Histology of digestive system

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DIGESTIVE SYSTEM

It is the site where the food is processed, digested, absorbed and its residues are eliminated.

The digestive system consists of:

I. Digestive tract:

A. Oral cavity.

B. Gastrointestinal tract (GIT) (alimentary tract): esophagus, stomach, small and large intestine and anal canal.

II. Associated glands: *salivary glands, liver and pancreas.*

- ***Functions of digestive system:***

It is involved in breaking down food into small simple molecules that are easily absorbed through the lining of the digestive tract, for the maintenance, growth and energy needs of the body

This process occurs in five main phases:

1. Ingestion .....oral cavity.

2. Fragmentation..... oral cavity,

3. Digestion..... oral cavity, salivary glands, stomach, small intestine (duodenum), liver and pancreas.

4. Absorption .....small intestine (mainly jejunum) and large intestine

5. Elimination of waste products..... anal canal.

I. DIGESTIVE TRACT

A. Oral Cavity

It is the entrance to the digestive tract, and its boundaries are:

Above..... ....hard & soft palate.

Anteriorly .....inner aspect of the gums (gingiva) and teeth.

Posteriorly.....two palatoglossal folds.

Inferiorly.....floor of the mouth.

The vestibule of the mouth: *is a narrow space between the inner surface of the lips and cheeks and the outer aspects of the gums and teeth.*

The mouth cavity: *is the site of ingestion, fragmentation and moistening of food, in addition to the digestive role of saliva. It is also involved in speech, facial expression, sensory reception and breathing.*

The oral mucosa: *it is the mucous membrane lining the oral cavity. It is formed of:*

a) Non-keratinized stratified squamous epithelium: *covers the soft palate, inner aspect of the lip, cheeks and floor of the mouth.*

b) Lamina propria: *formed of dense collagenous tissue containing minor salivary glands, blood and lymphatic capillaries and sensory nerves. It has papillae similar to those of the dermis of the skin. It is connected to the underlying submucosa by loose connective tissue in the soft palate and floor of the mouth.*

N.B.: *The gingiva (gums), dorsal surface of the tongue, and hard palate are covered by keratinized stratified squamous epithelium to protect the oral mucosa from damage during the masticatory process. It is tightly bound to the periosteum of the bones (hard palate and tooth-bearing ridges) by dense fibrous submucosa*

1-The lips

They are made up of the orbicularis oris skeletal muscle intermixed with fibroelastic connective tissue

- **The outer surface** is covered by hairy skin with hair follicles, sebaceous and sweat glands.
- **The inner surface** is covered by the mucous membrane lining the vestibule of the mouth and the mouth cavity(oral mucosa). **The submucosa** contains tubulo-acinar labial glands, which are predominantly mucous with occasional serous acini.
- **The red line (vermilion)** is the border or free edge of the lip. It is a transition zone between the epidermis of the skin and the epithelium of the oral mucosa. It is a hairless very thin skin with deep papillae. Its epidermis is transparent so that it shows the red color of the blood capillaries present in the dermis, giving the lip its characteristic red color. It is also highly sensitive due to its rich sensory innervation.

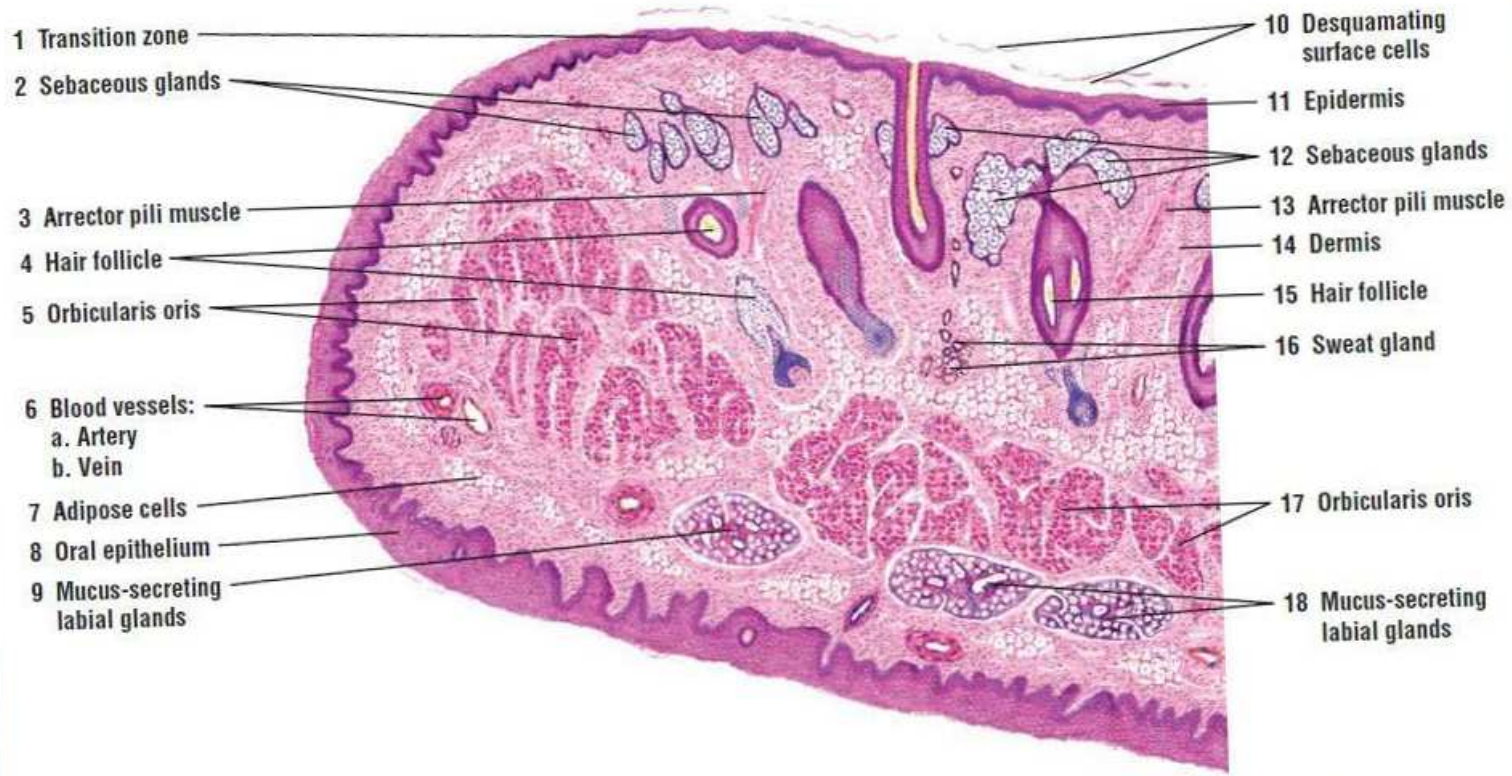


FIGURE 11.1 ■ Lip (longitudinal section). Stain: hematoxylin and eosin. Low magnification.

