HISTOLOGICAL STUDY OF THE FOLLOWING ORGANS

3.1 THE SKIN

The skin consists of a superficial layer the epidermis, made up of stratified squamous epithelium; and a deeper layer, the dermis, made up of connective tissue (Fig. 12.1). The dermis rests on subcutaneous tissue (subcutis). This is sometimes described as a third layer of skin. In sections through the skin the line of junction of the two layers is not straight, but is markedly wavy because of the presence of numerous finger-like projections of dermis upwards into the epidermis. These projections are called dermal papillae. The downward projections of the epidermis (in the intervals between the dermal papillae) are sometimes called epidermal papillae. The surface of the epidermis is also often marked by elevations and depressions. These are most prominent on the palms and ventral surfaces of the fingers, and on the corresponding surfaces of the feet. Here the elevations form characteristic epidermal ridges that are responsible for the highly specific fingerprints of each individual.

3.1.1 The Epidermis

The epidermis consists of stratified epithelium in which the following layers can be recognized

(a) The deepest or basal layer (**stratum basale**) is made up of a single layer of columnar cells that rest on a basal lamina. The basal layer contains stem cells that undergo mitosis to give off cells called keratinocytes. Keratinocytes form the more superficial layers of the epidermis described below. The basal layer is, therefore, also called the germinal layer (stratum germinativum).

(b) Above the basal layer there are several layers of polygonal keratinocytes that constitute the **stratum spinosum** (or Malpighian layer). The cells of this layer are attached to one another by numerous desmosomes. During routine preparation of tissue for sectioning the cells often retract from each other except at the desmosomes. As a result the cells appear to have a number of ‘spines’: this is the reason for calling this layer the stratum spinosum. For the same reason the keratinocytes of this layer are also called prickle cells. The cytoplasm of cells in the stratum spinosum is permeated with fibrils (made up of bundles of keratin filaments). The fibrils are attached to the cell wall at desmosomes. Some mitoses may be seen in the deeper cells of the stratum spinosum. Because of this fact the stratum spinosum is included, along with the basal cell layer, in the germinative zone of the epidermis.

(c) Overlying the stratum spinosum there are a few (1 to 5) layers of flattened cells that are characterised by the presence of deeply staining granules in their cytoplasm. These cells constitute the **stratum granulosum**. The granules in them consist of a protein called keratohyalin. The nuclei of cells in this layer are condensed and dark staining (pyknotic). With the EM it is seen that, in the cells of this layer, keratin filaments (already mentioned in relation to the stratum spinosum) have become much more numerous, and are arranged in the form of a thick layer. The fibres lie in a meshwork formed by keratohyalin granules.

(d) Superficial to the stratum granulosum there is the **stratum lucidum** (lucid = clear). This layer is so called because it appears homogeneous, the cell boundaries being extremely indistinct. Traces of flattened nuclei are seen in some cells.

(e) The most superficial layer of the epidermis is called the **stratum corneum**. This layer is acellular. It is made up of flattened scale-like elements (squames) containing keratin filaments embedded in protein. The squames are held together by a glue-like material contains lipids and carbohydrates. The presence of lipid makes this layer highly resistant to permeation by water. The thickness of the stratum corneum is greatest where the skin is exposed to maximal friction e.g., on the palms and soles. The superficial layers of the epidermis are being constantly shed off, and are replaced by proliferation of cells in deeper layers. The stratum corneum, the stratum lucidum, and the stratum granulosum are collectively referred to as the zone of keratinisation, or as the cornified zone (in distinction to the germinative zone described above). The stratum granulosum and the stratum lucidum are well formed only in thick non-hairy skin (e.g., on the palms)

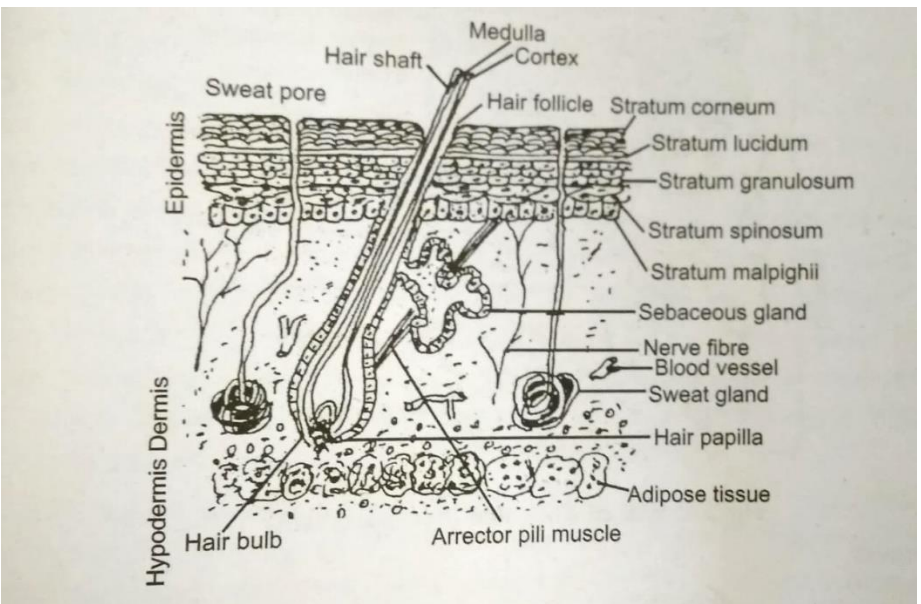


Fig. 3.1: V. S. of hairy skin

3.1.2 The Dermis

The dermis is made up of connective tissue. Just below the epidermis the connective tissue is dense and constitutes the papillary layer. Deep to this there is a network of thick fibre bundles that constitute the reticular layer of the dermis. The **papillary layer** includes the connective tissue of the dermal papillae. These papillae are best developed in the thick skin of the palms and soles. Each papilla contains a capillary loop. Some papillae contain tactile corpuscles. The **reticular layer** of the dermis consists mainly of bundles of collagen fibres. It also contains considerable numbers of elastic fibres. Intervals between the fibre bundles are usually occupied by adipose tissue. The dermis rests on the superficial fascia through which it is attached to deeper structures.

