oxyhaemoglobin releases an excess of H^+ which bind with bicarbonate ions (HCO_3^-), forming carbonic acid. The latter soon dissociates into H_2O and CO_2. This CO_2 diffuses into the alveoli.

Thus, in the lung, the haldane effect, increases release of CO_2 because of O_2 uptake by haemoglobin. In the tissues a reverse process occurs. The Haldane effect increases CO_2 uptake because of removal of O_2 from haemoglobin.

Control of breathing

Respiratory rhythm is controlled by nervous system. Inspiratory and expiratory centres are jointly called rhythmicity centres. Inspiratory centre is dominant over expiratory centre. When pneumotaxic is stimulated respiration rate increases inspiration as well as expiration is shortened. Respiratory movements are under control of *medulla oblongata*.

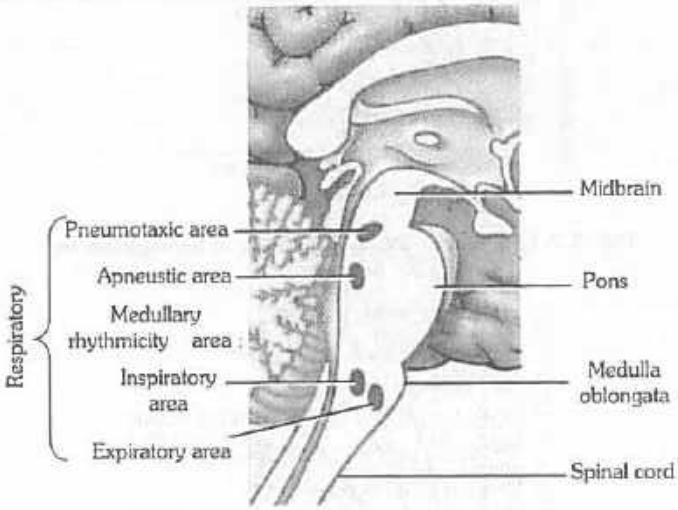
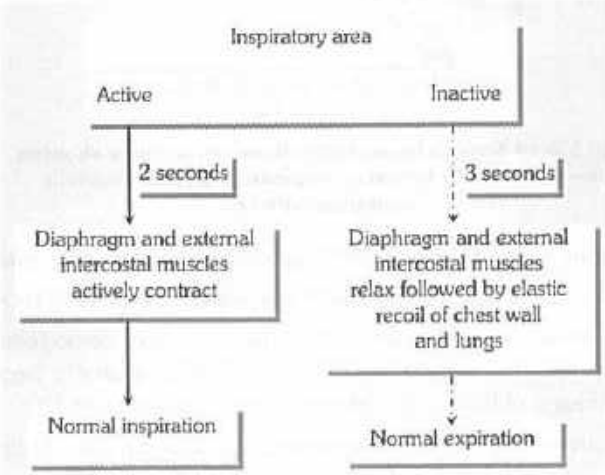
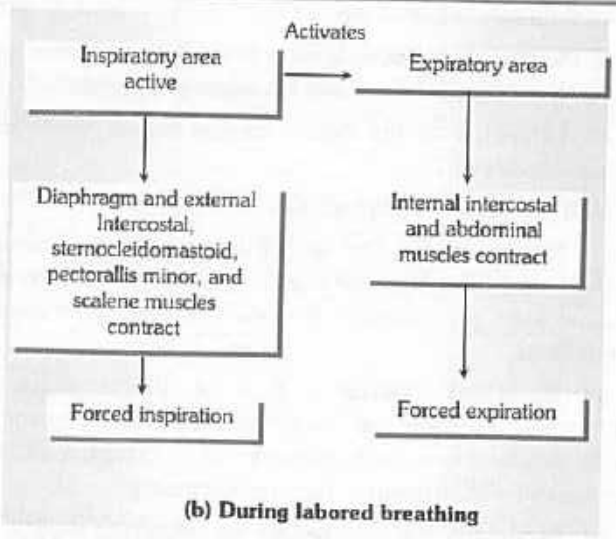


Fig : 5.2-16 Sagittal section of brain stem



(a) During normal quiet breathing



(b) During labored breathing

Table : 5.2-7 For the control of respiration following respiratory centres are found in hind brain

Type of centre	Location	Function
Inspiratory centre	Medulla oblongata	Inspiration (2 second active condition)
Expiratory centre	Medulla oblongata	Expiration (3 second inactive condition)
Apneustic centre	Pons	Slow and deep inspiration
Pneumotaxic centre	Pons	Control other centres and produce normal quite breathing
Gasping centre	Pons	Sudden and shallow respiration

(1) **Chemical control :** This includes CO_2, O_2 and H^+ conc. of blood. For detection of concentration of O_2, CO_2 and H^+ ions in blood two types of receptors are found. These receptors are called chemoreceptor.

(i) **Peripheral chemoreceptor :** These include two sets – Carotid body is present in the wall of the left and the right common carotid arteries and aortic bodies is present in the arch of aorta. They are placed in the vascular endothelium and come in contact with the blood. When PO_2 decreases or increases in arterial blood, these receptors are stimulated and send impulses to respiratory centre to respectively increases or decreases the rate intensity of inspiratory signals.

(ii) **Central chemoreceptors :** These are present on ventral surface of medulla. Cells of these centres are bathed in brain tissue fluid. They are in close vicinity of CSF. In brain tissue fluid as well as in CSF the CO_2 is converted into $H_2CO_3 \rightarrow H_2CO_3$ $H^+ + HCO_3^- \rightarrow H^+$ ions are liberated → H^+ ions stimulate the central chemoreceptor (C.C) cell → stimulation from C.C goes to respiratory centre → Respiration stimulate.

(2) **Effect of different gases**

(i) **Effect of CO_2 :** Rise in tension of arterial CO_2 or alveolar CO_2 causes stimulation of respiration. Both the rate and depth of respiration increased. This leads to washing out of CO_2 from body.

(ii) **Effect of O_2 :** Fall of O_2 concentration in inspired air causes stimulation of peripheral chemoreceptors. Neural impulse arises from peripheral chemoreceptors. These impulses go to respiratory centre and cause respiratory stimulation.

Respiration in frog

Frog is an amphibious animal i.e. they are live in water as well as on land hence according to their adaptations they posses different modes of respiration, which are as follows –

(1) **Cutaneous respiration :** By the skin. Under water, during hibernation frog respires by only skin. On land cutaneous respiration continues as usual. Thus cutaneous respiration take place always. By cutaneous respiration frog fulfill its 30% need of oxygen.

(2) **Buccopharyngeal respiration :** Like the skin, the mucosa of buccopharyngeal cavity in frog is also ideally adapted for gaseous exchange. Hence, while quietly floating upon water surface, and even when resting upon land, frogs respire by their buccopharyngeal cavity also. During this process, the mouth, gullet and glottis remain closed, but nares remain open.

(3) **Pulmonary respiration :** In frog, pulmonary respiration accounts for about 65% of the total O_2-intake. It particularly occurs when frogs lead an active life during rains and spring; either hopping upon land in search of food, or actively breeding in water.

Important concept of respiration

(1) **Respiratory quotient (R.Q.) :** Respiratory quotient is the ratio of carbon dioxide output to oxygen usage during respiration. It is measured by Ganong's respirometer.

$$\text{R.Q.} = \frac{\text{Volume of } CO_2 \text{ formed}}{\text{Volume of } O_2 \text{ utilized}}$$

Table : 5.2-8

High RQ	Low RQ
Due to fat deposition	When CO_2 is fixed
Due to fever	When CO_2 retain in tissue
Due to muscle exercise	In hibernating mammals
During glycolysis	Due to acidosis
In low O_2 environment	Due to alkalosis
Due to oxidation of pyruvic acid.	Due to diabetes
	In starvation
	During gluconeogenesis
	During glyconeogenesis

The volume of RQ depends upon the type of fuel substance being utilized for energy production.

Table : 5.2-9 RQ of various subtrates

Respiratory substrate	Respiratory quotient
Carbohydrate	1.00
Proteins	0.5 – 0.9 Slightly less than 1 (0.9)
Fats	0.7
Organic acid	1.33

In an organism utilizing carbohydrates as source of energy anaerobically, the RQ is likely to be infinity. When carbohydrates are substrates for respiration, it is called 'floating respiration'. Diabetic patient shows low R.Q. due to increased dissimilation of fats and the decreased dissimilation of carbohydrate.

(2) **Effect of *CO*** : Carbon monoxide is a poisonous gas. *Hb* has maximum affinity for *CO*. Carbon monoxide binds with haemoglobin at the same place where O_2 binds, but about 250 times more readily than O_2. Hence, it readily displaces O_2 from haemoglobin and even a *0.4 mm Hg* partial pressure of *CO* in alveolar air is enough to occupy about half of the haemoglobin of pulmonary blood rendering it useless for O_2 transport. A *CO* pressure of about 0.7 *mm Hg* (concentration of about 1%) in alveolar air can be lethal. That is why, the atmosphere of industrial areas, being loaded with chimney smoke, is regarded harmful to health. It forms carboxyhaemoglobin with *Hb* which is most stable. Sudden deep inspiration is due to either increase in concentration of CO_2 or decrease in concentration of O_2. Forced deep breathing for a few minutes by a person sitting at rest may be followed by a temporary cessation of breathing. This is influenced by too much O_2 and least CO_2 in blood.

(3) **Regulation at high altitudes** : At high altitudes, the composition of air remains almost the same as at sea-level, but the density (barometric pressure) of air gradually decreases. While ascending up a mountain, one inspires thin air, getting less oxygen. Less O_2 level in the blood results in hypoxia. The chemoreceptor simulatory mechanism progressively increases the rate of ventilation. Ventilation ordinarily does not increase significantly until one has ascended to about 2500 *metres*, because the P_{CO_2} and *pH* remain almost normal.

Disorders of Respiratory system

(i) **Hypoxia** : Hypoxia is a condition of oxygen shortage in the tissues. It is of two types :

(a) **Artificial Hypoxia** : It results from shortage of oxygen in the air as at high (over 2400 *m*.) altitudes. It causes mountain sickness characterised by breathlessness, headache, dizziness, nausea, vomiting, mental fatigue and bluish tinge on the skin and mucous membranes.

(b) **Anaemic Hypoxia** : It results from the reduced oxygen-carrying capacity of the blood due to anaemia (decreased haemoglobin content in blood) or carbon monoxide poisoning (some haemoglobin occupied by *CO*), in both cases, less haemoglobin is available for carrying O_2.

(ii) **Asphyxia (Suffocation)** : The O_2 content of blood falls and the CO_2 content rises and paralyses the respiratory centre. Breathing stops and death occurs.

(iii) **Bad cold** : Disease-causing microbes present in the air attack respiratory tract, producing inflammation of the mucous membrane and caused increased secretion :

(a) **Rhinitis** in the nasal chambers.

(b) **Sinusitis** in the sinuses.

(c) **Pharyngitis** in the pharynx, often called sore throat, and is usually accompanied by tonsillitis (enlargement of tonsils).

(d) **Laryngitis** in the larynx, causing hoarse voice and difficulty in speaking.

(e) **Bronchitis** in the bronchioles.

(iv) **Emphysema** : The air-pollutants that cause chronic bronchitis, may breakdown the alveoli of the lungs, reducing the surface area for gas exchange. The victim becomes permanently short of breath.

(v) **Bronchial asthma** : It is an allergic attack of breathlessness associated with bronchial obstruction or spasm of smooth muscle (contraction), characterized by coughing difficult breathing and wheezing patient has trouble exhaling.

(vi) **Bronchitis** : It is caused by the permanent swelling in bronchi. As a result of bronchitis cough is caused and thick mucus with pus cells is spitted out. Dyspnea and fever develops. Dyspnea means hunger of air or deficiency of oxygen in the blood or development of hypercapnia i.e., increase of CO_2 concentration in blood. This disease is accelerated by fatigue, malnutrition, cold etc. the patient experiences difficulty in breathing. Here hypertrophy and hyperplasia of bronchi takes place.