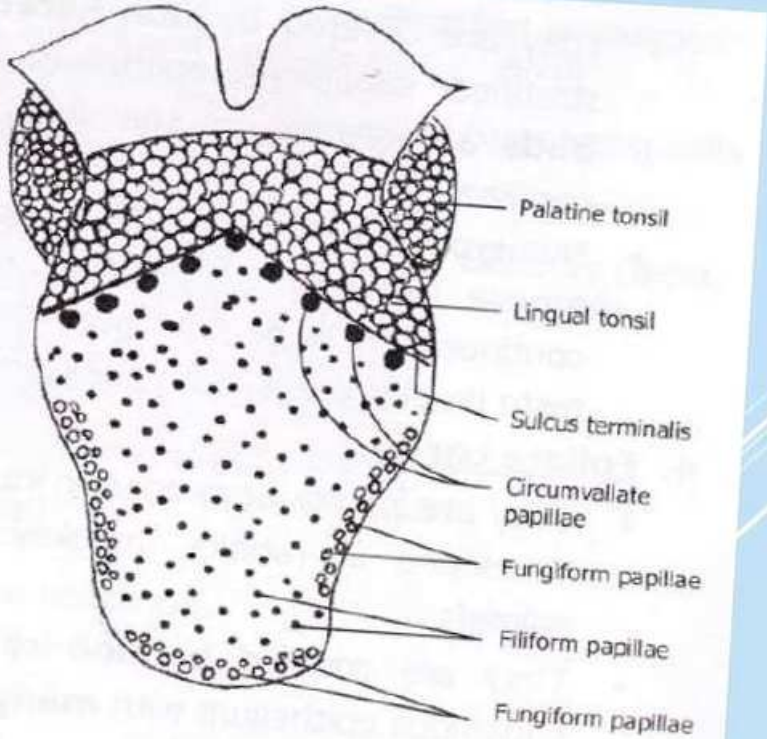
2. The Cheeks

- *They have the same structure as the lips.*
- *They are formed by the buccinator skeletal muscle.*
- ***The outside surface** is covered by skin with thick subcutaneous connective tissue.*
- ***The Inner surface** is covered by the oral mucosa. Muco-serous salivary glands, called buccal glands, are present in their lamina propria.*

3. The Tongue

- ✓ *It is a highly mobile muscular organ occupying much of the mouth cavity.*
- ✓ *It consists of Interlacing bundles of striated muscles arranged vertically, horizontally and longitudinally and intersecting at right angles.*
- ✓ *The arrangement of muscles ensures a higher degree of mobility essential for mastication, phonation and swallowing.*
- ✓ *The anterior two-thirds and the posterior one-third of the tongue are of different embryological origin and the boundary between the two is marked by a shallow V-shaped groove, the sulcus terminalis, with the apex of the V pointing posteriorly.*
- ✓ *The tongue is covered by oral mucosa.*

FIGURE 11.7 ■ Lingual tonsils (transverse section). Stain: hematoxylin and eosin. Low magnification.



Distribution of lingual papillae.

The dorsal surface of the tongue *is covered by rough, thick and firmly adherent mucosa. The mucosa of the anterior two thirds of the tongue is irregular due to the tongue is irregular due to the presence of small projections Skeletal called papillae. The posterior one-third shows small bulges composed mainly of small lymphoid aggregations called the lingual tonsils.* The mucosa of the dorsum of the tongue consists of partially keratinized stratified squamous epithelium and a thin papillated lamina propria. Keratin is situated on the tips of the fiform papllae.

The ventral surface of the tongue is covered by the smooth oral mucosa loosely adherent to the underlying connective tissue. It is covered by non- keratinized stratified squamous epithelium with no tongue papillae The lingual glands which are mixed seromucous glands are embedded in the ventral portion of the muscles of the tongue. Blood vessels and rich innervation are present in the connective tissue around the muscle bundles

The Tongue (Lingual) Papillae:

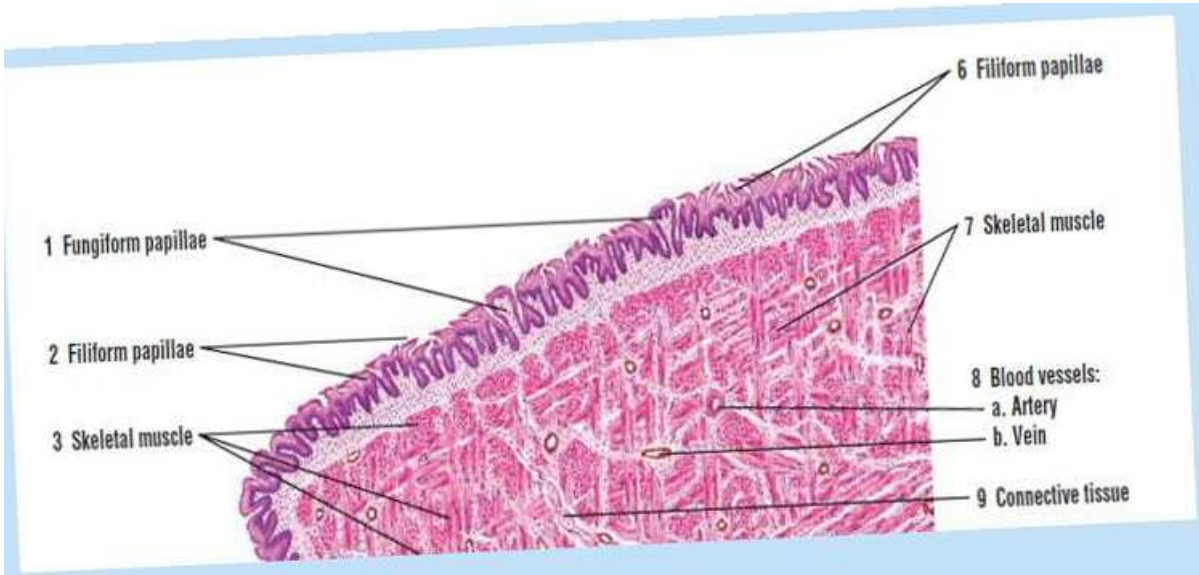
Papillae are elevations of the oral epithelium and lamina propria that assume various forms and functions. They are present on the anterior two thirds of the dorsum of the tongue There are four types:

1. Filiform papillae

They have an elongated conical shape and slightly curved. They are the most numerous .They are covered by keratinized stratified squamous epithelium. It does not contain taste buds .They are whitish in color.

2. Fungiform papillae

They resemble mushrooms (they have a narrow stalk and a smooth-surfaced, dilated upper part) They are covered by thin non-keratinized stratified squamous epithelium which contains scattered taste buds .They are irregularly scattered among the filiform papillae They have red appearance due to the richly vascularized connective tissue core