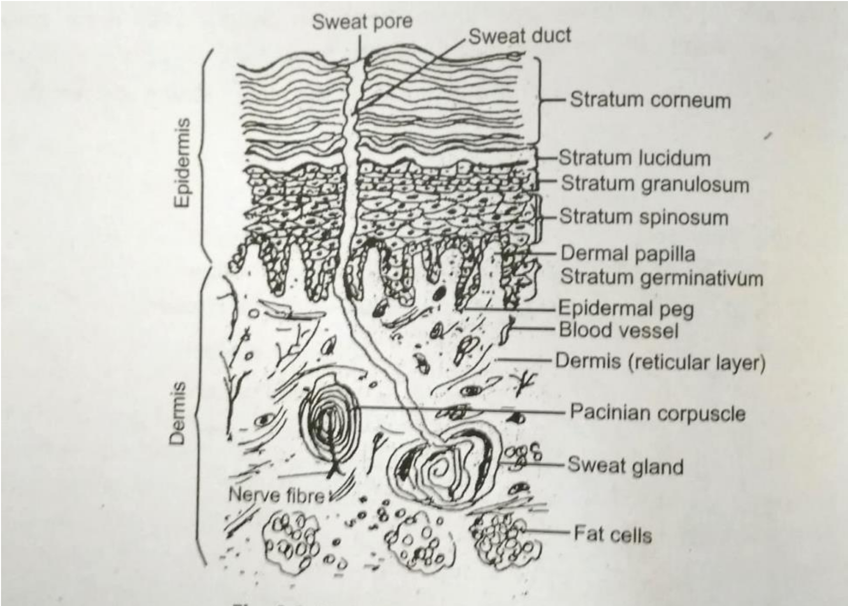


Fig. 3.2: V. S. of thick skin (non-hairy skin)

3.1.3 Appendages of the Skin

A) The Hair

Hairs are present on the skin covering almost the whole body. The sites where they are not present include the palms, the soles, the ventral surface and sides of the digits, and some parts of the male and female external genitalia.

Structure of Hair Shaft

A hair may be regarded as a modified part of the stratum corneum of the skin. An outer **cortex** and an inner **medulla** can be made out in large hair, but there is no medulla in thin hair. The cortex is acellular and is made up of keratin. In thick hair the medulla consists of cornified cells of irregular shape. The surface of the hair is covered by a thin membrane called the **cuticle** that is formed by flattened cornified cells. Each of these cells has a free edge (directed distally) that overlaps part of the next cell. The cornified elements making up the hair contain melanin that is responsible for their colour.

Structure of Hair Follicle

The hair follicle may be regarded as a part of the epidermis that has been invaginated into the dermis around the hair root. Its innermost layer, that immediately surrounds the hair root is, therefore, continuous with the surface of the skin; while the outermost layer of the follicle is continuous with the dermis. The wall of the follicle consists of three main layers. Beginning with the innermost layer they are as follows.

(a) The **inner root sheath** present only in the lower part of the follicle.

(b) The **outer root sheath** that is continuous with the stratum spinosum.

(c) A **connective tissue sheath** derived from the dermis.

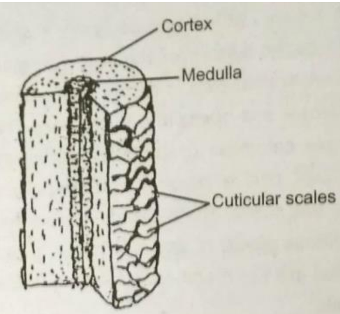


Fig. 3.4: Longitudinal section of hair shaft

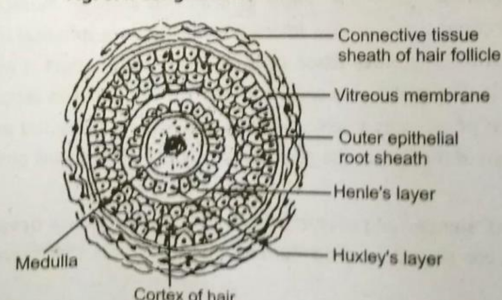


Fig. 3.5: T. S. of Hair

B) Glands

Sebaceous Glands

As mentioned above sebaceous glands are seen most typically in relation to hair follicles. Each gland consists of a number of alveoli that are connected to a broad duct that opens into a hair follicle. Each alveolus is pear shaped. It consists of a solid mass of polyhedral cells and has hardly any lumen. The outermost cells are small and rest on a basement membrane. The inner cells are larger, more rounded, and filled with lipid. This lipid is discharged by disintegration of the innermost cells that are replaced by proliferation of outer cells. The sebaceous glands are, therefore, examples of holocrine glands. The secretion of sebaceous glands is called sebum. Its oily nature helps to keep the skin and hair soft. It helps to prevent dryness of the skin and also makes it resistant to moisture. Sebum contains various lipids including triglycerides, cholesterol, cholesterol esters and fatty acids.

Sweat Glands

Sweat glands produce sweat or perspiration. They are present in the skin over most of the body. Apart from typical sweat glands there are atypical ones present at some sites. Exocrine glands discharge their secretions in various ways and are accordingly classified as merocrine (or eccrine), apocrine and holocrine. Typical sweat glands are of the merocrine variety.

3.2 THE TOOTH

General Structure

A tooth consists of an 'upper' part, the **crown**, which is seen in the mouth; and of one or more **roots** which are embedded in sockets in the jaw bone (mandible or maxilla). The greater part of the tooth is formed by a bone-like material called dentine. In the region of the crown the dentine is covered by a much harder white material called the enamel. Over the root the dentine is covered by a thin layer of cement. The cement is united to the wall of the bony socket in the jaw by a layer of fibrous tissue that is called the periodontal ligament. The external surface of the alveolar process is covered by the gum that normally overlaps the lower edge of the crown. Within the dentine there is a pulp canal (or pulp cavity) that contains a mass of cells, blood vessels, and nerves that constitute the pulp. The blood vessels and nerves enter the pulp canal through the apical foramen which is located at the apex of the root.

A) The Enamel

The enamel is the hardest material in the body. It is made up almost entirely (96%) of inorganic salts. These salts are mainly in the form of complex crystals of hydroxyapatite (as in bone). The crystals contain calcium phosphate and calcium carbonate. Some salts are also present in amorphous form.

B) The Dentine

Dentine is a hard material having several similarities to bone. It is made up basically of calcified ground substance (glycosaminoglycans) in which there are numerous collagen fibres (type 1). The calcium salts are mainly in the form of hydroxyapatite. Amorphous salts are also present. The inorganic salts account for 70% of the weight of dentine. Like bone, dentine is laid down in layers that are parallel to the pulp cavity. The layers may be separated by less mineralized tissue that forms the incremental lines of Von Ebner. Dentine is permeated by numerous fine canaliculi that pass radially from the pulp cavity towards the enamel (or towards cement). These are the dentinal tubules. The tubules may branch specially near the enamel-dentine junction.

C) The Cement

The cement may be regarded as a layer of true bone that covers the roots of the tooth. It covers the entire dentine not covered by enamel but in old people part of the cement may be lost, the dentine being then exposed. Cement is covered by a fibrous membrane called the periodontal membrane (or ligament). This membrane may be regarded as the periosteum of the cement. Collagen fibres from this membrane extend into the cement, and also into the alveolar bone (forming the socket in which the root lies) as fibres of Sharpey.

D) The Pulp

The dental pulp is made up of very loose connective tissue resembling embryonic mesenchyme (mucoid tissue). The ground substance is gelatinous and abundant. In it there are many spindle shaped and star shaped cells. Delicate collagen fibres, numerous blood vessels, lymphatics and nerve fibres are present. The nerve fibres are partly sensory and partly sympathetic.

Odontoblasts

Apart from the connective tissue cells of the pulp and of the periodontal membrane, and the cementocytes in cement, there are two main types of cells present in association with teeth. These are dentine forming odontoblasts, and enamel forming ameloblasts. To understand their significance brief reference has to be made to the development of teeth.