(vii) **Pneumonia** : Oxygen has difficulty diffusing through the inflammed alveoli and the blood PO_2 may be drastically reduced. Blood PCO_2 usually remain normal because CO_2 diffuses through the alveoli more easily than O_2. In chronic patients of common cold and influenza, the lining epithelium of bronchi and lungs is inflammated. This disease is caused by streptococus pneumoniae, other bacteria, fungi, protozoans, viruses and the patient feels difficulty in breathing. Its prominent symptoms are trembling, pain in chest, fever, cough delirium etc. This disease is prevalent in either children or elderly persons in old age.

(viii) **Lung cancer** : It is believed that by excess smoking, lung cancer (carcinoma of lungs) is caused. The tissue increases limitlessly, which is called malignancy. This disease is fatal. The frequency of occurrence of this disease in smokers is 20% more. Malignancy of tissues (neoplasia) causes pressure on the cells of other tissues and destroys them. The blood capillaries are ruptured, blood starts flowing and death is caused by excessive bleeding.

(ix) **Tuberculosis** : This disease is also called T.B. and was considered fatal, but these days its full cure is possible. Thus, disease is called curable, these days. It is caused by bacteria Mycobacterium tuberculosis. These bacteria settle in lungs at different places and convert normal tissue into fibrous tissue. Since the respiratory surface is decreased, the difficulty in breathing is also experienced. If the patients start taking medical advice and the medicines right from the initial stage regularly, the patients can be fully cured of the disease. Now a days a new therapy DOT (Direct observed treatment) is used for tuberculosis treatment, recently launched by Indian Government. Many other drugs like rifampin and isoniazid are successful for the treatment of tuberculosis. Tuberculosis bacteria are spread by inhalation and exhalation.

(x) **Coryza :** Common cold, due to rhinoviruses in adult.

(xi) **Influenza :** Flu.

(5) **Occupational lung disease :** It is caused because of the exposure of potentially harmful substances. Such as gas, fumes or dusts, present in the environment where a person works. Silicosis and asbestosis are the common examples, which occur due to chronic exposure of silica and asbestos dust in the mining industry. It is characterised by fibrosis (proliferation of fibrous connective tissue) of upper part of lung, causing inflammation.

(i) **Prevention and cure :** Almost all the occupational lung diseases, express symptoms after chronic exposure, *i.e.*, 10-15 years or even more. Not only this, diseases like silicosis and asbestosis are incurable. Hence, the person likely to be exposed to such irritants should adopt all possible preventive measures. These measures include :

(a) Minimizing the exposure of harmful dust at the work place.

(b) Workers should be well informed about the harm of the exposure to such dusts.

(c) Use of protective gears and clothing by the workers at the work place.

(d) Regular health check up.

(e) Holiday from duty at short intervals for the workers in such areas.

(f) The patient may be provided with symptomatic treatment, like bronchodilators and antibiotics, to remove underlying secondary infection.

(6) **Special respiratory movements**

Cough

(1) It is reflex action stimulation takes place from trachea and lungs.

(2) Centre is medulla oblongata.

(3) Cough is a forcible expiration usually produced after a prolonged inspiration.

(4) When some food particle enters the windpipe instead of oesophagus, it is expelled by a process of coughing.

(5) Air exploded through the mouth.

Sneezing

(1) Reflex action stimulated by olfactory epithelium of nasal chamber.

(2) Sneezing is a forcible expiration, air explodes out through nose and mouth.

Hiccuping

(1) Hiccuping is a noisy inspiration caused by muscular spasm of diaphragm at irregular intervals.

(2) Noise is due to sudden sucking of air through vocal cords.

(3) Stimulation of hiccuping is usually irritation of the sensory nerve endings of the digestive tract.

Yawning : Yawning is a prolonged inspiration. Low oxygen tension in the blood causes yawning.

Table : 5.2-10 Terminology

Apnea	Absence of breathing
Eupnea	Normal breathing
Hypopnea	Decreased breathing rate
Hyperpnea	Increased breathing rate
Dyspnea	Painful breathing
Orthopnea	Inability to breathe in a horizontal position
Acapnoea	Absence of CO_2 in blood
Hypocapnea	Deficiency of CO_2 in blood
Hypercapnea	Excess of CO_2 in blood
Hypoxaemia	Lack of O_2 in arterial blood
Anoxia	Absence of O_2 in tissues
Hypoxia	Lack of O_2 in tissues
Tachypnea	Rapid breathing

Table : 5.2-11 Respiratory pigments

Name of pigment	Colour (oxidised)	Metal	Place	Example
Haemoglobin	Red	Fe	RBC	Chordata (Vertebrate)
Haemocyanin	Blue	Cu	Plasma	Mollusca and arthropoda
Chlorocruorin	Green	Fe	Plasma	Annelida, sabella, serpulids
Haemoerythrin	Red	Fe	Corpuscle	Annelida, Sipunculoidea, lingula
Vanadium	Green	Va	Vanadocytes in Plasma	Urochordata
Echinochrome	Red	Fe	Coelomic fluid	Echinodermata
Pinnoglobin	Brown	Mn	Coelomic fluid	Pinna
Moledin	Brown	Mo	Coelomic fluid	Holothuria
Heamoglobin	Red	Fe	Plasma	Earthworm, nereis, arenicola, chironomas insect, planorbis.
Erythrocruonin	Red	Fe		Leech

Tips & Tricks

- Protoplasmic respiration refers to the respiration of proteins.
- Polarography is employed to measure the concentration of oxygen in fluid.
- Accumulation of blood in pleural cavity is called haemothorax.
- Accumulation of water is called hydrothorax.
- Accumulation of pus is called pyothorax.
- Accumulation of air is called pneumothorax.
- Besides lungs, the term alveolus is associated with bony socket for tooth, and in mammary glands also.
- In general, a man respires about 16 - 18 time in a minute.
- A new born child respires 32/min.
- A five year old child respires 26/min.
- A fifty year old man respires 18/min.
- No respiratory pigment in cockroach.
- Smaller the animal higher the respiratory rate.
- Rate of respiration is directly proportional to concentration of CO_2 in blood.
- Metabolic rate of body is directly proportional to the total pulmonary ventilation.
- Intra aortic balloon pump is inflated by helium.
- In pregnant woman diaphragm does not take part in breathing.
- In frog larynx and trachea are fused together to form laryngo tracheal chamber.
- Lungs of frog acts as positive pressure pump, while lungs of mammal acts as negative pressure pump.
- Disorder such as asthma and emphysema can greatly reduce the expiratory reserve volume.
- At about 4 weeks foetal development, the respiratory system begins as an outgrowth of endoderm of foregut, known as laryngotracheal bud.
- After 6 months, formation of alveoli of lungs.
- The pneumotoxic and the apneustic area in pons.
- If arterial PCO_2 is more than 40 *mm Hg*, the condition is called as hypercapnia.
- If arterial PCO_2 is lower than 40 *mm Hg*, the condition is called as hypocapnia.
- Double Bohr effect refers to the situation in the placenta where the Bohr effect is operative in both the maternal and foetal circulation.
- Ozone, a strong oxidizing agent, oxidises iron of *Hb* and forms a stable compound methaemoglobin which can not release O_2.
- Air bladder perform the functions of hydrostatic organ, sound production, audition and respiration.
- Foetal Hb takes O_2 from mother haemoglobin across the placenta due to double Bohr effect.
- In embryos of mammals, respiration takes place by chorion.
- In lungs of birds capillaries are present in place of alveoli.
- Exchange of O_2 takes place twice in lungs of birds. It is called double respiration.
- Aquatic salamander is lungless amphibians.
- In snakes, only right lung in functional, left lung is reduced.
- In penguins double trachea is present.
- In pregnant females most part during breathing is played by intercostal muscles.
- Whales and other aquatic mammals suffocate on land because their intercostal muscles can not expand their chest due to their massive body weight.
- In monkeys, kangaroo and other jumping animals, intercostal muscles play important role in breathing.
- **Smoke inhalation injury** – Has three components that occur in sequence

  Inhibition of O_2 delivery and utilization.

  Upper airway injury from heat.

  Lung damage from acid and aldehyde in smoke.
- **SARS – Severe Acute Respiratory Syndrome –**

  SARS is a highly infectious disease caused by corona virus.

  Corona virus is a RNA virus, its genome was sequenced within 15 days.

  The origin of SARS is from South China, this disease spread to Hongkong.

  Bird sellers and persons in contact with birds suffer from SARS.

  Symptoms of infections are flue like. Fever occurs with dry cough. There is difficulty in breathing. Fluid fills in lungs and death occurs within one week of infection from respiratory failure.

  Rate of death was initially 4% but now death rate has increased to 10%.

  Line of treatment is quarnatine and ribovinin durgs.

  The causative agent of SARS was identified by Dr. Malik Peiris of Microbiology Department of Hongkong University.

Ordinary Thinking

Objective Questions

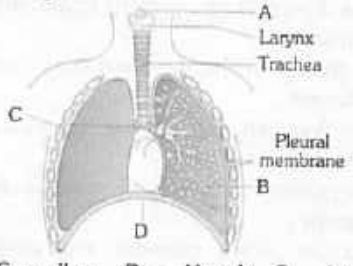
Respiratory organs

1. Which one of the following has the smallest diameter **[NCERT; Kerala CET 2003]**
   (a) Right primary bronchus (b) Left primary bronchus
   (c) Trachea (d) Respiratory bronchiole

2. Oxygen in lungs ultimately reaches in **[MP PMT 1998]**
   (a) Alveoli (b) Trachea
   (c) Bronchus (d) Bronchioles

3. Respiratory pigment in cockroach is **[RPMT 1999; Odisha JEE 2010]**
   (a) Haemozoin (b) Haemocyanin
   (c) Haemoglobin (d) Absent

4. See the following diagrammatic view of human respiratory system. Identify A to D **[NCERT]**



   (a) A - Soundbox, B - Alveoli, C - Bronchioles, D - Diaphragm
   (b) A - Soundbox, B - Alveoli, C - Bronchus, D - Diaphragm
   (c) A - Epiglottis, B - Alveoli, C - Bronchioles, D – Diaphragm
   (d) A - Epiglottis, B - Alveoli, C - Bronchus, D - Diaphragm

5. In man and mammals, air passes from outside into the lungs through **[NCERT; BHU 1999; CPMT 2000]**
   (a) Nasal cavity, larynx, pharynx, trachea bronchi, alveoli
   (b) Nasal cavity, larynx, pharynx, trachea, bronchioles, alveoli
   (c) Nasal cavity, pharynx, larynx, trachea, bronchioles, bronchi, alveoli
   (d) Nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, alveoli

6. Which of the following is a respiratory organ of scorpion **[CBSE PMT 2002; BVP 2002]**
   (a) Gill (b) Lung
   (c) Ctenidia (d) Book lung

7. During forced expiration, actively contracting muscles include the **[CBSE PMT 2001]**
   (a) Diaphragm
   (b) External intercostals
   (c) Abdominal muscles
   (d) Diaphragm and intestinal muscle

8. In which part gaseous exchange take place in rabbit **[NCERT; RPMT 2001]**
   (a) Trachea and alveolar duct
   (b) Trachea and bronchi
   (c) Alveolar duct and alveoli
   (d) Alveoli and tissues

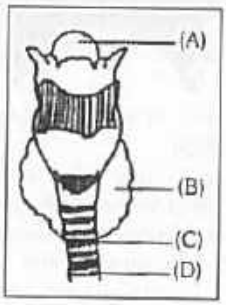
9. Difference between trachea and fallopian tube is **[CPMT 1995]**
   (a) Trachea is related with respiration where as fallopian tube is related with reproduction
   (b) Trachea is related with respiration and fallopian tube with excretion
   (c) Trachea is related with reproduction and fallopian tube with excretion
   (d) Trachea is related with reproduction and fallopian tube with respiration

10. Vocal cords are situated at **[MP PMT 1995, 99]**
    (a) Pharynx (b) Larynx
    (c) Glottis (d) Bronchial tube

11. Carbon dioxide is transported via blood to lungs mostly **[CBSE PMT 1995; Odisha JEE 2008]**
    (a) As carbaminohaemoglobin and as carbonic acid
    (b) In the form of carbonic acid only
    (c) In combination with haemoglobin only
    (d) Dissolved in blood plasma

12. Which is a common passage in swallowing food and breathing **[CPMT 1993; MP PMT 1995]**
    (a) Larynx (b) Gullet
    (c) Glottis (d) Pharynx