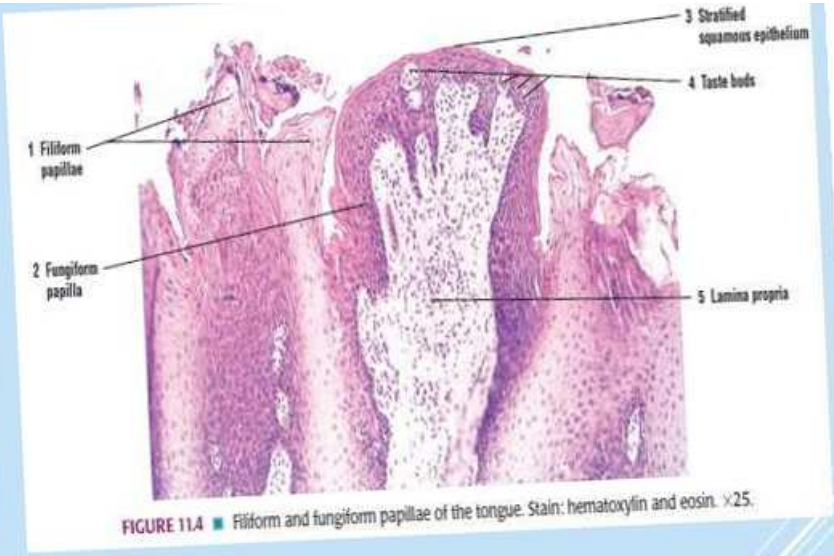
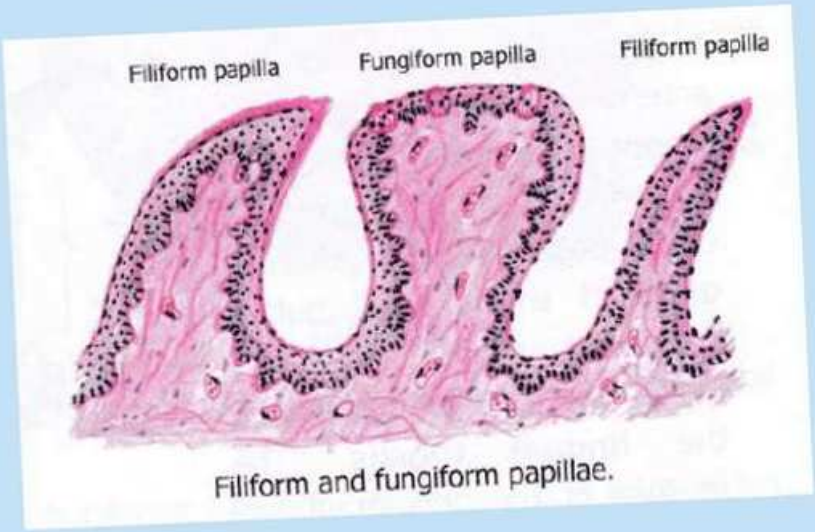
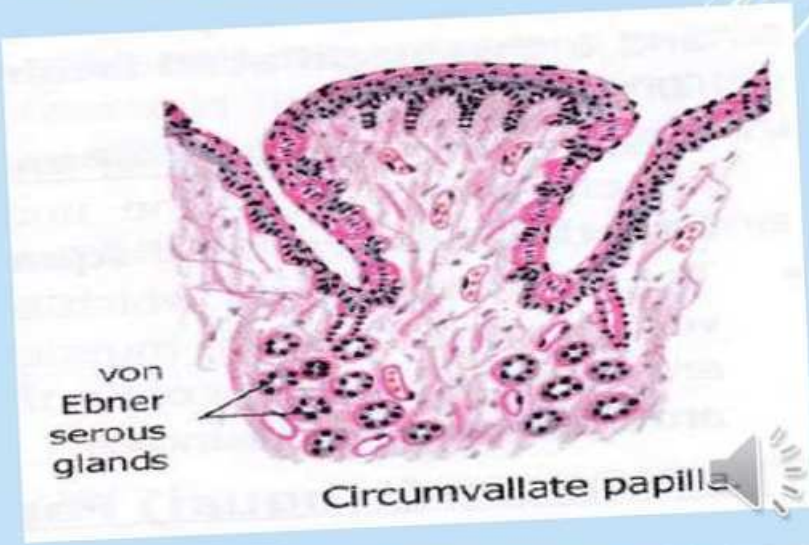


FIGURE 11.4 ■ Filiform and fungiform papillae of the tongue. Stain: hematoxylin and eosin. ×25.



Filiform and fungiform papillae.



3. Circumvallate papillae:

They are the largest and least common type of papillae. Their number sonly 6-14 papillae distributed in the V-shaped region in front of the sulcus terminalis

Each is surrounded by a circular furrow or sulcus (valley)

They are covered by non-keratinized stratified squamous epithelium .Taste buds are present on the sides of the papillae.

Numerous serous (von Ebner's) glands drain their secretion into the deep groove (valley) that encircles the periphery of each papilla, providing a continuous flow of fluid over the great number of taste buds present along the sides of these papillae.

4 Foliate papillae:

They are poorly developed in humans, but are well developed in rabbits, monkeys and many other animals.

They are covered by non-keratinized stratified squamous epithelium with many taste buds

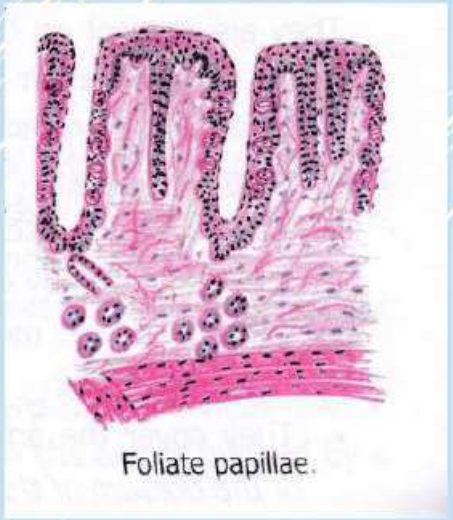
They consist of two or more parallel ridges and

furrows on the dorso-lateral surface of the tongue.

Serous glands in the lamina propria discharge

their secretion via ducts opening into the clefts

separating the papillae



Foliate papillae.

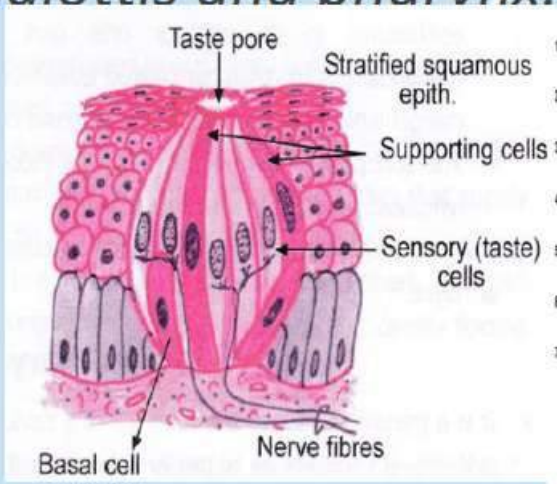
Taste Buds

They are onion-shaped structures, each one containing 50-100 cells. They have Wide bases and narrow apices.

They contain modified and specialized(taste cells) for taste perception: saltiness, sourness, sweetness and bitterness (chemoreceptors).

They are present on the tongue papillae (circumvallate, fungiform& folliate Papillae), soft palate, epialottis and pharynx.

The narrow apices of the taste buds converge on a small opening in the superficial layer called taste pore



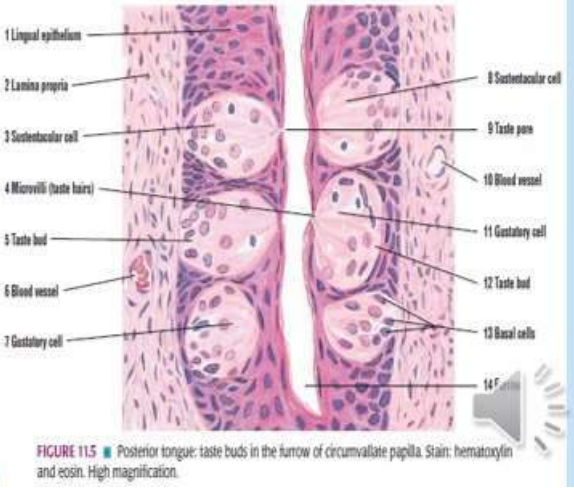


FIGURE 11.5 ■ Posterior tongue: taste buds in the furrow of circumvallate papilla. Stain: hematoxylin and eosin. High magnification.