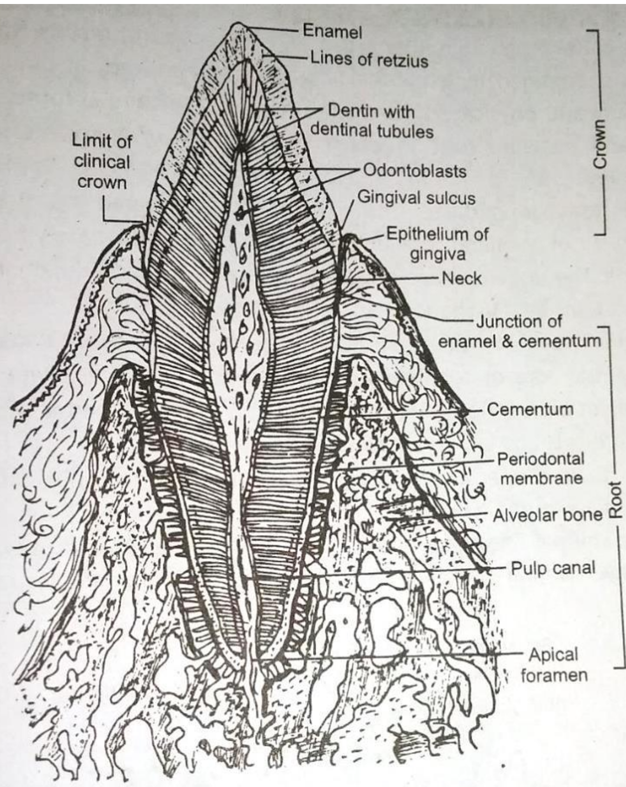


Fig. 3.6: V.S. of tooth (Incisor)

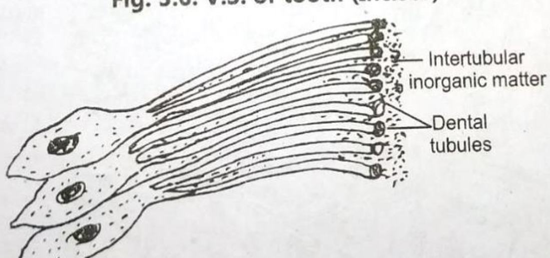


Fig. 3.7: Odontoblasts with dentinal tubules

3.3 THE TONGUE

The tongue lies on the floor of the oral cavity. It has a dorsal surface that is free; and a ventral surface that is free anteriorly, but is attached to the floor of the oral cavity posteriorly. The dorsal and ventral surfaces become continuous at the lateral margins, and at the tip (or apex) of the tongue. Near its posterior end the dorsum of the tongue is marked by a V-shaped groove called the sulcus terminalis. The apex of the 'V' points backwards and is marked by a depression called the foramen caecum. The limbs of the sulcus terminalis run forwards and laterally. The sulcus terminalis divides the tongue into a larger (2/3) anterior, or oral, part; and a smaller (1/3) posterior, or pharyngeal, part.

The papillae are of various types as follows

(a) The most numerous papillae are small and conical in shape. They are called **filiform papillae**. The epithelium at the tips of these papillae is keratinized. It may project in the form of threads.

(b) At the apex of the tongue, and along its lateral margins there are larger papillae with rounded summits and narrower bases. These are called **fungiform papillae**. Fungiform papillae bear taste buds (described below). In contrast to the filiform papillae the epithelium on fungiform papillae is (as a rule) not keratinized.

(c) The largest papillae of the tongue are called **circumvallate papillae**. They are arranged in a row just anterior to the sulcus terminalis. When viewed from the surface each papilla is seen to have a circular top demarcated from the rest of the mucosa by a groove. In sections through the papilla it is seen that the papilla has a circumferential 'lateral wall' that lies in the depth of the groove. Taste buds are present on this wall, and also on the 'outer' wall of the groove.

(d) Along the posteriolateral border of the tongue there are the folds of the mucuous membrane called **folliate papillae**.

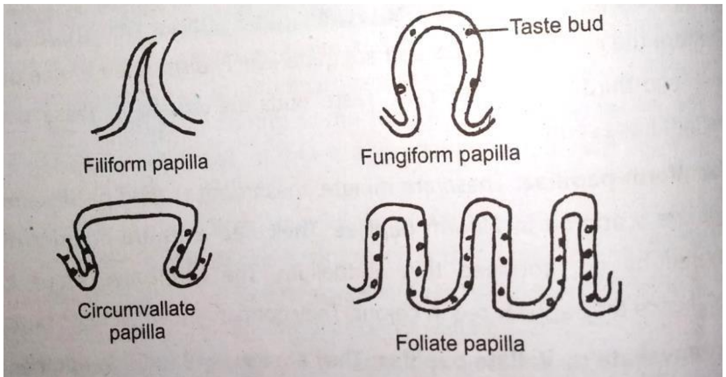


Fig. 3.10: Different types of lingual papillae

Taste Buds

Taste buds are present in relation to circumvallate papillae, to fungiform papillae, and to leaf-like folds of mucosa (folia linguae) present on the posterolateral part of the tongue. Taste buds are also present on the soft palate, the epiglottis, the palatoglossal arches, and the posterior wall of the oropharynx. Each taste bud is a piriform structure made up of modified epithelial cells. It extends through the entire thickness of the epithelium. Each bud has a small cavity that opens to the surface through a gustatory pore. The cavity is filled by a material rich in polysaccharides. The cells present in taste buds are elongated and are vertically orientated, those towards the periphery being curved like crescents. Each cell has a central broader part containing the nucleus, and tapering ends. The cells are of two basic types. Some of them are receptor cells or gustatory cells. Endings of afferent nerves end in relation to them. Other cells perform a supporting function.

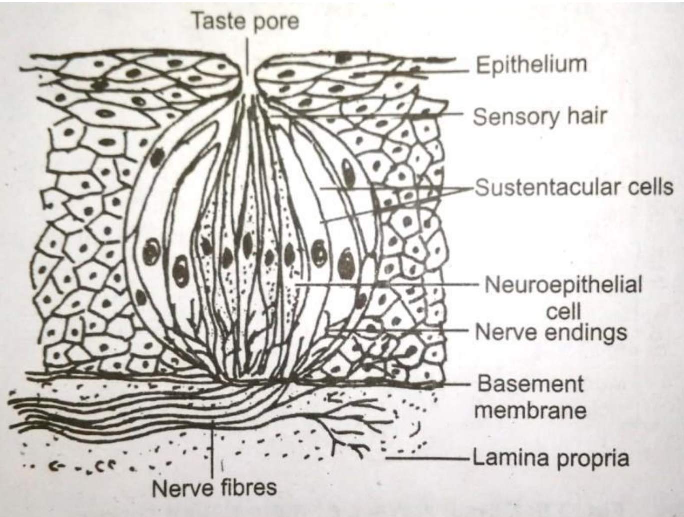


Fig. 3.11: V. S. of Taste bud

3.4 ALIMENTARY CANAL

BASIC PATTERN OF THE STRUCTURE OF THE ALIMENTARY CANAL

The structure of the alimentary canal, from the oesophagus up to the anal canal, shows several features that are common to all these parts. We shall consider these common features before examining the structure of individual parts of the canal. While considering the structure of the oral cavity, and of the pharynx, we have seen that the walls of these parts of the alimentary canal are partly bony, and partly muscular. From the upper end of the oesophagus up to the lower end of the anal canal the alimentary canal has the form of a fibromuscular tube. The wall of the tube is made up of the following layers (from inner to outer side).