13. The diagram represents the human larynx. Choose the correct combination of labelling from the options given **[Kerala PMT 2008]**



    (a) A – Larynx, B – Parathyroid, C – Tracheal cartilage, D – Trachea
    (b) A – Naso Larynx, B – Thyroid, C – Tracheal cartilage, D – Trachea
    (c) A – Trachea, B – Thyroid, C – Bronchiole, D – Tracheal cartilage
    (d) A – Epiglottis, B – Thyroid, C – Tracheal cartilage, D – Trachea
    (e) A – Epiglottis, B – Parathyroid, C – Trachea, D – Tracheal cartilage

14. In human beings, lungs are divided into
    (a) 3 right and 2 left lobes (b) 2 right and 3 left lobes
    (c) 2 right and 2 left lobes (d) None of these

15. Similarity between the trachea of cockroach and rabbit is that **[AFMC 1994; CPMT 1995]**
    (a) Both are paired and branched
    (b) Ciliated epithelium is present in both
    (c) Walls of both can not be deformed
    (d) In both head originates from pharynx

16. In rabbit alveolar ducts originate from
    (a) Bronchi (b) Trachea
    (c) Bronchiole (d) Respiratory bronchiole

17. The cartilage present in the larynx of rabbit are **[BHU 2002]**
(a) Thyroid, cricoid, arytenoid
(b) Thyroid, cricoid, epiglottis
(c) Thyroid, cricoid, ethmoid
(d) Thyroid, cricoid, palatine

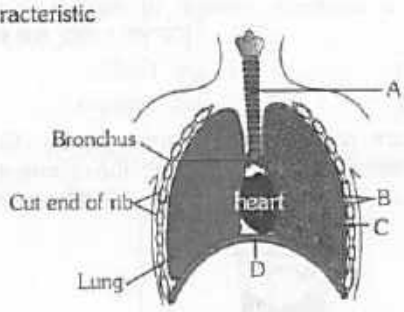
18. In which of the following animals Hb (Haemoglobin) is found dissolved in plasma **[CPMT 1998; DPMT 2007]**

Or

In which of the following animals, respiration occurs with out any respiratory organ **[CPMT 2003]**
(a) *Planaria* (b) Cockroach
(c) *Sepia* (d) Earthworm

19. The exchange of gases (O_2 and CO_2) in a mammal takes place in **[NCERT; CPMT 1992]**
(a) Trachea (b) Bronchi
(c) Bronchiole (d) Alveoli

20. The figure shows a diagrammatic view of human respiratory system with labels A, B, C and D. Select the option which gives correct identification and main function and/or characteristic



[NEET 2013]
(a) D – Lower end of lungs – diaphragm pulls it down during inspiration
(b) A – Trachea – long tube supported by complete cartilaginous rings for conducting inspired air
(c) B – Pleural membrane – surround ribs on both sides to provide cushion against rubbing
(d) C – Alveoli – thin walled vascular bag like structures for exchange of gases

21. Larynx is found in **[MP PMT 1992]**
(a) Both frog and rabbit (b) Neither frog nor rabbit
(c) Frog but not in rabbit (d) Rabbit but not in frog

22. The long trachea of rabbit contains **[CPMT 1992]**
(a) Buccal cord
(b) Thyroid
(c) Complete tracheal cartilage
(d) Incomplete tracheal cartilage

23. The right lung of rabbit has four lobes. They are **[CPMT 1992; MP PMT 1995]**
(a) Anterior lobe, anterior azygous, posterior lobe and right anterior
(b) Posterior lobe, posterior and anterior azygous, right anterior and right posterior
(c) Anterior azygous, right anterior, right posterior and posterior azygous lobe
(d) Anterior lobe, anterior azygous, right anterior and posterior azygous lobe

24. There is a membrane covering the lungs, called **[MP PMT 1994; KCET 1999; MH CET 2000; Pb. PMT 2004; AFMC 2005]**
(a) Peritonium (b) Pleura
(c) Pericardium (d) Duramater

25. In rabbit the lungs are lodged in **[CPMT 1992]**
(a) Thoracic cavity (b) Abdominal cavity
(c) Pleural cavity (d) Pericardial cavity

26. The most important function of diaphragm of the mammals is
(a) To divide the body cavity into compartment
(b) To protect lungs
(c) To aid in respiration
(d) To aid in ventilation

27. The pigment haemocyanin is found in **[BVP 2000; AIIMS 2000; CBSE PMT 2002; MHCET 2002]**
(a) Chordata (b) Annelida
(c) Mollusca (d) Echinodermata

28. Lung ventilation movements are due to **[Odisha JEE 2005]**
(a) Costal muscles and diaphragm
(b) Costal muscles
(c) Diaphragm
(d) Wall of the lungs

29. What is true about haemoglobin **[AIEEE Pharmacy 2006]**
(a) It is a dipeptide and present in red blood corpuscles in blood warm
(b) It is present in the dissolved state in blood plasma in earthworm
(c) It is a dipeptiede in mammals and localised in red blood corpuscles
(d) It is present in dissolved state in blood plasma in scorpions

30. The structure which prevents the entry of food into respiratory tract is
(a) Pharynx (b) Larynx
(c) Glottis (d) Epiglottis

31. In which animal, diaphragm has no role in respiration **[MH CET 2003]**
(a) Frog (b) Rat
(c) Camel (d) Rabbit

32. Thyroid is a cartilagenous plate in **[CPMT 1992, 93]**
(a) Skull of rabbit (b) Larynx of rabbit
(c) Vertebrae of rabbit (d) Sternum of rabbit

33. The diaphragm in rabbit is a **[J & K CET 2005]**
(a) Gap between the incisor and premolar teeth
(b) Membrane which surrounds and protects the brain
(c) Membrane which lies between the external auditory meatus and tympanic cavity of the ear
(d) Partition of muscular septum separating the thoracic cavity from abdominal cavity

Pulmonary volumes and capacities

1. What is vital capacity of our lungs **[CBSE PMT 2008]**
(a) Inspiratory reserve volume plus expiratory reserve volume
(b) Total lung capacity minus residual volume
(c) Inspiratory reserve volume plus tidal volume
(d) Total lung capacity *minus* expiratory reserve volume

2. The vital capacity of the lung signifies the volume of air
(a) Breathed in during normal inspiration
(b) Breathed out with forcible expiration
(c) Breathed in with forcible inspiration
(d) With deep inspiration and forcible expiration

3. Arrange the following in the order of increasing volume
(1) Tidal volume
(2) Residual volume
(3) Expiratory reserve volume
(4) Vital capacity **[NCERT; AIIMS 2007]**
(a) $1 < 2 < 3 < 4$ (b) $1 < 3 < 2 < 4$
(c) $1 < 4 < 3 < 2$ (d) $1 < 4 < 2 < 3$

4. The volume of air present in the lungs after forceful expiration is called as **[KCET 2006]**
(a) Tidal volume (b) Residual air
(c) Complementary air (d) None

5. The largest quantity of air that can be expired after a maximum inspiratory effort is **[NCERT; CPMT 1999; Pb. PMT 1999; CPMT 2004; MP PMT 2007; Odisha JEE 2011]**
(a) Residual volume (b) Tidal volume
(c) Vital capacity of lung (d) Lung volume

6. The volume of air which remains in the conducting airways and is not available for gas exchange is called **[J & K CET 2012]**
(a) Vital capacity
(b) Functional residual capacity
(c) Forced expiratory volume
(d) Anatomic dead space

7. How much amount of volume of air is in lungs FRC **[GUJCET 2015]**
(a) 1500 ml to 1600 ml (b) 2100 ml to 2500 ml
(c) 2500 ml to 3000 ml (d) 1600 ml to 2100 ml

8. The enzyme essential for the transport of CO_2 as bicarbonate in blood is **[MP PMT 2012; Kerala PMT 2012]**
(a) Carboxypeptidase (b) Succinic dehydrogenase
(c) Carbonic anhydrase (d) Thrombokinase
(e) Lactase

9. The amount of volume of air that can be inspired/expired normally is called **[DPMT 2007; AFMC 2009, 10; J & K CET 2010; GUJCET 2014]**
(a) Tidal volume (b) Vital capacity
(c) Residual volume (d) Normal volume

10. The area of inner surface of bronchiole is **[KCET 2001; MH CET 2003]**
(a) $1\ m^2$ (b) $10\ m^2$
(c) $100\ m^2$ (d) $1000\ m^2$

11. Capacity of human lung for air **[Odisha JEE 2005]**
(a) 3000 *ml* (b) 1500 *ml*
(c) 1000 *ml* (d) 500 *ml*

12. Residual volume is **[KCET 2007]**
(a) Lesser than tidal volume
(b) Greater than inspiratory volume
(c) Greater than vital capacity
(d) Greater than tidal volume

13. Vital capacity of the lung includes **[Kerala PMT 2007; DPMT 2007; BHU 2012]**

Or

After forceful inspiration, the amount of air that can be breathed out by maximum forced expiration is equal to **[WB JEE 2012]**
(a) $IRV + TV + ERV$ (b) $ERV + RV$
(c) $ERV + TV$ (d) $IRV + TV$
(e) $RV + ERV + TV + IRV$

14. Match the items in Column – I with Column – II and choose the correct option

Column – I		Column – II	
A.	Tidal volume	1.	2500 to 3000 *ml* of air
B.	Inspiratory reserve volume	2.	1000 *ml* of air
C.	Expiratory reserve volume	3.	500 *ml* of air
D.	Residual volume	4.	3400 to 4800 *ml* of air
E.	Vital capacity	5.	1200 *ml* of air

[NCERT; CBSE PMT 1996; Pb PMT 2004; Kerala PMT 2007; AFMC 2012]
(a) A – 3, B – 4, C – 2, D – 1, E – 5
(b) A – 3, B – 1, C – 2, D – 5, E – 4
(c) A – 3, B – 1, C – 4, D – 5, E – 4
(d) A – 5, B – 4, C – 2, D – 1, E – 2
(e) A – 4, B – 3, C – 2, D – 1, E – 5

15. The partial pressure of oxygen in the alveolar air is **[Kerala PMT 2010]**
(a) 45 *mm Hg* (b) 95 *mm Hg*
(c) 104 *mm Hg* (d) 110 *mm Hg*
(e) 125 *mm Hg*

16. The volume of 'anatomical dead space' air is normally **[WB JEE 2012]**
(a) 230 *ml* (b) 210*ml*
(c) 190*ml* (d) 150 *ml*

17. The volume and surface area of a deer is 1,50,000 cm^3 and 19,000 cm^2 and of a squirrel is 625 cm^3 and 530 cm^2. The area available for heat loss per cm^3 volume of the squirrel will be approximately **[AMU (Med.) 2010]**
(a) Seven times more than the deer
(b) Five times less than the deer
(c) Three times more than the deer
(d) Eleven times more than the deer

18. The urge to inhale in humans results from **[DUMET 2010]**
(a) Rising PCO_2 (b) Rising PO_2
(c) Falling PCO_2 (d) Falling PO_2

19. Listed below are four respiratory capacities $(A - D)$ and four jumbled respiratory volumes of a normal human adult

Respiratory capacities		Respiratory volumes
(A) Residual volume	-	2500 *mL*
(B) Vital capacity	-	3500 *mL*
(C) Inspiratory reserve volume	-	1200 *mL*
(D) Inspiratory capacity	-	4500 mL

Which one of the following is the correct matching of two capacities and volumes **[CBSE PMT (Pre.) 2010]**
(a) (A) 4500 *mL*, (B) 3500 *mL*
(b) (B) 2500 *mL*, (C) 4500 *mL*
(c) (C) 1200 *mL*, (D) 2500 *mL*
(d) (D) 3500 *mL*, (A) 1200 *mL*

20. Complete and balanced the following reaction
$Na_2HPO_4 + X \rightarrow Y + NaH_2PO_4$ **[GUJCET 2015]**
(a) X = $NaHCo_3$, Y = NaCl
(b) X = H_2CO_3, Y = NaH_2CO_3
(c) X = $NaHCO_3$, Y = H_2CO_3
(d) X = H_2CO_3, Y = $NaHCO_3$

21. Lungs are made up of air-filled sacs, the alveoli. They do not collapse even after forceful expiration because of **[NEET 2017]**
(a) Residual Volume (b) Inspiratory Reserve Volume
(c) Tidal Volume (d) Expiratory Reserve Volume