Each taste bud is formed of the following cells:

1.Dark supporting or sustentacular cells:

-Slender dark cells with central nuclei at the periphery and Interior of the taste bud.

They have long microvilli projecting into the taste pore Secrete a dense amorphous glycoprotein material that surrounds the microvilli in the taste pore.

2. Light gustatory or neuroepithelial taste Cells:

- Light elongated centrally located cells with central nuclei.

They have long Taste pore processes several times the diameter of the microvilli.

They contain dense- Core vesicles in their basal cytoplasm that contain neurotransmitter

The base of the taste cells is surrounded by non-myelinated nerve fibers that carry the impulses of taste sensation.

3.Basal cells:

-Present at the base of the taste bud.

They act as stem cells for renewal of taste cells and supporting cells.

Glands of the Tongue

1. The lingual glands: they are mixed seromucous glands. Their ducts are three or four ducts opening on the ventral side of the tip of the tongue.
2. ven Ebner's glands: they are pure serous glands. Their ducts open in the sulcus (valley) between the circumvallate papillae
3. Small mucous and mixed glands: found in the dorsum of the tongue.

4. The Palate

It constitutes the superior boundary of the oral cavity

It is formed of anterior hard palate and posterior soft palate

a) The hard palate:

It is the anterior part of the roof of the oral cavity.

tis covered by keratinized stratified squamous epithelium and a lamina propria of connective tissue.

The mucosa is firmly bound to the periosteum of the underlying maxilla and palatine bones by dense connective tissue.

b) The soft palate:

It is the posterior part of the roof of the oral cavity and is continuous with the hard palate anteriorly, and its posterior margin is continuous with the nasal mucosa (pseudostratified columnar ciliated epithelium with goblet cells).

It is covered by the oral mucosa (non-keratinized stratified squamous epithelium) in its anterior oral part and by respiratory mucosa (pseudostratifried columnar ciliated epithelium with goblet cells) in its posterior margin which is continuous with the nasal cavity.

The soft palate has a core of skeletal muscle, numerous mucous glands and lymphoid nodules in its submucosa.

N.B.: to assist mastication, the palatal mucosa is thrown up into transverse folds or rugae.

5. The Pharynx

It is a transitional space between the oral cavity and the respiratory and digestive systems. It conducts air to the larynx and food to the esophagus. It is divided into:

a) Oropharynx lined with oral mucosa (non-keratinized stratified squamous epithelium.

b) Nasopharynx: lined With respiratory epithelium (pseudostratified columnar ciliated with goblet cells)

c) Laryngopharynx lined with oral mucosa (non-keratinized stratified squamous epithelium).

The pharyngeal mucosa lacks muscularis mucosa

The lamina propria contains small pure mucous salivary glands

A dense fibrous layer rich in elastic fibers is present deep in the lamina propria resting on the pharyngeal muscle which consists of inner longitudinal and outer oblique striated muscle fibers

B. Gastrointestinal Tract (GIT) GIT)

it is composed of esophagus, stomach, small intestine, large intestine and anal canal. General Structure of Gastrointestinal Tract: It is a hollow tube, composed of a lumen whose diameter varies, surrounded by a wall made up of 4 layers:

1. MUCOSA: *consists of*

a) Epithelium: *Forms a wet Surface, which serves for conduction, secretion and absorption. It is formed of: Stratified squamous non-keratinized in oral cavity and esophagu5. Simple columnar in stomach and intestine.*

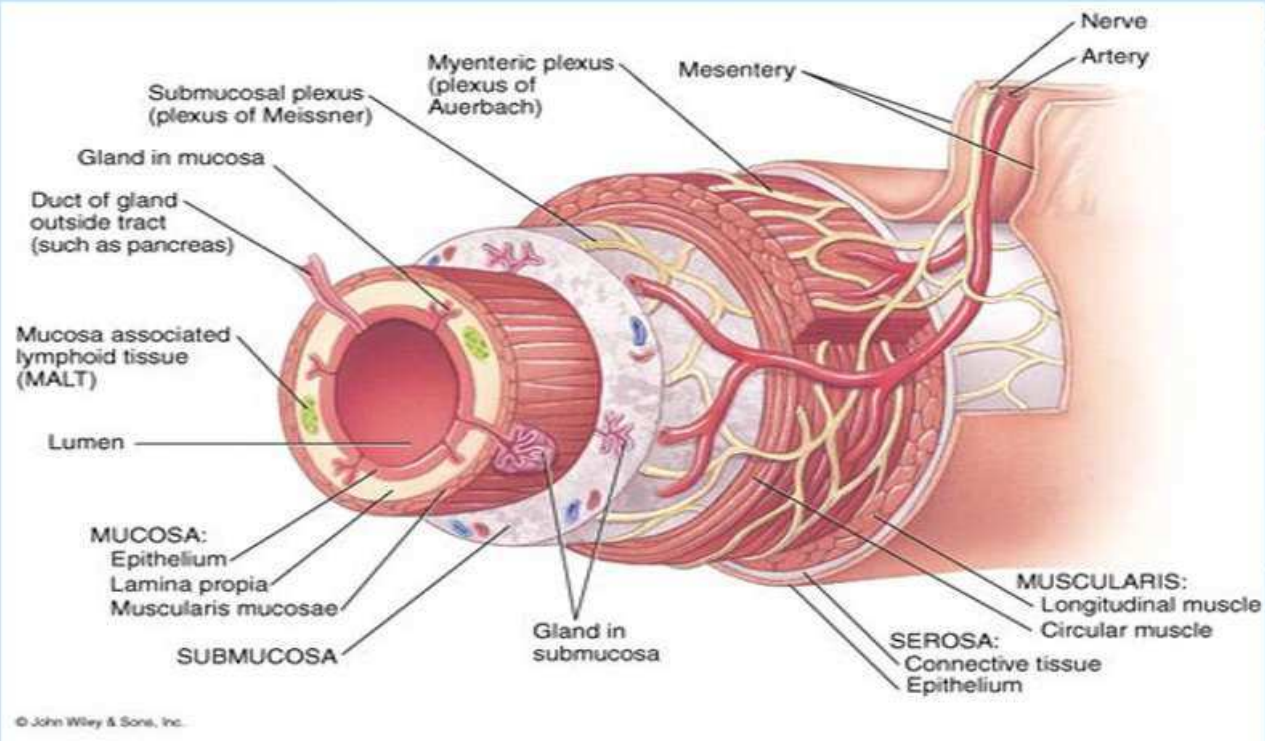
b) Lamina propria (C.T. corium): *it is a layer of loose C.T. under the epithelium to support it, containing blood vessels and lymphatics that supply the mucosa. it also contains the mucosal glands.*

C) Muscularis mucosae (MM): *a thin layer of smooth muscle fibers, arranged as inner circular and outer longitudinal layers. Its contraction causes folding and movements of the mucosa*

2. SUBMUCOSA: *A layer of dense irregular CT., formed of collagen and elastic fibers and C.T. cells. It contains the larger blood vessels and lymph vessels in addition to the Meissners parasympathetic plexus, which supplies the muscularis mucosae. It contains glands in some parts of the tube as esophagus and duodenum.*