A. The innermost layer is the mucous membrane that is made up of:

(a) A lining epithelium.

(b) A layer of connective tissue, the lamina propria, that supports the epithelium.

(c) A thin layer of smooth muscle called the muscularis mucosae.

B. The mucous membrane rests on a layer of loose areolar tissue called the submucosa.

C. The gut wall derives its main strength and form because of a thick layer of muscle (muscularis externa) that surrounds the submucosa.

D. Covering the muscularis externa there is a serous layer or (alternatively) an adventitial layer.

3.4.1 THE OESOPHAGUS

The oesophagus is a tube, the wall of which has the usual four layers viz., mucous membrane, submucosa, muscle layer and an external adventitia. The oesophagus does not have a serous covering except over a short length near its lower end.

The Mucosa

1. The mucous membrane of the oesophagus shows several longitudinal folds that disappear when the tube is distended.

2. The mucosa is lined by stratified squamous epithelium, which is normally not keratinized.

3. Finger like processes (or papillae) of the connective tissue of the lamina propria project into the epithelial layer (just like dermal papillae). This helps to prevent separation of epithelium from underlying connective tissue.

4. At the upper and lower ends of the oesophagus some tubulo-alveolar mucous glands are present in the lamina propria.

5. The muscularis mucosae is absent or poorly developed in the upper part of the oesophagus.

The Submucosa

The only special feature of the submucosa is the presence at some places of compound tubulo-alveolar mucous glands. They are most frequently seen at the level of the bifurcation of the trachea. Small aggregations of lymphoid tissue may be present in the submucosa, specially near the lower end. Some plasma cells and macrophages are also present.

The Muscle Layer

The muscle layer consists of the usual circular and longitudinal layers. However, it is unusual in that the muscle fibres are partly striated and partly smooth. In the upper one-third (or so) of the oesophagus the muscle fibres are entirely of the striated variety, while in the lower one-third all the fibres are of the smooth variety. Both types of fibres are present in the middle one-third of the oesophagus. The circular muscle fibres present at the lower end of the oesophagus could possibly act as a sphincter guarding the cardiooesophageal junction. The muscle layer of the oesophagus is surrounded by dense fibrous tissue that forms an adventitial coat for the oesophagus. The lowest part of the oesophagus is intra-abdominal and has a covering of peritoneum.

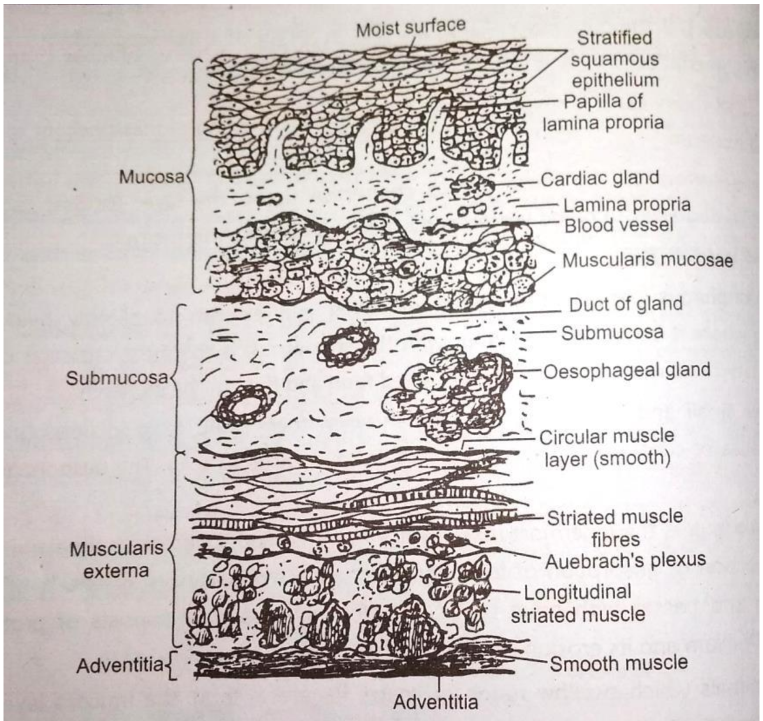


Fig. 3.13: T. S. of Oesophagus

3.4.2 THE STOMACH

The Mucous Membrane

As seen with the naked eye the mucous membrane shows numerous folds (or rugae) that disappear when the stomach is distended.

Lining Epithelium

The lining epithelium is columnar and mucous secreting. At numerous places the lining epithelium dips into the lamina propria to form the walls of depressions called gastric pits.

The Lamina Propria

As seen above the mucous membrane of the stomach is packed with glands. The connective tissue of the lamina propria is, therefore, scanty. It contains the usual connective tissue cells. Occasional aggregations of lymphoid tissue are present in it.

The Muscularis Mucosae

The muscularis mucosae of the stomach is well developed. Apart from the usual circular (inner) and longitudinal (outer) layers an additional circular layer may be present outside the longitudinal layer.

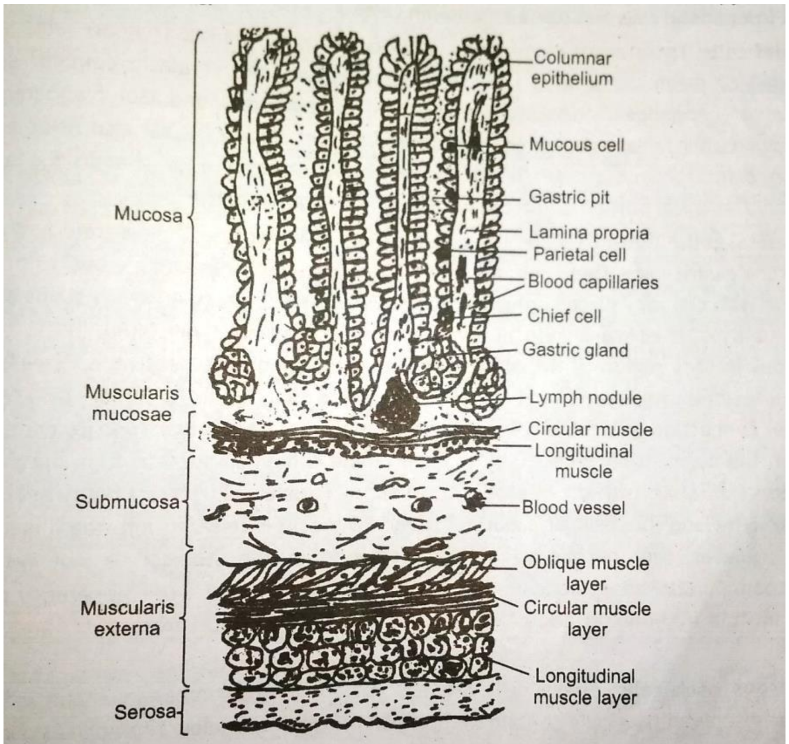


Fig. 3.16: T. S. of Stomach

The Muscularis Externa

The muscularis externa of the stomach is well developed. Three layers, oblique, circular and longitudinal (from inside out) are usually described. The appearance of the layers in sections is, however, highly variable depending upon the part of the stomach sectioned.