Process of respiration

1. Oxy-haemoglobin dissociates into oxygen and deoxy-haemoglobin at**[DPMT 1992; MP PMT 1995; JIPMER 2002]**
(a) Low O_2 pressure in tissue
(b) High O_2 pressure in tissue
(c) Equal O_2 pressure inside and outside tissue
(d) All times irrespective of O_2 pressure

2. In lungs, the air is separated from the venous blood through **[CBSE PMT 1997]**
(a) Squamous epithelium + endothelium of blood vessel
(b) Squamous epithelium + tunica media blood vessel
(c) Transitional epithelium + tunica external blood vessel
(d) None of these

3. The exchange of gases in the alveoli of the lungs takes place by **[CBSE PMT 1998; AFMC 2002; Bihar BCECE 2005; Odisha JEE 2010]**
(a) Osmosis (b) Simple diffusion
(c) Passive transport (d) Active transport

4. Which of the following enzymes is absent in mitochondria **[CPMT 1998]**
(a) Aconitase (b) Maleic dehydrogenase
(c) Hexokinase (d) None of these

5. If concentration of CO_2 is more the curve of oxygen will shift towards **[MP PMT 2002]**
Or
Increase in body temperature makes oxygen haemoglobin dissociation curve shift to **[BHU 2012]**
(a) Right (b) Left
(c) Central (d) None of these

6. The respiratory substrate yielding maximum number of ATP molecules among the following is **[CBSE PMT 1994]**
(a) Glycogen (b) Amylase
(c) Ketogenic amino acid (d) Glucose

7. Division of mammalian lungs into a very large number of tiny alveoli around alveolar ducts opening into bronchioles, is **[CBSE PMT 1995]**
(a) An inefficient system of ventilation of alveoli though with very little residual air
(b) An inefficient system of ventilating the alveoli resulting in very high percentage of residual air in the lungs
(c) A very efficient system of ventilating the alveoli with no residual air
(d) An efficient system of ventilation of alveoli with little or no residual air

8. Choose the right sequential phenomena among the following during the delivery of O_2 from blood to tissue
P. Absorption of CO_2 by the blood
Q. Reaction of absorbed CO_2 with H_2O to from H_2CO_3 within RBC and its conversion into H^+ and HCO_3^- ions
R. Reaction of absorbed CO_2 with H_2O in plasma to form H_2CO_3 and its conversion into H^+ and HCO_3^- ions
S. Combination of H^+ with haem portion of HbO_2 to release O_2
T. Combination of HCO_3^- with haem portion HbO_2 to form reduced haemoglobin and release of O_2 **[WB JEE 2012]**
(a) P, Q, T (b) P, R, S
(c) P, Q, S (d) P, R, T

9. The alveoli of lungs are lined by **[Kerala PMT 2008]**
(a) Simple epithelium (b) Squamous epithelium
(c) Cuboidal epithelium (d) Columnar epithelium
(e) Ciliated epithelium

10. Which of the following is used for long term energy storage by animals **[Odisha JEE 2009]**
(a) Amino acids (b) Glucose
(c) Fat (d) Glycogen

11. Intra aortic balloon pump is inflated by **[JIPMER 2002]**
(a) Hydrogen (b) Oxygen
(c) Helium (d) Chlorine

12. Energy is stored in the liver and muscles in the form of **[CPMT 1998; MP PMT 1999; AFMC 2003; Odisha JEE 2009]**
Or
In the muscles carbohydrates are stored in the form of **[WB JEE 2016]**
(a) Carbohydrates (b) Glycogen
(c) Fat (d) Protein

13. The major fraction of CO_2 released during cellular respiration is transported by the blood to the lung capillaries **[NCERT; CPMT 1998; MP PMT 1998, 2002; AIEEE Pharmacy 2003; Odisha JEE 2010]**
Or
Approximately seventy percent of carbon-dioxide absorbed by the blood will be transported to the lungs **[CBSE PMT 2014]**
(a) In combination with haemoglobin
(b) As free CO_2
(c) As carbonic acid or H_2CO_3
(d) In the form of bicarbonate ions

14. The amount of O_2 transported in a dissolved state through plasma is approximately **[NCERT; Kerala PMT 2012]**
(a) 97% (b) 20 – 25%
(c) 7% (d) 49%
(e) 3%

15. During inspiration the diaphragm **[BHU 2004; CPMT 2010]**
(a) Relaxes to become dome-shaped
(b) Contracts and flattens
(c) Expands
(d) Shows no change

16. In hurdle race, which of the following is accumulated in the leg muscle **[DUMET 2009]**
(a) Performed ATP (b) Glycolysis
(c) Lactate (d) Oxidative metabolism

17. Which of the following sets is most correct for the catabolism of an 18 carbon fatty acid **[AMU (Med.) 2009]**
(a) Mitochondria, beta-oxidation, 140 ATP molecules
(b) Cytosol, beta oxidation, 146 ATP molecules
(c) Mitochondria, beta oxidation, 146 ATP molecules
(d) Cytosol, beta oxidation, 140 ATP molecules

18. In humans, which among these is not a step in respiration **[NCERT; Kerala PMT 2012]**
(a) Pulmonary ventilation
(b) Alveolar diffusion of O_2 and CO_2
(c) Transport of gases by blood
(d) Diffusion of O_2 and CO_2 between blood and tissues
(e) Utilization of CO_2 by cells for catabolic reactions

19. *Hb* is a **[MP PMT 2007]**
(a) Reproductive pigment (b) Respiratory pigment
(c) Carbohydrate (d) Fat

20. According to Boyle's law, the product of pressure and volume is a constant. Hence, **[KCET 2010]**
(a) If volume of lungs is increased, the pressure decreases, proportionately
(b) If volume of lungs is increased, the pressure also increases proportionately
(c) If volume of lungs is increased, the pressure decreases disproportionately
(d) If volume of lungs is increased, the pressure remains the same

21. Chloride shift occurs in respond to **[DPMT 2007]**
(a) H^+ (b) K^+
(c) HCO_3^- (d) Na^+

22. Which one of the following is a possibility for most of us in regards to breathing, by making a conscious effort **[NCERT; CBSE PMT (Mains) 2011]**
(a) One can consciously breathe in and breathe out by moving the diaphragm alone, without moving the ribs at all
(b) The lungs can be made fully empty by forcefully breathing out all air from them
(c) One can breathe out air totally without oxygen
(d) One can breathe out air through eustachian tubes by closing both the nose and the mouth

23. Identify the correct statement with reference to transport of respiratory gases by blood **[KCET 2006]**
(a) Haemoglobin is necessary for transport of carbon dioxide and carbonic anhydrase for transport of oxygen
(b) Haemoglobin is necessary for transport of oxygen and carbonic anhydrase for transport of carbon dioxide
(c) Only oxygen is transported by blood
(d) Only carbon dioxide is transported by blood

24. Which of the following statement correctly defines "Bohr effects"
(a) Rise in PCO_2 with a decrease in CO_2 concentration
(b) Rise in PCO_2 with an increase in CO_2 concentration
(c) Rise in PCO_2 with an increase in CO_2 and decrease in PO_2
(d) Rise in PCO_2 with a decrease in pH (concentration at which 50% haemoglobin of blood is saturated with oxygen)

25. Under a given concentration in blood, dissociation of oxyhaemoglobin will increase if
(a) pH of blood falls
(b) pH of blood rises
(c) CO_2 concentration in blood falls
(d) Free fatty acid concentration in blood falls

26. Oxygen binding to haemoglobin in blood is **[AIIMS 2012]**
(a) Directly proportional to the concentration of CO_2 in the medium
(b) Inversely proportional to the concentration of CO_2 in the medium
(c) Directly proportional to the concentration of CO in the medium
(d) Independent of the concentration of CO in the medium

27. Bulk of carbon dioxide (CO_2) released from body tissues into the blood is present as **[NCERT; CBSE PMT (Mains) 2011]**
(a) 70% carbamino-haemoglobin and 30% as bicarbonate
(b) Carbamino-haemoglobin in RBCs
(c) Bicarbonate in blood plasma and RBCs
(d) Free CO_2 in blood plasma

28. O_2 dissociation curve is **[NCERT; BHU 1995, 2000; CPMT 2000; DPMT 2007]**
(a) Sigmoid (b) Slope
(c) Straight line (d) Parabola

29. In expiration condition, diaphragm becomes **[CPMT 1993]**
(a) Circular (b) Relaxed
(c) Fully contracted (d) Expanded

30. Maximum amount of oxygen is lost from the blood in the **[KCET 2006]**
(a) Capillaries surrounding the tissue cells
(b) Arteries of the body
(c) Capillaries surrounding the alveoli
(d) Left auricle of the heart

31. Which of the following activity does not take place during pulmonary respiration **[Bihar MDAT 1995]**
(a) Movement of buccal cavity
(b) Contraction and relaxation of sternohyal and pterohyal muscles
(c) Successive opening and closing of mouth and external nostrils
(d) All the above
(e) No activity takes place

32. In anaerobic respiration the pyruvic acid in muscle will form **[CPMT 1995, 99; AFMC 2002, 08; DPMT 2003]**
(a) Lactic acid ($C_3H_6O_3$) and H_2O
(b) Alcohol (C_2H_5OH) and H_2O
(c) Acetaldehyde and H_2O
(d) Acetyl *CoA* and H_2O

33. Blood contains CO_2 in which of the following forms
(a) $NaHCO_3$ (b) Carbonic acid
(c) $Hb-CO_2$ (d) $Hb-CO_2$ and CO

34. Oxygen is transported to every cell of the body through **[MP PMT 1994]**
(a) RBC (b) WBC
(c) RBC and WBC (d) RBC and hormones

35. Acquiring an oxygen debt is evidence that **[CPMT 2005]**
(a) O_2 cannot be stored in tissue
(b) Aerobic respiration is more complex than glycolysis
(c) Lactic acid can be converted into glycogen
(d) Anaerobic process are slower than aerobic processes

36. The dissociation curve is associated with **[NCERT]**
(a) Oxygen (b) Oxyhaemoglobin
(c) Carbon dioxide (d) Carbonic anhydrase

37. Respiratory system is derived from **[CPMT 1993]**
(a) Ectoderm (b) Mesoderm
(c) Endoderm (d) None of these

38. The breakdown product of haemoglobin is called as **[CBSE PMT 1993]**
(a) Iron (b) Bilirubin
(c) Haemocynin (d) Skatol

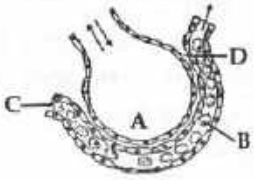
39. During respiration CO_2 is transported in the form of **[NCERT; CBSE PMT 1995, 2006; AFMC 2006, 10; BHU 2006]**
(a) Dissolved plasma
(b) Sodium carbonate
(c) $KHCO_3$
(d) Partly dissolved in plasma and partly in the form of sodium and potassium bicarbonate

40. CO_2 is dissolved in haemoglobin or blood plasma as **[CBSE PMT 1993; WB JEE 2016]**
(a) Carbonates (b) Bicarbonates
(c) Oxyhaemoglobin (d) Carboxyhaemoglobin

41. The factor which does not affect the rate of alveolar diffusion is **[NCERT; Kerala PMT 2011]**
(a) Solubility of gases (b) Thickness of the membranes
(c) Pressure gradient (d) Concentration gradient
(e) Reactivity of the gases

42. In Bhor's effect curve shift to right **[Bihar CECE 2006]**
(a) P_{50} CO_2 decreases and P_{50} O_2 increases
(b) P_{50} CO_2 increases and P_{50} O_2 decreases
(c) P_{50} CO_2 increases and P_{50} O_2 increases
(d) P_{50} CO_2 increases and P_{50} O_2 decreases and pH increases

43. The figure given below shows a small part of human lung where exchange of gases takes place. In which one of the option given below, the one part A, B, C or D is correctly identified along with its functions



Options **[CBSE PMT (Pre.) 2011]**
(a) B : Red blood cell – transport of CO_2 mainly
(b) C : Arterial capillary – passes oxygen to tissues
(c) A : alveolar cavity – main site of exchange of respiratory gases
(d) D : Capillary wall – exchange of O_2 and CO_2 takes place here