3. MUSCULOSA (muscularis externa): *Composed of thick layer of smooth muscles, arranged in most parts of the tube as inner circular and outer longitudinal layers. In-between these 2 layers, the myenteric autonomic plexus called Auerbach's plexus is present, which regulates the movements of the musculosa (the peristaltic movements). This layer is formed of striated muscles in the upper 1/3 of esophagus.*

4.SEROSA OR ADVENTITIA: *It is the outermost layer It is formed of loose CT, Containing blood vessels and lymph vessels, and adipose tissue in Some parts. It is covered by simple squamous epithelium (mesothelium), in parts which are included inside the peritoneal cavity, where it is called serosa, while in retroperitoneal region it is called adventitia.*



Esophagus

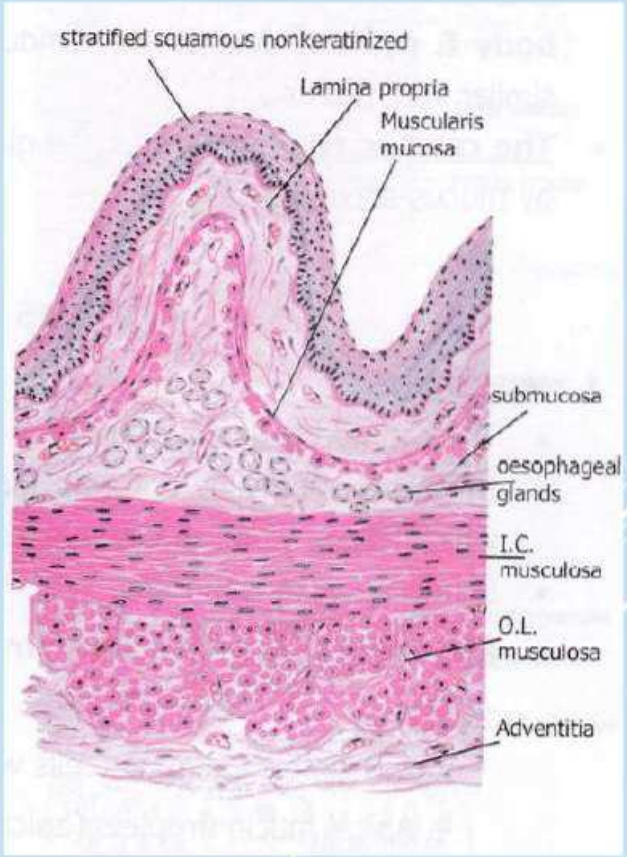
- *The esophagus is a straight, long, muscular tube that transports the ingested food from the pharynx to the stomach.*
- *It lies in the thorax, but it pierces the diaphragm to join the stomach*
- *It consists of 4 layers, from inside outwards:*

1. MUCOSA: it shows longitudinal folds and consists of:

a) Epithelium: stratified squamous (non-keratinized) It protects against injury, which may occur due to passage of rough food.

b) Lamina propria: loose C.T. which contains simple tubular mucous glands(cardiac glands), in the upper & lower ends of the esophagus

c) Muscularis mucosae: outer longitudinal (O.L.) & inner circular (I.C.) thin layers of smooth muscle.



2. SUBMUCOSA:

Consists of loose C.T., blood vessels, lymphatics & Meissner's plexus of nerve fibers.

It contains the esophageal glands (mucous, compound tubuloalveolar glands), their ducts pierce the mucosa to open into the lumen. Their secretion protects the mucosa of the esophagus

3. MUSCULOSA:

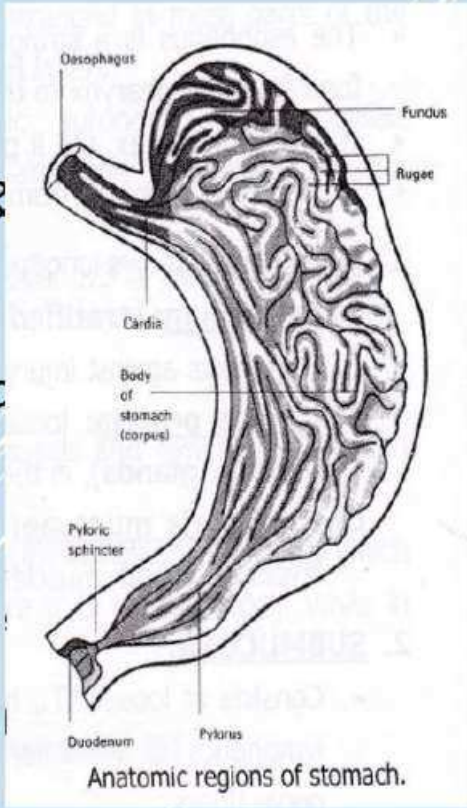
It is formed of inner circular (1.C.) & outer longitudinal (O.L.) muscle layers:

- *In upper 1/3.....muscles are striated.*
- *In middle 1/3.....muscles are mixed (smooth & striated).*
- *In lower 1/3..... .muscles are smooth.*

4. ADVENTITIA: loose C.T. binds the esophagus to adjacent structures. Below the diaphragm, the adventitia is replaced by serosa.

Stomach

- *The most dilated portion of GIT.*
- *It is a food reservoir; it acidifies and converts it by mechanical & chemical reduction into a thick viscous fluid (the chyme).*
- *The mucosa of the stomach contains the gastric glands (cardiac , fundic and pyloric). They secrete gastric juice which contains:*
  - *acidic secretion: HCl*
  - *mucus secretion*
  - *enzymes: pepsinogen, rennin & lipase*
- *It is divided anatomically into: cardiac, fundus, body & pyloric regions. The fundus & body are similar in structure.*
- *The cardias region: its mucosal glands are lined by mucus-secreting cells.*



Anatomic regions of stomach.

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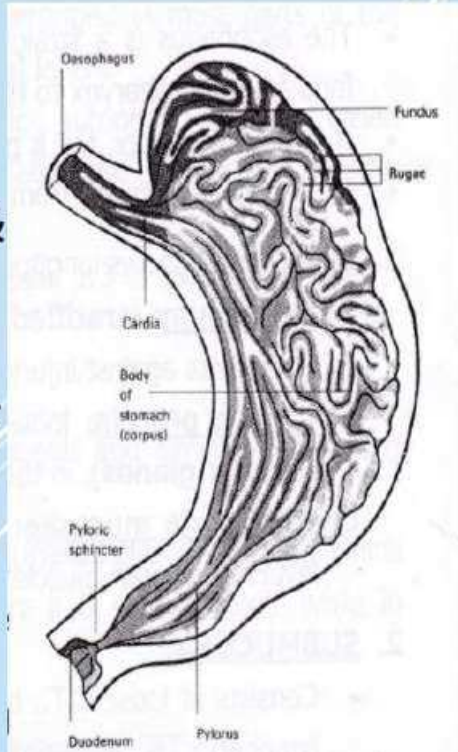


Anatomic regions of stomach.

Fundus of Stomach

1. MUCOSA:

- *Thick, pitted & darkly stained.*

In empty stomach, it forms longitudinal branching folds (gastric rugae), which flatten when the stomach is full.

- *Fundic mucosa is made of:*

a. Epithelium: simple columnar (surface mucous cells):

LM: *Tall simple columnar cells with basal oval nuclei.*

Apical mucin droplets (apical vacuolation).