The following varieties of cells are present in the epithelium lining the glands.

(a) The most numerous cells are called **chief cells, peptic cells, or zymogen cells**. They are particularly numerous in the basal parts of the glands. The cells are cuboidal or low columnar. Their cytoplasm is basophilic. With special methods the chief cells are seen to contain prominent secretory granules in the apical parts of their cytoplasm. The granules contain pepsinogen that is a precursor of pepsin.

(b) The **oxyntic or parietal cells** are large, ovoid or polyhedral, with a large central nucleus. They are present singly, amongst the peptic cells. They are more numerous in the upper half of the gland than in its lower half. They are called oxyntic cells because they stain strongly with eosin. They are called parietal cells as they lie against the basement membrane.

(c) Near the upper end (or 'neck') of the glands there are mucous secreting cells that are called **mucous neck cells**. These are large cells with a clear cytoplasm. The nucleus is flattened and is pushed to the base of the cell by accumulated mucous. The supranuclear part of the cell contains prominent granules. The chemical structure of the mucous secreted by these cells is different from that secreted by mucous cells lining the surface of the gastric mucosa.

(d) Near the basal parts of the gastric glands there are endocrine cells that contain membrane bound neurosecretory granules. As the granules stain with silver salts these have, in the past, been called **argentaffin cells**. These cells are flattened. They do not reach the lumen, but lie between the chief cells and the basement membrane. These cells probably secrete the hormone gastrin.

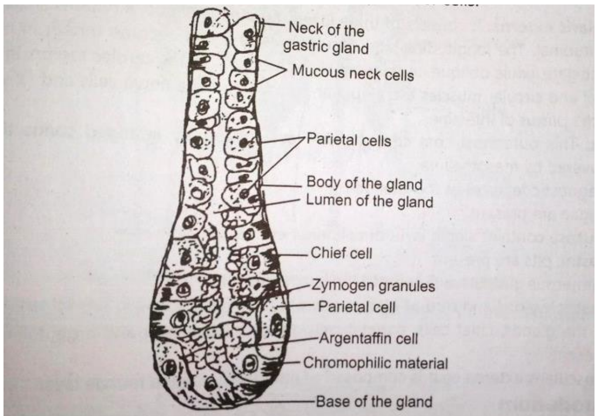


Fig. 3.17: V. S. of Gastric gland showing different cells

The Cardiac Glands

These are confined to a small area near the opening of the oesophagus. In this region the mucosa is relatively thin. Gastric pits are shallow (as in the body of the stomach). The cardiac glands are either simple tubular, or compound tubulo-alveolar.

The Pyloric Glands

In the pyloric region of the stomach the gastric pits are deep and occupy two thirds of the depth of the mucosa. The pyloric glands that open into these pits are short and occupy the deeper one-third of the mucosa. They are simple or branched tubular glands that are coiled. The glands are lined by mucous secreting cells.

3.4.3 THE SMALL INTESTINE

The small intestine is a tube about five meters long. It is divided into three parts. These are (in crania caudal sequence) the duodenum (about 25 cm long); the jejunum (about 2 meters long); and the ileum (about 3 meters long).

The Mucous Membrane

The surface area of the mucous membrane of the small intestine is extensive (to allow adequate absorption of food). This is achieved by virtue of the following.

(a) The considerable length of the intestine.

(b) The presence of numerous circular folds in the mucosa.

(c) The presence of numerous finger-like processes, or villi, that project from the surface of the mucosa into the lumen.

(d) The presence of numerous depressions or crypts that invade the lamina propria.

(e) The presence of microvilli on the luminal surfaces of the cells lining the mucosa.

Circular Folds: The circular folds are also called the **valves of Kerkring**. Each fold is made up of all layers of the mucosa. The submucosa also extends into the folds. The folds are large and readily seen with the naked eye.

The Villi: The villi are, typically, finger-like projections consisting of a core of reticular tissue covered by a surface epithelium.

The Crypts: The crypts (of Lieberkuhn) are tubular invaginations of the epithelium into the lamina propria. They are really simple tubular intestinal glands that are lined by epithelium. The epithelium is supported on the outside by a basement membrane.

Goblet Cells: [A goblet is literally a drinking glass that is broad above, and has a narrow stem attached to a base. Goblet cells are so named because of a similar shape]. Each goblet cell has an expanded upper part that is distended with mucin granules. The nucleus is flattened and is situated near the base of the cell. Goblet cells are mucous secreting cells. In consonance with their secretory function these cells have a prominent Golgi complex and abundant rough endoplasmic reticulum.

Zymogen Cells (Paneth Cells): These cells are found only in the deeper parts of intestinal crypts. They contain prominent eosinophilic secretory granules. The function of zymogen cells is not well known. They are known to produce lysozyme that destroys bacteria. They may also produce other enzymes.

Distinguishing Features of Duodenum & Ileum:

1. Sections through the small intestine are readily distinguished from those of other parts of the gut because of the presence of villi.

2. The duodenum is easily distinguished from the jejunum or ileum because of the presence in it of glands in the submucosa. (No glands are present in the submucosa of the jejunum or ileum). These duodenal glands (of Brunner) are compound tubulo-alveolar glands.