44. Reduction in pH of blood will **[NEET (Phase-I) 2016]**
(a) Reduce the rate of heart beat
(b) Reduce the blood supply to the brain
(c) Decrease the affinity of hemoglobin with oxygen
(d) Release bicarbonate ions by the liver

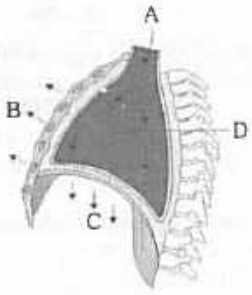
45. When you hold your breath, which of the following gas changes in blood would first lead to the urge to breathe **[AIPMT (Cancelled) 2015]**
(a) Rising CO_2 concentration
(b) Falling CO_2 concentration
(c) Rising CO_2 and falling O_2 concentration
(d) Falling O_2 concentration

46. In lungs there is definite exchange of ions between RBC and plasma. Removal of CO_2 from blood involves **[CPMT 2005]**
(a) Influx of Cl^- ions into RBC
(b) Influx of HCO_3^- ions into RBC
(c) Efflux of Cl^- ions into RBC
(d) Efflux of HCO_3^- ions into RBC

47. In a minute normal man respires **[NCERT; MP PMT 1993]**
(a) 10 times (b) 16 times
(c) 30 times (d) 4 times

48. The process by which chloride ions pass into R.B.C. and bicarbonate ions pass out is called **[DPMT 1992; RPMT 1999; Kerala CET 2003]**
(a) Bicarbonate shift (b) Chloride shift
(c) Buffer system (d) Enzyme shift

49. Following diagram indicates the mechanism of breathing. Identify all the parts A, B, C and D correctly **[NCERT]**



(a) A – Air expelled from lungs; B – Ribs and sternum raised; C – Diaphragm contracted; D – Volume of thorax decreased
(b) A – Air expelled from lungs; B – Ribs and sternum raised; C – Diaphragm relaxed; D – Volume of thorax decreased
(c) A – Air expelled from lungs; B – Ribs and sternum return to original position; C – Diaphragm relaxed; D – Volume of thorax decreased
(d) A – Air entering into lungs; B – Ribs and sternum raised; C – Diaphragm contracted; D – Volume of thorax raised

50. Muscles which help in respiration are
(a) Sternum and petrohyal (b) Sternohyal and petrohyal
(c) Jugal and tendons (d) None of these

51. Of the following, the one which is an example of buffer system in blood is **[Kerala PMT 2004]**
(a) Haemoglobin and oxyhaemoglobin
(b) Oxygen and carbon dioxide
(c) Albumin and globulin
(d) Sodium bicarbonate and carbonic acid

52. In a normal man to help the transport of O_2 and CO_2 properly, the blood is
(a) Slightly alkaline (b) Slightly acidic
(c) Strongly alkaline (d) Strongly acidic

53. In mammals how much CO_2 is transported as bicarbonates of sodium and potassium in the blood **[AIIMS 1993]**
(a) 5–10 % (b) 10–90 %
(c) 70–72 % (d) 90–95 %

54. A large proportion of oxygen is left unused the human blood even after its uptake by the body tissue. This O_2 **[NCERT; CBSE PMT (Pre.) 2011]**
(a) Helps in releasing more O_2 to the epithelium tissues
(b) Acts as a reserve during muscular exercise
(c) Raises the pCO_2 of blood to 75 mm of Hg
(d) Is enough to keep oxyhaemoglobin saturation at 96%

55. Chloride shift is essential for the transport of **[CBSE PMT 1990]**
(a) CO_2 and O_2 (b) N_2
(c) CO_2 (d) O_2

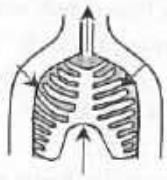
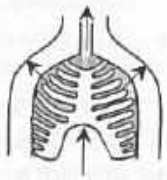
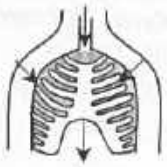
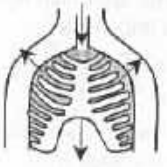
56. Which is true for CO_2 concentration **[Odisha JEE 2004]**
(a) More in alveolar air than in expired air
(b) More in expired air than in alveolar air
(c) More in inspired air than in expired air
(d) More in inspired air than in alveolar air

57. The two waste products of oxidation in cells are
(a) CO_2 and N_2 (b) C and O
(c) CO_2 and water (d) Water and N_2

58. The function of tracheal hair is to **[BVP 2003]**
(a) Pass mucus out (b) Pass mucus in
(c) Pass air out (d) Pass air in

59. The function of surfactant is/are **[J & K CET 2012]**
(a) Facilitating lung expansion
(b) Maintaining the stable size of the alveoli
(c) To reduce the surface tension on the alveoli
(d) All the above

60. During cellular respiration the energy produced is stored in
Or
The common immediate source of energy in cellular activity
(a) Protoplasm (b) Cytoplasm
(c) ATP (d) Nucleus

61. Exhalation is the process of expulsion of air through the respiratory tract. Which figure correctly shows the process of exhalation **[NCERT]**
(a) 
(b) 
(c) 
(d) 

62. Respiration is the physiological process in which
(a) Breathing occurs
(b) Breathing and external respiration occur
(c) Breathing, external respiration and cellular respiration occur
(d) Only inspiration occurs

63. In rabbit the inspiration occurs by contraction of
(a) External intercostal muscles and muscles of the diaphragm
(b) Internal intercostal muscles and muscles of the diaphragm
(c) External intercostal muscles only
(d) Muscles of the diaphragm only

64. Left shift of oxyhaemoglobin curve is noticed under **[EAMCET 2009]**
(a) Normal temperature and pH
(b) Low temperature and high pH
(c) Low pH and high temperature
(d) Low pH and low temperature

65. Lungs do not collapse between breaths and some air always remains in the lungs which can never be expelled because **[NEET (Phase-II) 2016]**
(a) Pressure in the lungs is higher than the atmospheric pressure
(b) There is a negative pressure in the lungs
(c) There is a negative intrapleural pressure pulling at the lung walls
(d) There is a positive intrapleural pressure

66. The partial pressure of oxygen in the alveoli of the lungs is **[NEET (Phase-II) 2016]**
(a) Less than that of carbon dioxide
(b) Equal to that in the blood
(c) More than that in the blood
(d) Less than that in the blood

Control of breathing

1. How much amount of air can be inspired or expired during normal breathing **[DPMT 2003; BVP 2004]**
(a) 0.5*l* (b) 2.5*l*
(c) 1.5*l* (d) 5.5*l*

2. Breathing differs from respiration by [AFMC 1993]
(a) Both are same and there is no difference
(b) Breathing refers to respiration in human beings whereas respiration occurs in rest of the animals and plants
(c) Breathing refers to chest movements due to inhalation of O_2 and exhalation of carbon dioxide whereas respiration refers to gaseous exchange
(d) None of these

3. The air which is taken in or given out during a single breath is known as [Kerala CET 2002; BHU 2008]
(a) Residual air (b) Vital air
(c) Tidal air (d) All of these

4. Combination of haemoglobin with O_2 in lungs can be promoted by [MP PMT 2006]
(a) Increasing CO_2 concentration in blood
(b) Increasing O_2 concentration in blood
(c) Decreasing O_2 concentration in blood
(d) Introducing CO in blood

5. Step of respiration are controlled by [RPMT 2005]
(a) Substrates (b) Enzymes
(c) Hormone (d) Bile juice

6. Respiration mechanism is controlled by
(a) Central nervous system
(b) Autonomic nervous system
(c) Sympathetic nervous system
(d) Parasympathetic nervous system

7. Which of the following conditions is responsible for increase in ventilation rate of lungs [CPMT 2005]
(a) Increase of CO_2 content in inhaled air
(b) Increase of CO_2 content in exhaled air
(c) Decrease of O_2 content in inhaled air
(d) Decrease of O_2 content in exhaled air

8. The respiratory centre in brain which controls inspiration and expiration is situated in [CPMT 1993, 99; CBSE PMT 1994, 99; BHU 1995; AFMC 1995; RPMT 1995, 99, 2005, 06; MP PMT 1996; Pb. PMT 1999; AIIMS 2001; Kerala PMT 2010]

Or

Respiratory and vomitting centres are located in [NCERT; MH CET 2002; DUMET 2009]
(a) Medulla oblongata (b) Cerebellum
(c) Hypothalamus (d) Pericardium

9. When CO_2 concentration in blood increases, breathing becomes [CPMT 2004]
(a) Slow and deep
(b) Faster and deeper
(c) Shallower and slow
(d) There is no effect on breathing

10. Respiratory centre of brain is sensitive to [NCERT; Odisha JEE 2004]
(a) More O_2 conc. in blood
(b) More CO_2 conc. in blood
(c) Accumulation of blood in brain
(d) All of these

11. A substance that prevents or delays oxidation is [J & K CET 2005]
(a) Bactericidal (b) Hormone
(c) Antioxidant (d) Enzyme

12. Rate of breathing is controlled by [Kerela CET 2005]
(a) The amount of freely available oxygen
(b) Carbon dioxide
(c) Muscular function of the body
(d) Stress

Important concepts of respiration

1. What is R.Q. for human fat [DPMT 1992]
(a) 0.673 (b) 0.655
(c) 0.703 (d) 0.825

2. The form of energy used in respiration is [CPMT 1993]
(a) Chemical energy (b) Electrical energy
(c) Mechanical energy (d) Radiant energy

3. In human blood, the oxygen carrier is [CPMT 1994]
(a) Iron (b) Meth–haemoglobin
(c) Haemocyanin (d) Haemoglobin

4. The toxic effect of carbon monoxide is due to its greater affinity for haemoglobin as compared to oxygen, approximately by [BHU 2002]
(a) 2 times (b) 20 times
(c) 200 times (d) 1000 times

5. During strenous exercise, which of the following change occurs [CPMT 2000]
(a) Glucose is converted into glycogen
(b) Glucose is converted into pyruvic acid
(c) Starch is converted into glucose
(d) Pyruvic acid is converted into lactic acid

6. Which of the following blood vessels in the circulatory system of frog has more oxygenated blood [AFMC 2006]
(a) Pulmocutaneous artery (b) Pulmocutaneous vein
(c) Pulmonary artery (d) Precaval veins

Disorders of respiration system

1. After fast running, man has fast heart beat, slow pulse and shallow breathing, in such conditions he has
(a) Oxygen debt
(b) Poisoning due to lactic acid
(c) No pulmonary pressure
(d) Weak heart

2. Increased asthmatic attacks in certain seasons are related to [CBSE PMT 2007; MP PMT 2013]
(a) Hot and humid environment
(b) Eating fruits preserved in tin containers
(c) Inhalation of seasonal pollen
(d) Low temperature

3. After taking a long deep breath we do not respire for some seconds due to [BHU 2005]
(a) More CO_2 in blood (b) More O_2 in blood
(c) Less CO_2 in blood (d) Less O_2 in blood

4. Ascent of high mountains may cause altitude sickness in men. Prime cause of this is [NCERT; CPMT 2005]
(a) Excess of CO_2 in blood
(b) Decreased efficiency of haemoglobin
(c) Decreased partial pressure of oxygen
(d) Decreased proportion of oxygen in air

5. The state during which the respiratory centre is inhibited is termed as **[DPMT 1993]**
(a) Asphyxia (b) Suffocation
(c) Anoxia (d) Chocking

6. Ravi, who lived at sea level, had around 5 million RBC per cubic millimeter of his blood. Later when he lived at an altitude of 18,000 ft, showed around 8 million RBC per cubic millimeter of blood. This is an adaptation because **[AIEEE Pharmacy 2004; RPMT 2005]**
(a) At high altitude he ate more nutritive food
(b) He had pollution free air to balance breathe
(c) At high altitude O_2 level is less hence more RBCs were required to absorb enough oxygen
(d) At high altitude there is more UV radiation which enhances RBCs production

7. During rest, the metabolic needs of the body are at their minimum. Which of the following is indicative of this situation **[AFMC 1994]**
(a) Rate of breathing (b) Pulse rate
(c) O_2 intake and CO_2 output (d) All of these

8. Cyanosis is
(a) Lack of oxygen in body fluids
(b) Difficult or heavy breathing
(c) Excess of carbon dixode in the body fluids
(d) 'Skin turning blue' due to excessive amount of deoxygenated haemoglobin in the skin blood vessels