EM: *Well developed supranuclear Golgi, rER and mitochondria.*

Functions: they secrete neutral mucus which forms a layer covering the surface (thick blanket) for lubrication and protection against abrasion by food and autodigestion and ulceration by the acid and enzymes.

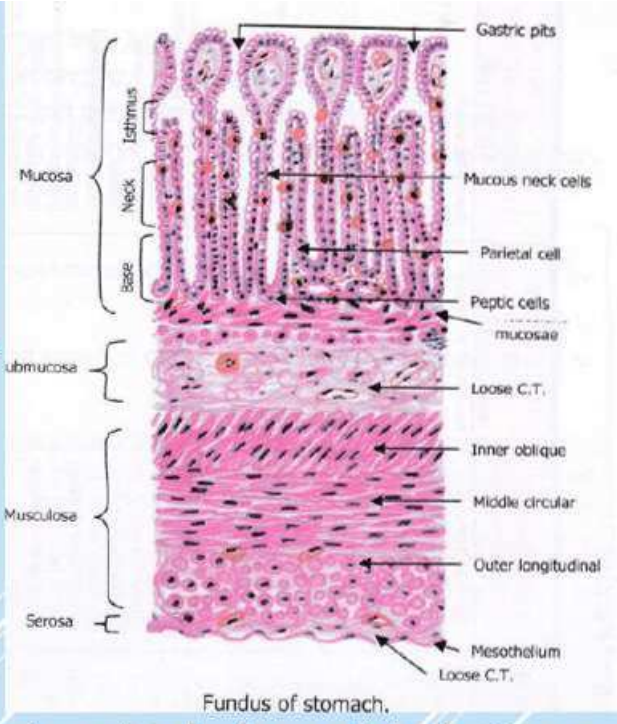
b. Lamina propria (C.T. corium): loose C.T. containing the fundic glands.

c. Muscularis mucosae: thin layer of smooth muscle fibers, arranged as inner circular (IC) and outer longitudinal (OL) layers.

Fundic glands

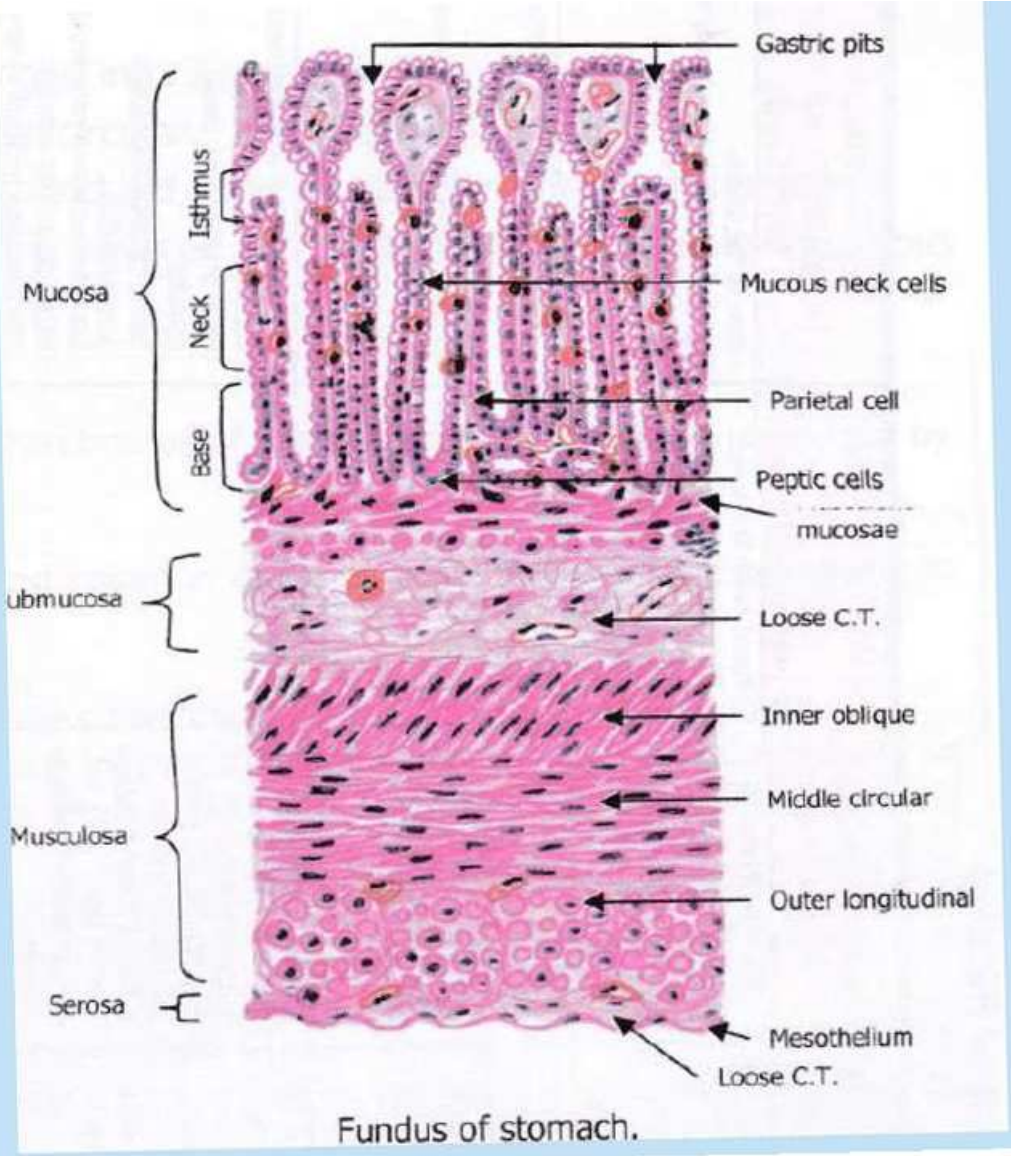
They are characterized by:

- *They occupy most of the thickness of the mucosa.*
- *Simple branched tubular glands.*
- *Very crowded, with little amount of C.T. between.*
- *Arranged perpendicular to the surface.*



Fundus of stomach.

- *Open into the lumen by short, narrow ducts (gastric pits), in which 2 or 3 glands open they occupy 1/4-1/3 the gland length i.e. pit/secretory portion = 1:3.*
- *Formed of: isthmus, neck & body.*



Fundus of stomach.

Lined by 6 types of cells:

1.Surface mucous cells

Site: Line the isthmus

L.M: Tall columnar cells with basal oval nuclei. Apical vacuolated cytoplasm (dissolve of mucin in the secretory granules) - stained red with PAS reaction.

EM: Prominent supranuclear Golgi complex Apical secretory granules, - PER Mitochondria.

Functions:

Secretion of neutral mucus which forms a layer covering the surface of the stomach (thick blanket) for lubrication & protection of the gastric mucosa from digestion by HCl & the gastric juice.

2.Mucous necks cells

Site: Located at the neck of the glands

L.M: Low columnar cells with basal flat nuclei. Pale vacuolated (foamy) cytoplasm dissolve of mucin in the secretory granules) - stained red with PAS reaction

E.M: Supranuclear Golgi complex Apical secretory granules Basal rER

Numerous polyribosomes

Functions:

Secretion of acidic mucus (low pH than the surface cells) which protects the gastric mucosa

3.Oxyntic (parietal) cells

Site: Located mainly in the upper half of the glands (peripheral or parietal). Few cells are scattered in the base of the glands

L.M: Large, rounded or triangular cells, that do not reach the lumen, with large central rounded nuclei.