3. The proximal part of the jejunum shows significant differences in structure from the terminal part of the ileum.

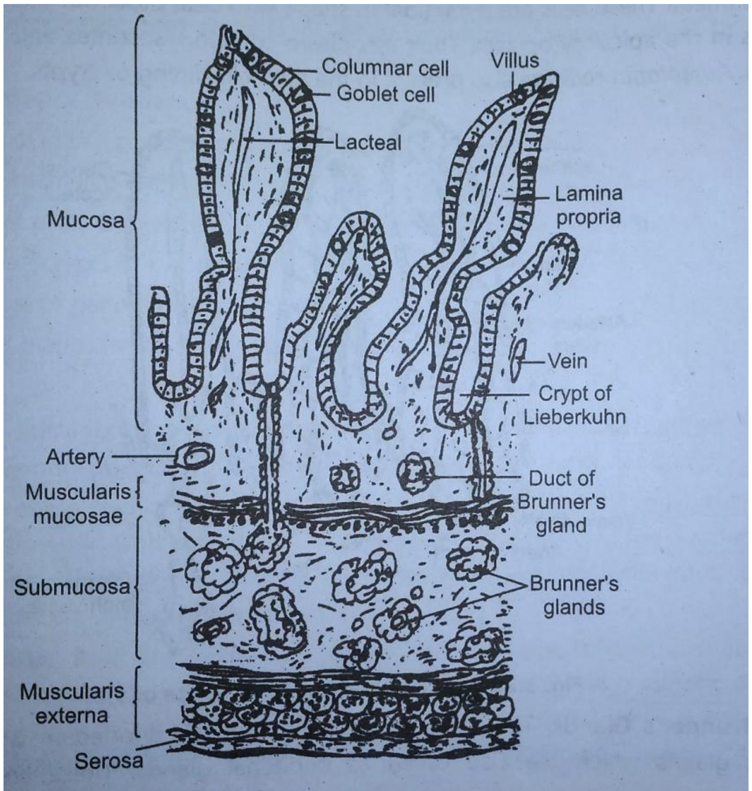


Fig. 3.19: T. S. of Duodenum

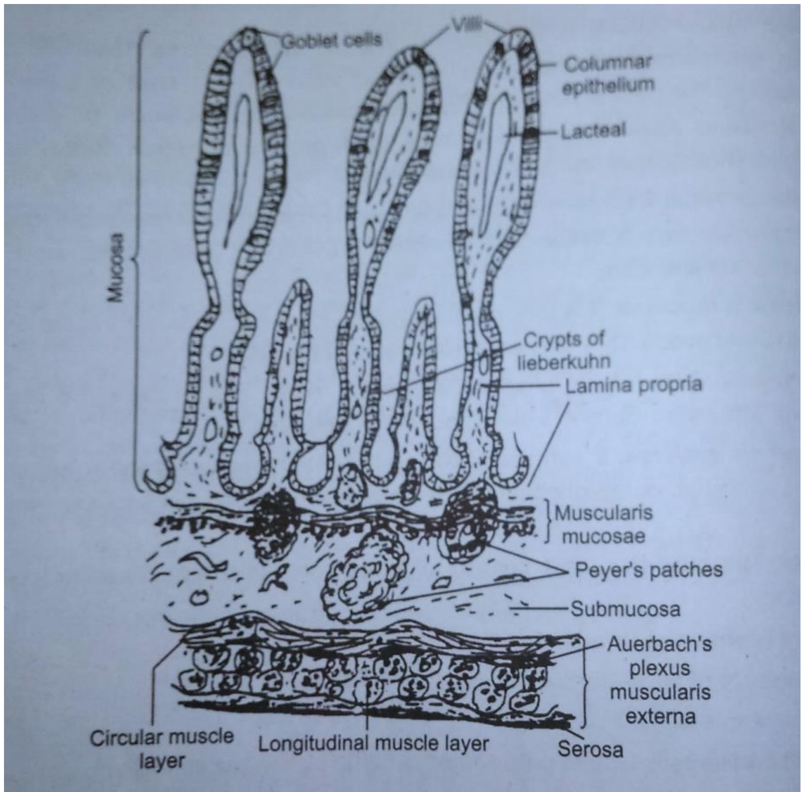


Fig. 3.21: T. S. of Ileum

3.4.4 THE RECTUM

The structure of the rectum is similar to that of the colon except for the following.

1. A continuous coat of longitudinal muscle is present. There are no taenia.

2. Peritoneum covers the front and sides of the upper one-third of the rectum; and only the front of the middle third. The rest of the rectum is devoid of a serous covering.