9. Pneumotaxis centre is associated with
(a) Breathing (b) Respiration
(c) Movement (d) Closure of glottis

10. Congestion of the lungs is one of the main symptoms in **[Kerala PMT 2011]**
(a) Hypotension (b) Coronary artery disease
(c) Angina (d) Heart failure
(e) Atherosclerosis

11. When O_2 is inadequate during respiration, the condition is called **[BVP 2000; WB JEE 2011; Odisha JEE 2012]**
(a) Anoxia (b) Pleurisy
(c) Asphyxia (d) Hypoxia

12. The oxygen toxicity is related with **[BHU 2004]**
(a) Blood poisoning
(b) Collapse of alveolar walls
(c) Failure of ventilation of lungs
(d) Both (a) and (b)

13. The diabetic patient shows
(a) High respiratory quotient (b) Low respiratory quotient
(c) Zero respiratory quotient (d) None of these

14. The 'blue baby' syndrome results from **[CBSE PMT 2006]**
(a) Excess of dissolved oxygen
(b) Excess of TDS (total dissolved solids)
(c) Excess of chloride
(d) Methaemoglobin

15. Asthma is characterised by **[NCERT; Odisha JEE 2011]**
(a) Spasm in bronchial muscle
(b) Alveolar wall degradation
(c) Pain in lungs
(d) Damage in diaphragm

16. In which disease, due to flattening of tracheal vessels, alveoli are deprived of oxygen **[NCERT; GUJCET 2007]**

Or

Name the pulmonary disease in which alveolar surface area involved in gas exchange is drastically reduced due to damage in the alveolar walls **[AIPMT 2015]**
(a) Bronchitis (b) Asthma
(c) Pneumonia (d) Emphysema

17. Blood analysis of a patient reveals an unusually high quantity of carboxyhaemoglobin content. Which of the following conclusions is most likely to be correct **[CPMT 2004]**
(a) Carbon dioxide (b) Carbon monoxide
(c) Carbon disulphide (d) Chloroform

NCERT Exemplar Questions

1. Respiration in insects is called direct because **[NCERT]**
(a) The tissues exchange O_2/CO_2 directly with the air in the tubes
(b) The tissues exchange O_2/CO_2 directly with coelomic fluid
(c) The tissues exchange O_2/CO_2 directly with the air outside through body surface
(d) Tracheal tubes exchange O_2/CO_2 directly with the haemocoel which then exchange with tissues

2. Regarding the functions of our respiratory system, mark the wrong entry **[NCERT]**
(a) Humidifies the air (b) Warms up the air
(c) Diffusion of gases (d) Cleans up the air

3. A person suffers punctures in his chest cavity in an accident, without any damage to the lungs its effect could be **[NCERT]**
(a) Reduced breathing rate
(b) Rapid increase in breathing rate
(c) No change in respiration
(d) Cessation of breathing

4. Mark the true statement among the following with reference to normal breathing **[NCERT]**
(a) Inspiration is a passive process where as expiration is active
(b) Inspiration is a active process where as expiration is passive
(c) Inspiration and expiration are active processes
(d) Inspiration and expiration are passive processes

5. A person breathes in some volume of air by forced inspiration after having a forced expiration. This quantity of air taken in is **[NCERT]**
(a) Total lung capacity (b) Tidal volume
(c) Vital capacity (d) Inspiratory capacity

6. Mark the incorrect statement in context to O_2 binding to Hb **[NCERT]**
(a) Higher pH (b) Lower temperature
(c) Lower pCO_2 (d) Higher PO_2

7. Mark the correct pair of muscles involved in the normal breathing in humans [NCERT]
   (a) External and internal intercostals muscles
   (b) Diaphragm and abdominal muscles
   (c) Diaphragm and external intercostals muscles
   (d) Diaphragm and internal intercostals muscles

8. Incidence of Emphysema – a respiratory disorder is high in cigarette smokers. In such cases [NCERT]
   (a) The bronchioles are found damaged
   (b) The alveolar walls are found damaged
   (c) The plasma membrane is found damaged
   (d) The respiratory muscles are found damaged

9. Respiratory process is regulated by certain specialized centres in the brain. One of the following listed centres can reduce the inspiratory duration upon stimulation [NCERT]
   (a) Medullary inspiratory centre (b) Pneumotaxic centre
   (c) Apneustic centre (d) Chemosensitive centre

10. CO_2 dissociates from carbamino haemoglobin when [NCERT]
   (a) pCO_2 is high and pO_2 is low
   (b) pO_2 is high and pCO_2 is low
   (c) pCO_2 and pO_2 are equal
   (d) None of the above

11. Identify the correct and incorrect match about respiratory volume and capacities and mark the correct answer
   (i) Inspiratory capacity (IC) = Tidal Volume + Residual volume
   (ii) Vital Capacity (VC) = Tidal Volume (TV) + Inspiratory Reserve Volume (IRV) + Expiratory Reserve Volume (ERV)
   (iii) Residual Volume (RV) = Vital Capacity (VC) – Inspiratory Reserve Volume (IRV)
   (iv) Tidal Volume (TV) = Inspiratory Capacity (IC) – Inspiratory Reserve Volume (IRV)
   Options: [NCERT]
   (a) (i) Incorrect, (ii) Incorrect, (iii) Incorrect, (iv) Correct
   (b) (i) Incorrect, (ii) Correct, (iii) Incorrect, (iv) Correct
   (c) (i) Correct, (ii) Correct, (iii) Incorrect, (iv) Correct
   (d) (i) Correct, (ii) Incorrect, (iii) Correct, (iv) Incorrect

12. The oxygen – haemoglobin dissociation curve will show a right shift in case of [NCERT]
   (a) High pCO_2 (b) High pO_2
   (c) Low pCO_2 (d) Less H^+ concentration

13. Match the following and mark the correct options

Animal	Repiratory organ
A. Earthworm	i. Moist cuticle
B. Aquatic Arthropods	ii. Gills
C. Fishes	iii. Lungs
D. Birds/Reptiles	iv. Trachea

   Options [NCERT]
   (a) A-ii, B-i, C-iv, D-iii (b) A-i, B-iv, C-ii, D-iii
   (c) A-i, B-iii, C-ii, D-iv (d) A-i, B-ii, C-iv, D-iii

Critical Thinking

Objective Questions

1. Which animal has unpaired lungs
   (a) Monkey (b) Whale
   (c) Some frogs (d) Some snakes

2. Mammalian lungs have enormous number of minute alveoli (air sacs). It is to allow [AFMC 1994; MP PMT 1995]
   (a) More space for increasing the volume of inspired air
   (b) More surface area for diffusion of gases
   (c) More spongy texture for keeping lungs in proper shape
   (d) More nerve supply to keep organs active when working

3. True organ of sound production in birds is [Kerala CET 2003]
   (a) Larynx (b) Sound box
   (c) Vocal sac (d) Syrinx

4. The nerve impulses which stimulate the intercostal muscles and diaphragm and thus permit breathing, originate in the [AIIMS 1992]
   (a) Cerebellum (b) Pons
   (c) Hypothalamus (d) Medulla oblongata

5. Number of alveoli in human lung is about [Odisha JEE 2012]
   (a) One million (b) More than two millions
   (c) More than five millions (d) More than seven millions

6. Which of the following statements is not true [Kerala PMT 2007]
   (a) The partial pressure of oxygen in deoxygenated blood is 40 *mm Hg*
   (b) The partial pressure of oxygen in oxygenated blood is 95 *mm Hg*
   (c) The partial pressure of oxygen in the alveolar air is 104 *mm Hg*
   (d) The partial pressure of carbon dioxide in the alveolar air is 40 *mm Hg*
   (e) The partial pressure of carbon dioxide in deoxygenated blood is 95 *mm Hg*

7. Which option is completely correct for the given statements
   Statement 1 – The nerve impulse ordered by respiratory centre passes through nerve to the diaphragm and the intercostal muscles and regulates respiration
   Statement 2 – Respiratory centres scatterly located in the brain stem gives of rhythmic stimuli to diaphragm and respiratory muscle and regulate respiration [GUJCET 2014]
   (a) First statement is correct and second statement is wrong
   (b) First statement is wrong and second statement is correct
   (c) Both of the statements are wrong
   (d) Both of the statements are correct

8. The impulse for voluntary muscles for forced breathing starts in
   (a) Medulla (b) Vagus nerve
   (c) Cerebrum (d) Cerebellum

9. How much CO_2 is present per 100 ml of venous blood
(a) 52.1 ml (b) 3.7 ml
(c) 40 ml (d) 20 ml

10. Which of the following statements are true / false
A. The blood transports CO_2 comparatively easily because of its higher solubility
B. Approximately 8.9% of CO_2 is transported being dissolved in the plasma of blood
C. The carbon dioxide produced by the tissues, diffuses passively into the blood stream and passes into red blood corpsucles and react with water to form H_2CO_3
D. The oxyhaemoglobin (HbO_2) of the erythrocytes is basic
E. The chloride ions diffuse from plasma into the erythrocytes to maintain ionic balance
[Kerala PMT 2006]
(a) A, C and E are true, B and D are false
(b) A, C and E are false, B and D are true
(c) A, B and D are true, C and E are false
(d) A, B and D are false, C and E are true
(e) A, B and C are true, D and E are false

11. Which one of the following is the correct statement for respiration in humans **[NCERT; CBSE PMT (Pre.) 2012]**
(a) Cigarette smoking may lead to inflammation of bronchi
(b) Neural signals from pneumotoxic centre in pons region of brain can increase the duration of inspiration
(c) Workers in grinding and stone-breaking industries may suffer, from lung fibrosis
(d) About 90% of carbon dioxide (CO_2) is carried by haemoglobin as carbamino haemoglobin

12. Concentration of carbonic acid does not increase in blood due to the presence of
(a) Na^+ (b) K^+
(c) Ca^{++} (d) Mg^{++}

13. A pyrophosphate cleavage takes place when **[CPMT 1998]**
(a) ATP is converted into AMP
(b) ATP is converted into ADP
(c) ADP is converted into AMP
(d) AMP is converted into ATP

14. Haemoglobin is having maximum affinity with
[CPMT 1995; MP PMT 1999; RPMT 1999]
(a) CO_2 (b) CO
(c) O_2 (d) NH_3

15. When a man inhales air containing normal concentration of O_2 as well as CO he suffers from suffocation because
[AIIMS 1993; BVP 2003]
(a) CO reacts with O_2 reducing its percentage in air
(b) Haemoglobin combines with CO instead of O_2 and the product cannot dissociate
(c) CO affects diaphragm and intercostal muscles
(d) CO affects the nerve of the lungs

16. Which two of the following changes ($A-B$) usually tend to occur in the plain dwellers when they move to high altitudes (3500 m or more)
(A) Increase in red blood cell size
(B) Increase in red blood cell production
(C) Increased breathing rate
(D) Increase in thrombocyte count
Changes occurring are **[CBSE PMT (Pre.) 2010]**
(a) (A) and (B) (b) (B) and (C)
(c) (C) and (D) (d) (A) and (D)

17. If a person breathes with maximal effort but with his nose and mouth closed, the alveolar pressure can be decreased to as low as
(a) −80 $mm\ Hg$ (b) +10 $mm\ Hg$
(c) −180 $mm\ Hg$ (d) −250 $mm\ Hg$

18. Rate of respiration is directly proportional to **[CPMT 1993]**
(a) Concentration of oxygen in blood
(b) Concentration of carbon dioxide in blood
(c) Oxygen in trachea
(d) Diaphragm expansion

19. If a man from sea coast goes to Everest peak then
[CPMT 1996; MP PMT 2002]
(a) His breathing and heart beat will increase
(b) His breathing and heart beat will decrease
(c) His respiratory rate will decrease
(d) His heart beat will decrease

20. Exposure to carbon monoxide (from coal gas) is extremely dangerous and can kill a patient because
[NCERT; KCET 1996]
(a) The compound carboxyhaemoglobin ($COHb$) it forms with heamoglobin can gradually clot the blood resulting in circulatory failure
(b) $COHb$ reduces the ability of blood for transport oxygen by ruputring a vast majority of erythrocytes
(c) $COHb$ greatly modifies the structure of haemoglobin, thus making it lose its affinity for oxygen
(d) None of the above