- Cytoplasm is deeply acidophilic

E.M: Deep invginations at the apical surface forming intracellular canaliculi lined with numerous microvilli.

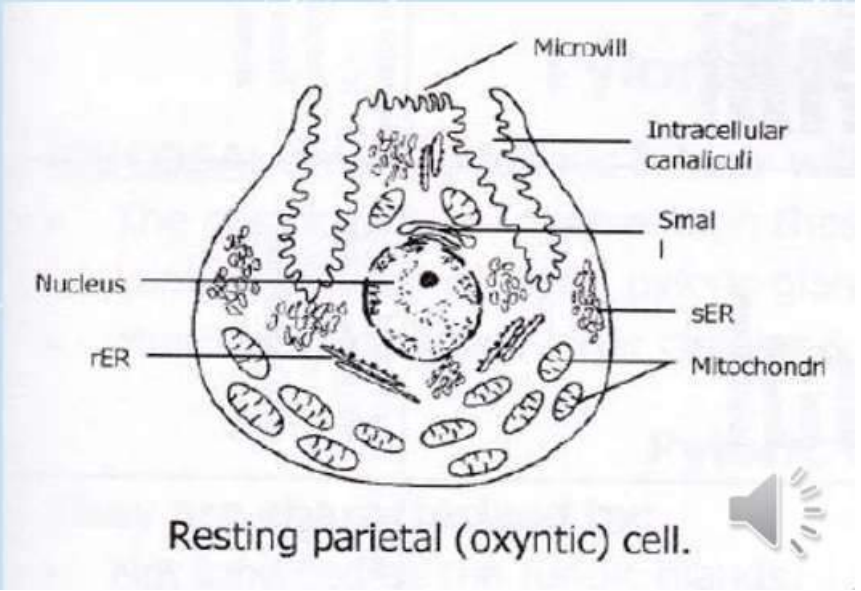
Numerous mitochondria.

Many SER few rER & small Golgi.

Function: Secretion & formation of:

(1) HCL

(2) Gastric intrinsic Antiperinicious anemia factor



Resting parietal (oxyntic) cell.

4.peptic (chief or central) cells

Site: The most numerous (chief) cell in the fundic glands. Found mainly in the base of the glands.

L.M: Pyramidal cells, with rounded basal nuclei, Cytoplasm has basal deep basophilia (rER) & apical acidophilic zymogen granules.

E.M: Luminal surface has short microvilli.

Cytoplasm shows characteristics of protein synthesizing cell:

- *Parallel cisternae of rER in the base.*
- *Prominent supranuclear Golgi.*
- *Apical electron dense secretory granules & numerous lysosomes.*

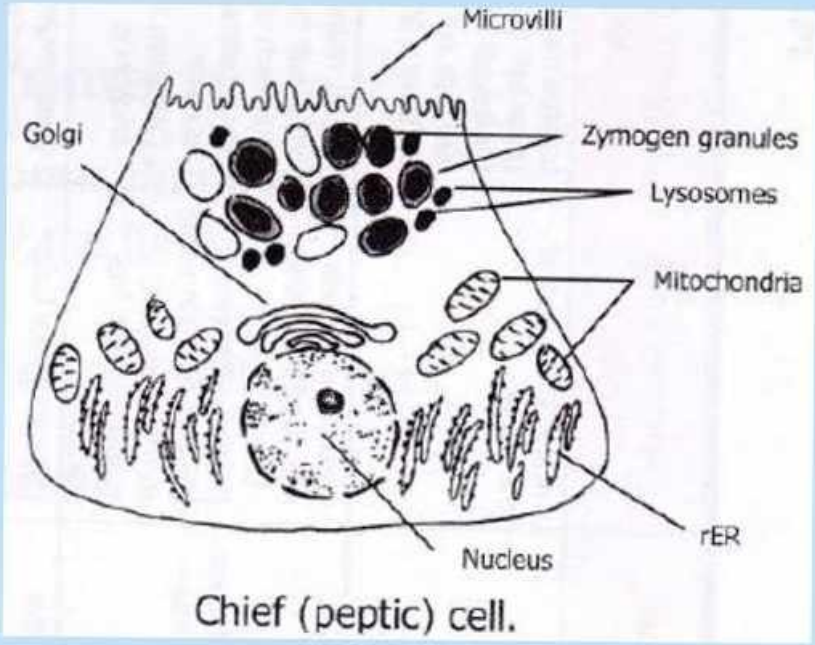
Nucleus show's euchromatin & heterochromatin and a prominent nucleolus.

Function: Secretion of:

(1) Pepsinogen pepsin

(2) Rennin

(3) Little amount of lipase.



Chief (peptic) cell.

5.Undifferentiated stem or regenerative cells

Site: Found mainly in the neck.

Dividing (differentiated) cells migrate upward (Surface) or deep into the gland to replace the damaged other cell types.

L.M: Low columnar cells with basal oval nuclei & prominent nucleoli. Pale cytoplasm.

E.M: Few organelles. Polyribosomes.

Function: Renewal of other cell types:

Proliferation differentiation migration:

upward replace Surface Epithelium , Downward (deep into the gland) replace oxyntic, Peptic & anteroendocrine (APUD) cells.

6.Entero-endocrine (argentaffin, APUD) cells

Site: Base of the glands.

- Their secretions passes directly in the lamina propria.

L.M: Small columnar cells with rounded apical nuclei & prominent nucleolus.

- Basal granules appear only when stained with silver stain called argentaffin cells

E.M: Nucleus is apical with prominent nucleolus. Basal small electron dense granules. Many free ribosomes & well developed rER. Elongated numerous mitochondria. Infranuclear Golgi complex.

Few thin apical microvilli serve to monitor the contents of gastric lumen.

Function: Many types of cells secrete many hormones:

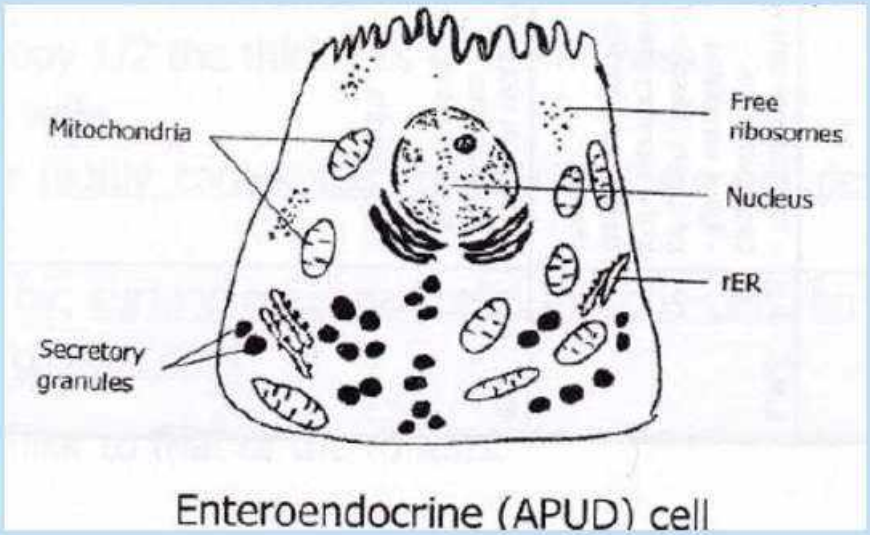
G-cells *gastrin (stimulate HCl secretion).*

EC-cells *serotonin (vasoconstrictor).*

A-cells *glucagons (elevated blood sugar level).*

D-cells *somatostatin (antigrowth hormone).*

E-cells *endorphin (pain killer)*



Enteroendocrine (APUD) cell

2. SUBMUCOSA: loose C.T. containing large blood vessels, lymphatics and Meissner's plexus of nerves.

3. MUSCULOSA:

- *Smooth muscle fibers, arranged into 3 layers:*

- Inner oblique. Middle circular. Outer longitudinal.