3. There are no appendices epiploicae.

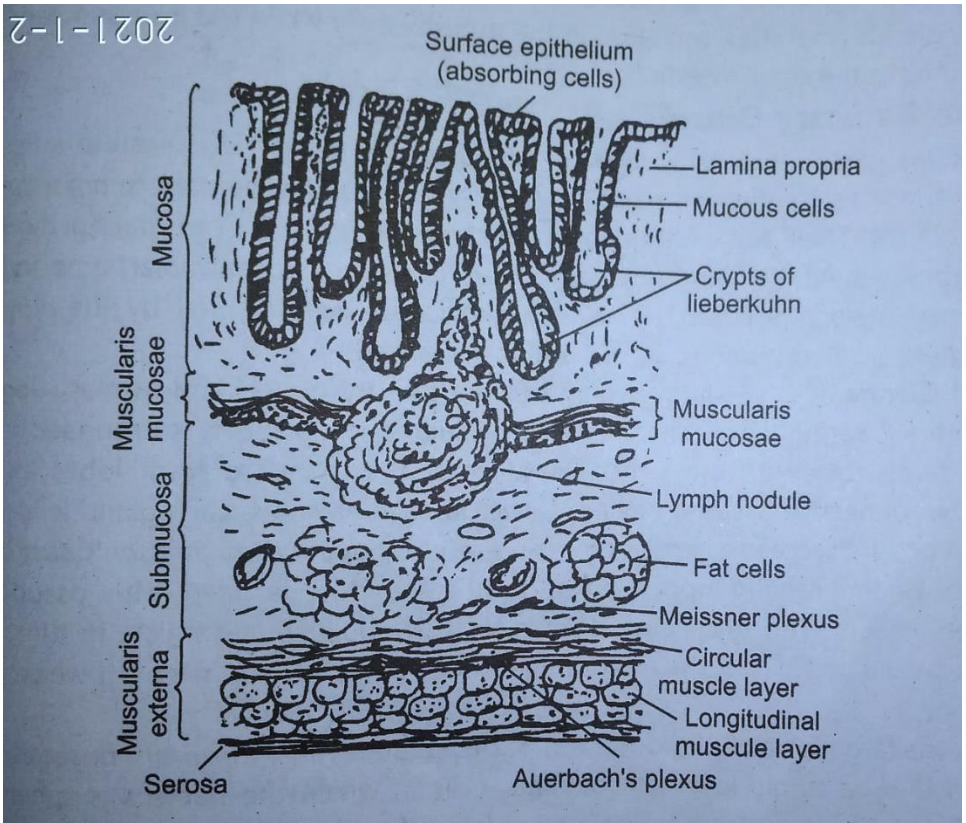


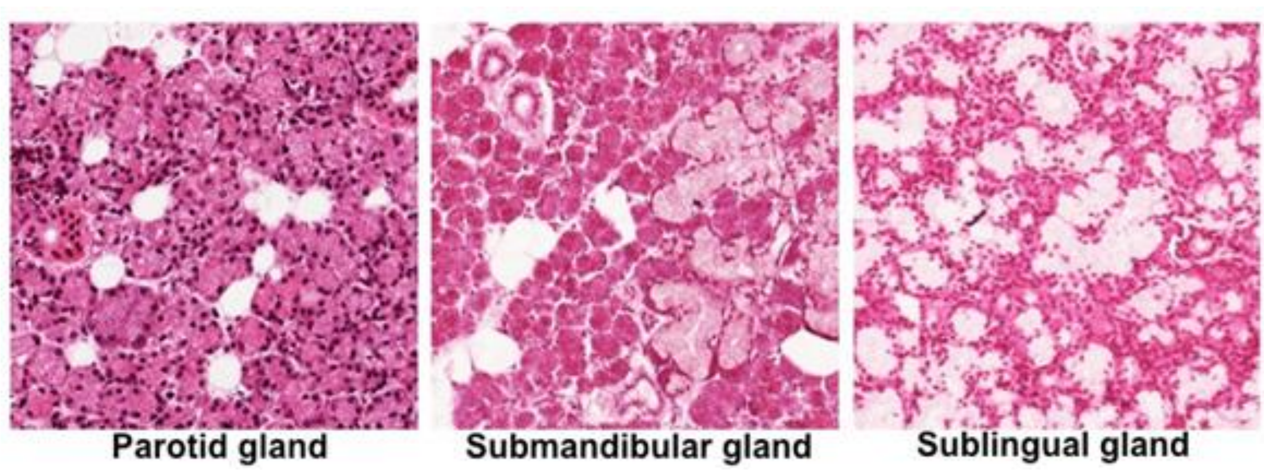
Fig. 3.22: T. S. of Rectum

3.5 GLANDS ASSOCIATED WITH DIGESTIVE SYSTEM

3.5.1 SALIVARY GLANDS

These are the parotid, submandibular and sublingual glands, and numerous small glands situated in the mucous membrane of the lips (labial glands), cheeks (buccal glands), tongue (lingual glands), and palate (palatine glands). Some salivary gland tissues may be seen in the palatine and pharyngeal tonsils. The secretions of these glands help to keep the mouth moist, and provide a protective and lubricant coat of mucous. Some enzymes (amylase, lysozyme), and immunoglobulin IgA are also present in the secretions. Salivary glands are compound tubulo-alveolar glands (racemose glands). Their secretory elements (also referred to as end pieces or as the portio terminalis) may be rounded (acini), pear shaped (alveoli), tubular, or a mixture of these (tubulo-acinar, tubulo-alveolar). The secretory elements lead into a series of ducts through which their secretions are poured into the oral cavity.

Salivary glands are made up of secretory **acini** (acini - means a rounded secretory unit) and ducts. There are two types of secretions - **serous** and **mucous**. The **acini** can either be **serous, mucous**, or a mixture of serous and mucous. A **serous acinus** secretes proteins in an isotonic watery fluid.
A **mucous acinuss** secretes secretes mucin – lubricant In a mixed serous-mucous acinus, the **serous** acinus forms a serous **demilune** around **mucous** acinus, as shown in the diagram. The secretory units merge into **intercalated** ducts, which are lined by simple low cuboidal epithelium, and surrounded by myoepithelial cells. These ducts continue on as **striated ducts.** These have a folded basal membrane, to enable active transport of substances out of the duct. Water resorption, and ion secretion takes place in the striated ducts, to make saliva **hypotonic** (reduced Na,Cl ions and increased carbonate, and potassium ions).
The striated ducts lead into **interlobular** (excretory) ducts, lined with a tall columnar epithelium. The **glands** are divided into lobules by connective tissue septa. Each lobule contains numerous secretory units, or acini.



3.5.2 The Liver

The liver may be regarded as a modified exocrine gland that also has other functions. It is made up, predominantly, of liver cells or hepatocytes.

Basic Histology of the Liver: In sections through the liver, the substance of the organ appears to be made up of hexagonal areas that constitute the hepatic lobules. In some species (e.g., the pig) the lobules are distinctly demarcated by connective tissue septa, but in the human liver the connective tissue is scanty and the lobules often appear to merge with one another. In transverse sections each lobule appears to be made up of cords of liver cells that are separated by sinusoids. However, the cells are really arranged in the form of plates (one cell thick) that branch and anastomose with one another to form a network. Spaces within the network are occupied by sinusoids. Along the periphery of each lobule there are angular intervals filled by connective tissue. These intervals are called portal canals, the ‘canals’ forming a connective tissue network permeating the entire liver substance. Each ‘canal’ contains (a) a branch of the portal vein; (b) a branch of the hepatic artery, and (c) an interlobular bile duct. These three structures collectively form a portal triad. Blood from the branch of the portal vein, and from the branch of the hepatic artery, enters the sinusoids at the periphery of the lobule and passes towards its centre. Here the sinusoids open into a central vein that occupies the centre of the lobule. The liver is covered by a capsule (Glisson’s capsule) made up of connective tissue.

1. The cytoplasm of liver cells contains numerous mitochondria, abundant rough and smooth endoplasmic reticulum, a well-developed Golgi complex, lysosomes, and vacuoles containing various enzymes. Numerous free ribosomes are present
2. Although the liver performs numerous functions all liver cells look alike. Each cell is probably capable of performing all functions.
3. Interspersed amongst the endothelial cells there are hepatic macrophages (Kupffer cells). The surface of the liver cell is separated from the endothelial lining of the sinusoid by a narrow perisinusoidal space.
4. Blood vessels and hepatic ducts present in portal canals are surrounded by a narrow interval called the space of Mall.
5. The surface of a hepatocyte can show three kinds of specialisation.
   (a) Sinusoidal surface: As mentioned above the cell surfaces adjoining sinusoids bears microvilli that project into the space of Disse.
   (b) Canalicular surface: Such areas of cell membrane bear longitudinal depressions that are apposed to similar depressions on neighbouring hepatocytes, to form the wall of a bile canaliculus.
   (c) Intercellular surface: These are areas of cell surface where adjacent hepatocytes are united to each other just as in typical cells. Communicating junctions allow exchanges between the cells. About 15% of the hepatocyte surface is intercellular.

3.5.3 THE PANCREAS

The pancreas is a gland that is partly exocrine, and partly endocrine, the main bulk of the gland being constituted by its exocrine part. The exocrine pancreas secretes enzymes that play a very important role in the digestion of carbohydrates, proteins and fats. The endocrine part of the pancreas produces two very important hormones, insulin and glucagon.

The Exocrine Part: The exocrine part of the pancreas is in the form of a serous, compound tubulo-alveolar gland. Secretions produced in the alveoli are poured into intercalated ducts (also called intralobular ducts). These ducts are invaginated deeply into the secretory elements. As a result of this invagination the ducts are not conspicuous in sections. From the intercalated ducts the secretions pass into larger, interlobular ducts. They finally pass into the duodenum through the main pancreatic duct and the accessory pancreatic duct. The cells lining the pancreatic ducts control the bicarbonate and water content of pancreatic secretion. These actions are under hormonal and neural control. The walls of the larger ducts are formed mainly of fibrous tissue. They are lined by a columnar epithelium.

The Endocrine Part: The endocrine part of the pancreas is in the form of numerous rounded collections of cells that are embedded within the exocrine part. These collections of cells are called the pancreatic islets, or the islets of Langerhans.

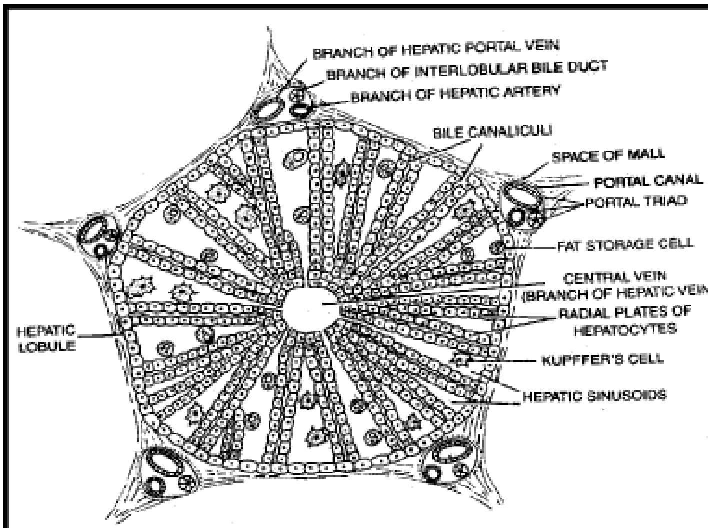
In ordinary preparations stained with haematoxylin and eosin, all the cells appear similar, but with the use of special procedures three main types of cells can be distinguished as follows.