21. Blood does not transport oxygen in **[CPMT 1992]**
(a) Cockroach (b) Earthworm
(c) Frog's tadpole (d) Mammalian foetus

22. Forced deep breathing for a few minutes by a person sitting at rest may be followed by a temporary cessation of breathing. This is due to
(a) Too much O_2 in the blood
(b) Too much CO_2 in the blood
(c) Very little CO_2 in the blood
(d) Both too much O_2 and very little CO_2 in the blood

23. Hamburger phenomenon is also known as
[CMC Vellore 1993; AIIMS 1993; BHU 2001, 08; JIPMER 2002; MP PMT 2007, 09, 10]
(a) Hydrogen shift mechanism
(b) Chloride shift mechanism
(c) Carbonic acid shift mechanism
(d) Sodium-potassium pump

24. In an accident, a man dies immediately although their was no injury to brain, kidney, stomach and heart. The probable cause of death may be
(a) Coagulation of RBC
(b) Digestion stopped
(c) Diaphragm got punctured
(d) Larynx got punctured

25. Buccopharyngeal respiration in frog **[MP PMT 2000]**
(a) Is increased when nostrils are closed
(b) Stops when there is pulmonary respiration
(c) Is increased when it is catching fly
(d) Stops when mouth is opened

26. Name the chronic respiratory disorder caused mainly by cigarette smoking **[NEET (Phase-I) 2016]**
(a) Emphysema (b) Asthma
(c) Respiratory acidosis (d) Respiratory alkalosis

27. Asthma may be attributed to **[NEET (Phase-I) 2016]**
(a) Bacterial infection of the lungs
(b) Allergic reaction of the mast cells in the lungs
(c) Inflammation of the trachea
(d) Accumulation of fluid in the lungs

28. Which of the following statement(s) is/are correct **[WB JEE 2016]**
(a) Silicosis is the result of exposure to silica that causes permanent lung damage and death
(b) Transportation of gases and digested food materials in the body of higher animals causes muscle weakness and fatigue
(c) ADH is a neurohypophysial hormone that regulates body water
(d) Myasthenia gravis is a neuromuscular disease that is mediated by circulatory system

A R Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Aerobic animals are not truely aerobic.
Reason : They produce lactic acid anaerobically.

2. Assertion : Coughing and sneezing are necessary.
Reason : Coughing and sneezing are reflex actions.

3. Assertion : Most fish when out of water, die of suffocation.
Reason : Atmospheric air contains far less oxygen content than the dissolved oxygen in water.

4. Assertion : Symptoms of emphysema develops when a person living on plains ascends and stays on a mountain.
Reason : Air pressure and partial pressure of oxygen falls with the rise in altitude.

5. Assertion : If there is no air in trachea, it will collapse.
Reason : Trachea is having the cartilagenous ring. **[AIIMS 1999]**

6. Assertion : Inspiration occurs due to muscular relaxation.
Reason : During inspiration, the diaphragm and external intercostal muscle contract simultaneously. **[AIIMS 1995]**

7. Assertion : Severe Acute Respiratory Syndrome (SARS) originated in China.
Reason : China is the most populated country of the world. **[AIIMS 2003]**

8. Assertion : Blood of insects is colourless.
Reason : The blood of insect does not play any role in transport of oxygen. **[AIIMS 1994]**

9. Assertion : Gill-lamellae in aquatic animals help in exchange of gases.
Reason : Each gill lamella carries many blood capillaries.

10. Assertion : In mammals, complex respiratory system has developed.
Reason : Mammalian skin is impermeable to gases.

11. Assertion : Insects develop a complex system of air tubes called trachea for respiratory purpose.
Reason : Exchange through body surface is not possible in insects.

12. Assertion : Aerobic respiration involves the exchange of respiratory gases twice.
Reason : Exchange occurs from lung to heart and then heart to lung.

13. Assertion : Carbonic anhydrase is present in the erythrocytes.
Reason : In erythrocytes the carbon dioxide combine with water and is transported. **[Kerala PMT 2006]**

Answers

Respiratory organs

1	d	2	a	3	d	4	d	5	d
6	d	7	c	8	d	9	a	10	b
11	a	12	d	13	d	14	a	15	c
16	d	17	a	18	d	19	d	20	d
21	a	22	d	23	c	24	b	25	c
26	d	27	c	28	a	29	c	30	d
31	a	32	b	33	d				

Pulmonary volumes and capacities

1	b	2	d	3	b	4	b	5	c
6	d	7	b	8	c	9	a	10	b
11	a	12	d	13	a	14	b	15	c
16	d	17	a	18	a	19	d	20	d
21	a								

Process of respiration

1	a	2	a	3	b	4	c	5	a
6	c	7	d	8	c	9	b	10	c
11	c	12	b	13	d	14	e	15	b
16	b	17	c	18	e	19	b	20	a
21	c	22	d	23	b	24	d	25	a
26	b	27	c	28	a	29	b	30	c
31	c	32	a	33	a	34	a	35	a
36	b	37	c	38	b	39	d	40	d
41	e	42	b	43	c	44	c	45	a
46	d	47	b	48	b	49	d	50	b
51	d	52	a	53	c	54	b	55	c
56	a	57	c	58	a	59	d	60	c
61	a	62	c	63	a	64	b	65	c
66	c								

Control of breathing

1	a	2	c	3	c	4	c	5	b
6	a	7	a	8	a	9	b	10	b
11	c	12	b						

Important concepts of respiration

1	c	2	a	3	d	4	c	5	d
6	b								

Disorders of respiration system

1	a	2	c	3	c	4	c	5	c
6	c	7	d	8	d	9	a	10	d
11	d	12	c	13	b	14	d	15	a
16	d	17	b						

NCERT Exemplar Questions

1	d	2	d	3	d	4	b	5	a
6	d	7	d	8	b	9	b	10	b
11	b	12	b	13	b				

Critical Thinking Questions

1	d	2	b	3	d	4	d	5	d
6	e	7	d	8	c	9	b	10	a
11	a	12	a	13	b	14	b	15	b
16	b	17	a	18	b	19	a	20	c
21	a	22	d	23	b	24	c	25	d
26	a	27	b	28	acd				

Assertion and Reason

1	a	2	b	3	c	4	e	5	e
6	e	7	b	8	b	9	a	10	b
11	a	12	c	13	a				

Answers and Solutions

Respiratory organs

3. (d) Haemolymph is found in insect blood which is colourless.

7. (c) In forced expiration internal intercostal muscles and some abdominal muscles contract to reduce the volume of thorax.

10. (b) Inside the larynx there are vocal cords. These are two pairs of fold of mucous membrane that extend into the lumen of the larynx from the sides.

12. (d) The pharynx provides passage to both air and food.

14. (a) In man, the left lungs has two lobes, superior lobe and inferior lobe, the right lungs has three lobes superior lobe, middle lobe and inferior lobe.

18. (d) Earthworm has a closed circulatory system. *Hb* dissolved in plasma of blood acts as a respiratory pigment, transporting O_2 to the body tissues.

23. (c) In rabbit, the left lung is divided into two lobes, left anterior and left posterior whereas the right lung has four lobes, anterior azygous, right anterior right posterior and posterior azygous.

24. (b) Each lung is enclosed in two membranes called pleurae. The outer covering is adhered to chest wall and diaphragm and is called parietal pleura. The inner covering membrane, which closely covers the lung, is called visceral pleura.

27. (c) Haemocyanin is copper containing pigment. It is respiratory pigment of Prawn. Haemocyanin becomes blue when oxygenated and colourless during deoxygenation.

30. (d) It serves to close the glottis during deglutition thereby preventing entry of food into respiratory tract.

31. (a) Diaphragm has no role in the respiration in frog but in mammals it increase the surface area for respiration.

33. (d) Presence of diaphragm is mammalian character, which is dome-shaped partition that separates the thoracic and abdominal cavities.

Pulmonary volumes and capacities

5. (c) Vital capacity of lungs to expire maximum volume of air after a deep inspiration. The largest quantity of air that can be expired after a maximal inspiratory. Vital capacity is equal the sum of the tidal complemental and supplemental air (500 + 3100 + 1200 = 4800 *ml*).

9. (a) The volume of air inspired and expired with each normal breath is tidal volume, which is approximately 500 ml.

12. (d) The residual volume is that part of the air in the lung which cannot be exhaled; it represents the remaining volume of lung when forced exhalation of the lung has occurred.

Process of respiration

1. (a) More active tissue has much lower PO_2. Therefore much more oxygen is released from oxyhaemoglobin in the active tissue.

3. (b) The gaseous exchange is the simple diffusion of oxygen from alveolar air into the blood and diffusion of CO_2 from blood to alveolar air.

5. (a) Oxygen tends to displace CO_2 so that the curve shifts more to the right.

11. (c) This pump is connected through a tube to an external machine for inflating or deflating it with helium.

13. (d) Nearly 20-25 percent of CO_2 is transported by RBCs, whereas, 70 percent of it is carried as bicarbonates. About 7 percent of CO_2 is carried as dissolved state in plasma.

25. (a) Under a given oxygen concentration in blood, dissociation of oxyhaemoglobin will increase if *p*H of blood falls.

28. (a) O_2 dissociation curve for haemoglobin is sigmoid in shape.

29. (b) During expiration diaphragm relaxes and becomes dome-shaped thereby reducing intrathoracic volume to pass out the air from body.

31. (c) During pulmonary respiration mouth remains closed all the time whereas nostrils are opened only when air is taken in or passed out *i.e.* during first stroke of inspiration and second stroke of expiration respectively.

32. (a) In anaerobic respiration pyruvate undergoes two types of incomplete reduction. In one case it results in the production of ethyl alcohol (Yeast) and in other it produces lactic acid (muscles).

38. (b) Billirubin is an orange pigment that is one of the end product of haemoglobin breakdown in the hepatocyte and is excreted as a waste material in bile.

39. (d) In the form of H_2CO_3 dissolved in plasma and $NaCO_3$ and $KHCO_3$ as bicarbonates.

43. (c) A is the alveolar cavity which is the main site of exchange of respiratory gases.

45. (a) Rise in CO_2 concentration is detected by chemosensitive area activates inspiratory centre in Medulla oblongata, which lead to urge of breathing. Role of O_2 concentration is non significant.

47. (b) During normal breathing the respiratory movement in 25 years old is about 16/*min*.

48. (b) To maintain electrostatic neutrality of plasma, many chloride ions diffuse from plasma into RBCs and bicarbonate ions pass out. The chloride content of RBCs increases when oxygenated blood becomes deoxygenated. This termed as chloride shift or Hamburger shift.

50. (b) Sternohyal and petrohyal helps in respiration of frog. Contraction of sternohyal muscle during breathing in frog lowers floor of oral cavity. While contraction of petrohyal muscle during breathing in frog raises the floor of buccal cavity.

53. (c) 7% of CO_2 is transported in dissolved form in the plasma, 23% as carbaminohaemoglobin and 70% in the form of bicarbonates.

54. (b) Our tissues are able to utilise only 25% of O_2 carried by artetrial blood. Our venous blood is still 75% saturated with O_2. This O_2 acts as a reserve during muscular exercise.

57. (c) Respiration is the process of oxidation by which food material are oxidized and produce CO_2 and water as waste product.

59. (d) Surfactant is a lipoprotein secreted by surfactant secreting cells, which form part of alveolar epithelium. This tends to reduce the surface tension of fluid lining the alveoli and thus facilitates lung expansion and also maintains the stable size of the alveoli.

60. (c) In the form of phosphate bond energy.

63. (a) During inspiration the diaphragm and external intercostal contract simultaneously. This moves the lateral thoracic walls outward and upward.

66. (c) PO_2 in Alveoli is 104, while in oxygenated blood, it is 95.

Control of breathing

1. (a) Tidal volume is the volume of air breathed in and out during normal respiration and is equal to about 500 *ml* or 0.5*l*

3. (c) Tidal volume is the volume of air inspired or expired with each breath. This is about 500 *ml* in an adult person.

6. (a) Because the respiratory centres are located in the medulla oblongata and pons varoli in the hind brain.

8. (a) Breathing is controlled by pneumotaxic and apneustic centres in pons varoli and expiratory and inspiratory centres in medulla oblongata.

10. (b) A chemosensitive area located close to the respiratory centre in medulla is highly sensitive to changes in PCO_2 or *pH* of the blood.

Important concepts of respiration

3. (d) Hemoglobin, an iron containing red pigment is responsible for transport of O_2 and CO_2 in human blood.

4. (c) The affinity of haemoglobin for CO is approximately 210 times greater than O_2.

6. (b) The oxygenated blood from two lungs is collected by right and left pulmmonary veins, which unite to form a common pulmonary vein (Pulmocutaneous vein) which open directly into the left auricle, on the dorsal side.

Disorders of respiration system

1. (a) Rate of O_2 supply by lungs into muscles falls down during active work or in exercise. Muscles accumulate lactic acid and slowly breathing becomes hard so as to increase O_2 intake in lungs. This stage is called oxygen debt.

2. (c) Because plants release pollen grain a fix time and it is generally March-April or Aug. – Sep.

8. (d) Cyanosis is blueness of skin and occurs due to large amount of deoxygenated haemoglobin in cutaneous vessels.

12. (c) Oxygen toxicity develops when pure oxygen is breathed in for a prolonged period. This is formed due to progressive failure of ventilation of lungs.

13. (b) Diabetic patient shows low R.Q. due to the increased dissimilation of fats and decreased dissimilation of carbohydrates.

16. (d) Emphysema is the respiratory disorder in which the septa between the alveoli are destroyed and much of the elastic tissue of the lungs is replaced by connective tissue. It is generally caused by a long term irritation. Air pollution, occupational exposure to industrial dust and cigarette smoke are the most common irritants.

Critical Thinking Question

1. (d) Some snakes have only one bronchus and the right lung.

2. (b) In mammalian lungs each alveolar duct ends in a passage, called atrium, which leads into a number of rounded alveolar sacs. Each alveolar sac is studded with a large number of air sacs or alveoli. Alveoli are the sites of respiration.

3. (d) Syrinx is a sound producing organ in birds.

4. (d) The respiratory centres that control the breathing mechanism are present in medulla oblongata. These respiratory centres are expiratory centre and inspiratory centre.

5. (d) The number of alveoli in human lungs has been estimated to be approximately 750 million, exposing a surface area of nearly 100 m^2.

7. (d) The nerve impulse ordered by respiratory centre passes through vagus nerve to the intercostal muscles and diaphragm and regulates respiration. The respiratory centres are scattered in brain stem and are constantly giving off rhythmically stimuli to the respiratory muscles in virtue of their inherent rhythm causing inspiration and expiration.

9. (b) Every 100 *ml* of blood receives an average 3.7 *ml* of CO_2 from tissues.

15. (b) Carbon monoxide has 210 times more affinity with haemoglobin as compared to O_2 and forms a stable compound.

18. (b) Due to direct chemical control on respiratory centres, CO_2 stimulates respiratory centres in CNS.

19. (a) At high altitude, PO_2 of alveolar air falls because of low O_2 tension of tissues. So, O_2 is absorbed very quickly from alveoli, thus, increasing breathing rate. Heart beat also increases to supply required amount of O_2 to tissues.

20. (c) $COHb$ is a stable compound formed by the combination of carbon monoxide and haemoglobin. It has more affinity than oxygen.

21. (a) Due to absence of respiratory pigment.

22. (d) Deep breathing rises the O_2 level of the blood. By excess formation of oxyhaemoglobin the acidity of blood increases. To control it, more of free CO_2 changes into bicarbonates and the free CO_2 level in the blood decreases. So due to lack of stimulant for inspiratory centre cessation of breathing takes place, after some time O_2 is consumed by the tissues and rise in CO_2 stimulates breathing again.

23. (b) To maintain electrostatic neutrality of plasma, many chloride ions diffuse from plasma into RBCs and bicarbonate ions pass out. The chloride content of RBCs increase when oxygenated blood become deoxygenated. This is termed as chloride shift or Hamburger phenomenon.

25. (d) This process occurs through nares and mouth and gullet are kept closed during the process.

28. (acd) Silicosis is an occupational lung disease that causes progressive respiratory failure and death. ADH is synthesized from hypothalamic nuclei and are responsible for water absorption by nephron. Myasthenia gravis is an autoimmune disorder mediated by antibodies.

Assertion and Reason

1. (a) In most animals, tissue oxidation are carried out by aerobic respiration. But sometimes in aerobically respiring animals, anaerobic metabolism take place in certain tissues like skeletal muscles which do not immediately get as much oxygen as in necessary for their acid anaeorbically from glucose during vigorous movements.

2. (b) Coughing and sneezing are necessary to take place because these reactions serve to keep the air passages free from foreign matter. Coughing is a reflex action under nervous control. The minute receptors found in the wall of trachea, bronchi, bronchioles and alveoli are highly sensitive to foreign matter (smoke, dust etc.) Like coughing, sneezing is also a reflex action triggered because of irritation to nasal passages. In this, sensory impulses travel from nasal passages to the medulla through trigeminal nerves. The reaction involves the same series of events as in cough reflex, but the air explodes out both through nose and mouth, expelling the foreign matter from nasal passages.

3. (c) Although atmospheric air contains far more oxygen content than the water (air contain 21% oxygen and water contains 0.5-0.9% oxygen by volume depending on the temperature), still most fish when out of water die of suffocation due to lack of oxygen. When fish is taken out of water the gills stick together thereby reducing the surface area. Reduced surface area lowers gas exchange so death ensues.

4. (e) When a person living on plains ascend and stays on a mountain above 8000 feet from the sea level, he develops symptoms of mountain sickness which includes breathlessness, headache, dizziness, irritability, nausea, vomiting, mental fatigue and a bluish tinge on the skin, nails and lips.
We know that with the rise in altitude, the barometric pressure and consequently the partial pressure of oxygen falls in the atmospheric air. This lowers the alveolar partial pressure of oxygen which causes reduction in the diffusion of oxygen from the alveolar air to the blood. So oxygenation of blood is decreased progressively, which produces the symptoms of mountain sickness, Emphysema.

5. (e) There is no air in trachea, it does not collapse due to the presence of C-shaped narrow cartilaginous ring or discs.

6. (e) Inspiration is the result of muscular contraction. The diaphragm and external intercostal muscle contracts simultaneously. The lateral thoracic wall moves outward and upward.

7. (b) The world health organization (WHO) reported China as the origin place of SARS. Several other countries have reported SARS cases after travel to China and its nearby areas/countries in Asia or close contact with a person affected with SARS. Microbiologists of Hongkong Central University initially detected a virus metapneumovirus and identified as corona virus causative agent of SARS. It is very known fact that the China is the most populated country. This fact cannot be correlated with SARS

8. (b) Blood is colorless in insects. Insects have tracheal respiration. It is carried on by an extensive system of inter-communicating tubes called trachea.

9. (a) Gills are the main respiratory organs of aquatic animals. Each gill bears rows of comb-like, soft, thin gill-filament, each gill-filament bears many flat, parallel membrane-like gill-lamellae. Each gill lamella carries many blood capillaries. Water taken through the mouth, is made to flow from the pharynx in a single direction between the gill lamella. Blood flows in the capillaries of gill-lamella in a direction opposite to the flow of water over the lamellar surfaces. This greatly helps in the gaseous exchange across the lamellar membrane between the capillary blood and the flowing water.

10. (b) Mammalian skin in impermeable so that water loss through it is minimized. But mammals need far more oxygen to maintain their high metabolic rates than lower animals; so they need a more extensive respiratory surface. Thus a complex respiratory system has evolved in mammals to meet this need. The mammalian respiratory system consists of the nasal cavity, nasopharynx, larynx, trachea, bronchi, bronchiole and lungs.

11. (a) As the integument of insect is thick and impermeable to minimize lose of body water, they can not carryout gas exchange through their body surface. To overcome this difficulty they have developed a complex system of air tubes called trachea to reach the air directly near the tissue cells. Each trachea communicates with the exterior through openings in the body wall.

12. (c) Aerobic respiration involves the exchange of respiratory gases at two places in multicellular animals-one between the body surface and surrounding medium, the other between the individual cells and the extra cellular fluid. Lungs are involved in the first step of exchange, but not the heart.

13. (a)

Breathing and Exchange of Gases

SET Self Evaluation Test

1. Voice in mammal produced **[MP PMT 2000]**
   (a) By syrinx (b) By bronchus
   (c) During inhalation (d) During exhalation
2. In vertebrate blood which respiratory pigment is the carrier of oxygen to the tissues. **[MP PMT 1998]**
   (a) Plasma (b) Lymphocytes
   (c) Leucocytes (d) Haemoglobin
3. The haemoglobin of a human foetus **[CBSE PMT 2008]**
   (a) Has only 2 protein subunits instead of 4
   (b) Has a higher affinity for oxygen than that of an adult
   (c) Has a lower affinity for oxygen than that of the adult
   (d) Its affinity for oxygen is the same as that of an adult
4. Which of the following disease is associated with lungs **[DPMT 1993]**
   (a) Bronchitis (b) Pneumonia
   (c) Asthama (d) All the above
5. What is the total vital capacity of lungs in man **[MP PMT 1997; BVP 2000]**
   (a) 500 *ml* (b) 2,000 *ml*
   (c) 4,600 *ml* (d) 5,800 *ml*
6. Which one of the following disorders and characteristic is correctly matched **[AIIMS 2009]**
   (a) Cystic fibrosis – Production of thick mucous that clogs airways
   (b) Sickle cell anaemia – Brain deterioration beginning at months of age
   (c) Achondroplasia – Extra fingers or toes
   (d) Huntington's disease – Skeletal, eye and cardiovascular defects
7. Pick the correct statement **[Kerala PMT 2010]**
   (a) The contraction of internal intercostal muscles lifts up the ribs and sternum
   (b) The RBCs transports oxygen only
   (c) The thoracic cavity is anatomically an air tight chamber
   (d) Healthy man can inspire approximately 500 *ml* of air per minute
   (e) During expiration, the intrapulmonary pressure is slightly below the surrounding atmospheric pressure
8. Which mammal lacks true vocal cords
   (a) Monkey (b) Elephant
   (c) *Hippopotamus* (d) Man
9. The haeme-protein complexes which act is oxidising agents are known as **[Kerala PMT 2009]**
   (a) Haemoglobin (b) Myoglobin
   (c) Chlorophyll (d) Cytochrome
10. How many molecules of oxygen are bound to one molecule of haemoglobin **[NCERT; MP PMT 1997; RPMT 2005; Odisha JEE 2009; AFMC 2010]**
    (a) 1 (b) 2
    (c) 3 (d) 4
11. Read the following statements and select the correct one **[Kerala PMT 2009]**
    (a) The H^+ released from carbonic acid combines with haemoglobin to form haemoglobinic acid
    (b) Oxyhaemoglobin of erythrocytes is alkaline
    (c) More than 70% of carbon dioxide is transferred from tissues to the lungs in the form of carbamino compounds
    (d) In a healthy person, the haemoglobin content is more than 25 gms per 100 ml
    (e) In lungs, the oxygen from the alveolus reaches the blood through active transport
12. Oxygen content reduction makes the glycolyse (glycogenesis) intensity increased due to **[AIIMS 2010]**
    (a) Increase of ADP concentration in cell
    (b) Increase of NAD^+ concentration in cell
    (c) Increase of ATP concentration in cell
    (d) Increase of concentration of peroxides and free radicals
13. Amount of air exchanged in breathing can be measured with a **[NCERT]**
    (a) Spherometer (b) Barometer
    (c) Spirometer (d) Sphygmomanometer
14. It is much easier for a small animal to run uphill than for a large animal, because **[NEET (Phase-I) 2016]**
    (a) It is easier to carry a small body weight
    (b) Smaller animals have a higher metabolic rate
    (c) Small animals have a lower O_2 requirement
    (d) The efficiency of muscles in large animals is less than in the small animals

AS Answers and Solutions

1	d	2	d	3	b	4	d	5	c
6	a	7	c	8	c	9	d	10	d
11	a	12	a	13	c	14	b		

10. (d) One molecule of the haemoglobin has 4 haem groups and each of them is capable of taking up one molecule of O_2.

13. (c) Spirometry is the process of recording the changes in the volume movement of air into and out of lung and the instrument used for the purpose is called spirometer or respirometer.

* * *