(a) The alpha cells (or A-cells) secrete the hormone glucagon. They form about 20% of the islet cells.

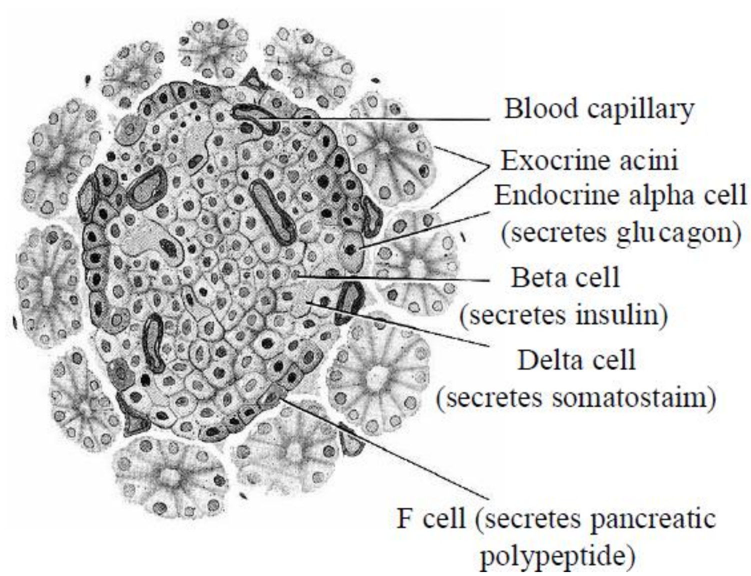
(b) The beta cells (or B-cells) secrete the hormone insulin. About 70% of the cells are of this type.

(c) The delta cells (or D-cells) probably produce the hormones gastrin and somatostatin. Somatostatin inhibits the secretion of glucagon by alpha cells, and (to a lesser extent) that of insulin by beta cells.

In islets of the human pancreas the alpha cells tend to be arranged towards the periphery (or cortex) of the islets. In contrast the beta cells tend to lie near the centre (or medulla) of the islet. Delta cells are also peripherally placed.



A part of transverse section of mammalian liver

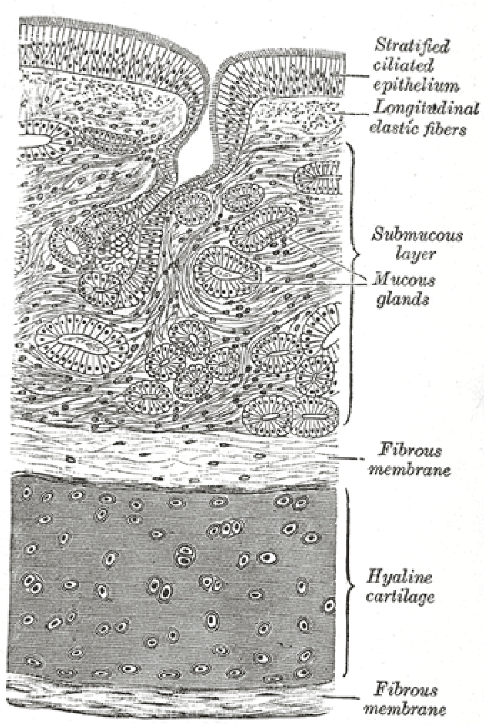


TRACHEA

The skeletal basis of the trachea is made up of 16 to 20 tracheal cartilages. Each of these is a C-shaped mass of hyaline cartilage. The open end of the 'C' is directed posteriorly. Occasionally, adjoining cartilages may partly fuse with each other or may have Y-shaped ends. The intervals between the cartilages are filled by fibrous tissue that becomes continuous with the perichondrium covering the cartilages. The gaps between the cartilage ends, present on the posterior aspect, are filled in by smooth muscle and fibrous tissue. The connective tissue in the wall of the trachea contains many elastic fibers. The lumen of the trachea is lined by mucous membrane that consists of a lining epithelium and an underlying layer of connective tissue. The lining epithelium is pseudostratified ciliated columnar. It contains numerous goblet cells, and basal cells that lie next to the basement membrane. Numerous lymphocytes are seen in deeper parts of the epithelium.

The subepithelial connective tissue contains numerous elastic fibers. It contains serous glands that keep the epithelium moist; and mucous glands that provide a covering of mucous in which dust particles get caught. The mucous is continuously moved towards the larynx by ciliary action. Numerous aggregations of lymphoid tissue are present in the sub epithelial connective tissue. Eosinophil leucocytes are also present.

Principal bronchi: The right and left principal bronchi (primary or main bronchi) have a structure similar to that of the trachea described above. The intrapulmonary bronchi are described with the lung



THE LUNGS

The structure of the lungs has to be understood keeping in mind their function of oxygenation of blood. The following features are essential for this purpose.

(1) A surface at which air (containing oxygen) can be brought into close contact with circulating blood. The barrier between air and blood has to be very thin to allow oxygen (and carbon dioxide) to pass through it. The surface has to be extensive enough to meet the oxygen requirements of the body.

(2) A system of tubes to convey air to and away from the surface at which exchanges take place.

(3) A rich network of blood capillaries present in intimate relationship to the surface at which exchanges take place.

The structure of the larger intrapulmonary bronchi is similar to that of the trachea. As these bronchi divide into smaller ones the following changes in structure are observed.

(1) The cartilages in the walls of the bronchi become irregular in shape, and are progressively smaller. Cartilage is absent in the walls of bronchioles: this is the criterion that distinguishes a bronchiole from a bronchus.

(2) The amount of muscle in the bronchial wall increases as the bronchi become smaller. The presence of muscle in the walls of bronchi is of considerable clinical significance. Spasm of this muscle constricts the bronchi and can cause difficulty in breathing. This is specially likely to occur in allergic conditions and leads to a disease called asthma.

(3) Subepithelial lymphoid tissue increases in quantity as bronchi become smaller. Glands become fewer, and are absent in the walls of bronchioles.

(4) We have seen that the trachea and larger bronchi are lined by pseudostratified ciliated columnar epithelium. As the bronchi become smaller the epithelium first becomes simple ciliated columnar, then non-ciliated columnar, and finally cuboidal (in respiratory bronchioles). The cells contain lysosomes and numerous mitochondria.

Structure of Alveolar: Wall Each alveolus has a very thin wall. The wall is lined by an epithelium consisting mainly of flattened squamous cells. The epithelium rests on a basement membrane. Deep to the basement membrane there is a layer of delicate connective tissue through which pulmonary capillaries run. These capillaries have the usual endothelial lining that rests on a basement membrane. The barrier between air and blood is made up of the epithelial cells and their basement membrane; by endothelial cells and their basement membrane; and by intervening connective tissue.