Auerbach's nerve plexus is found between the circular & longitudinal layers.

4. SEROSA: thin layer of loose C.T. covered with mesothelium (simple squamous epithelium)

Pylorus of Stomach

I. MUCOSA: similar to fundus & body with some changes:

- *The gastric pits are deeper than those of the fundus.*
- *Lamina propria: contains pyloric glands.*
- *Muscularis mucosae: inner circular & outer longitudinal layers.*

***Pyloric Glands:** They are characterized by:*

- *Not crowded as the fundic glands.*
- *The glands occupy 1/2 the thickness of the mucosa.*
- *Gastric pits are wide.*

- *The glands are highly convoluted (coiled) and are not perpendicular to the surface.*
- *They are lined by: surface columnar cells, mucous cells, enteroendocrine cells and occasional oxyntic cells.*

2 SUBMUCOSA: similar to that of the fundus.

3. MUSCULOSA:

Formed of 2 layers only: inner circular and outer longitudinal. The circular muscle layer is thickened to form the pyloric sphincter.

4. SEROSA: like that of the fundus.

Changes at the Gastro-Esophageal Junction:

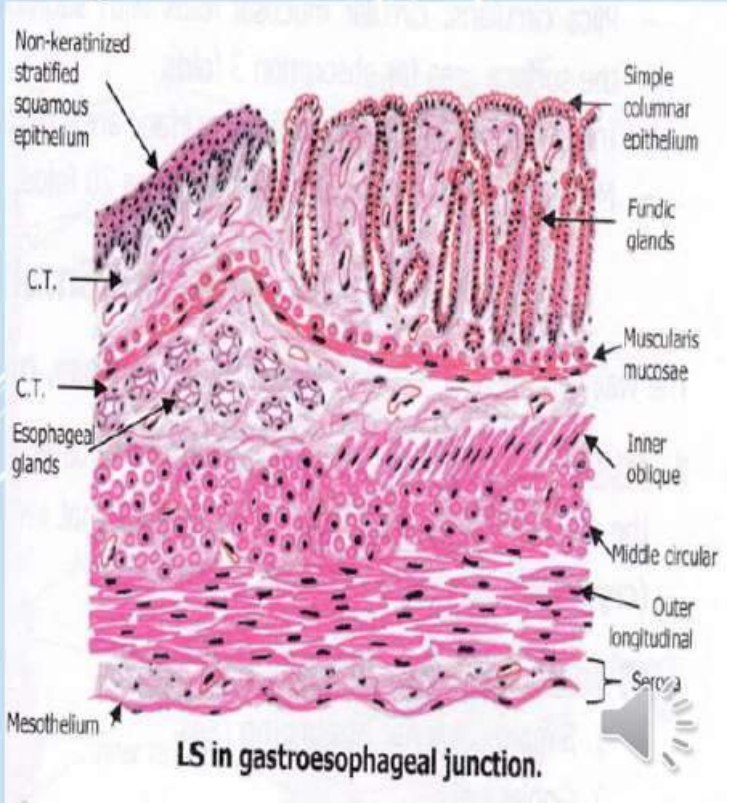
1. The stratified squamous epithelium, lining the esophagus, changes to simple columnar mucous secreting epithelium in the gastric part.

2. The corium of the stomach is wide and contains gastric glands.

3. The muscularis mucosae passes unchanged.

4. Esophageal mucous glands in the submucosa of the esophagus stop in the submucosa of the stomach.

5. The musculosa is more thick in the stomach, being formed of three layers: inner oblique, middle circular & outer longitudinal.



LS in gastroesophageal junction.

Small Intestine

Small intestine is the site of terminal food digestion absorption and endocrine secretion.

It is connected to the stomach at the pyloric sphincter.

It is about 6 meters long.

It is formed of 3 parts:

1. Duodenum: 25 cm long, C-shaped surrounding the head of pancreas.

2. Jejunum: constitutes the proximal 2/5 after the duodenum, 2.5 meters long.

3. Ileum: the distal 3/5, 3.5 meters long,

- *The digestion which started in the stomach is completed, and is helped in the small intestine with the secretions of a group of glands:*

a) Liver & pancreas with long ducts that open into the lumen.

b) Submucosal glands: small glands that secrete mucus, and open into the lumen.

c) Mucosal glands (intestinal crypts): which secrete enzymes, hormones & mucus.

d) Goblet cells

The absorption:

the surface area available for absorption in the intestine is augmented by:

Intestinal length (6 m).

Plica circularis: circular mucosal folds with submucosal core, which increase the surface area for absorption 3 folds.

Intestinal villi: which increase the surface area 10 folds.

Microvilli: which increase the surface area 20 folds.

General Structure of the Small Intestine

The wall is formed of 4 layers: mucosa, submucosa, musculosa & serosa

1. MUCOSA: it is characterized by the appearance of finger like projections above the surface (villi) and simple tubular glands that invaginate into the C.T. corium (crypts of Lieberkühn).

a) Epithelial lining:

1. Simple columnar absorping cells.

2. Goblet cells.

3. Enteroendocrine cells.

4. Undifferentiated columnar stem cells.

5. Paneth cells.

6. M-cells.

b) Lamina propria (C.T. corium): *Loose C.T., forming the cores of the villi and filling the spaces between the crypts. It is very rich in arterioles, blood & lymphatic capillaries. The terminal branches of lymphatic capillaries are found in the central axis of the villi, start with blind ends and are called (central lacteals).*

The C.T corium is very rich also in lymphocytes, plasma cells, neutrophils, eosinophils & macrophages.

In the corium of the ileum Peyer's patches are present.

c) Muscularis mucosae: *thin layer of smooth muscles, arranged in an inner circular & outer longitudinal layers.*

2. SUBMUCOSA: loose C.T. containing the larger blood vessels and lymph plexuses and Meissner's plexus of nerves.

In duodenum, it contains Brunner's glands (compound tubuloalveolar glands, which secrete mucous and open by ducts into the bases of the crypts)

In Ileum, it contains Peyer's patches which are lymphocyte aggregations, forming large oval nodules present at the antimesenteric side of the submucosa. They may pierce the muscularis mucosae.

3. MUSCULOSA: smooth muscles arranged in an inner circular & outer longitudinal layers separated by CT. containing Aeurbach's nerve plexus

4. SEROSA: areolar CT covered with simple squamous mesothelium.

Intestinal Villi:

Outgrowth of intestinal mucosa (epithelium + C.T. core of lamina propria).

They project into the lumen to increase surface area for absorption.

Each contains a central blind-ended lymphatic capillary (central lacteal).

In duodenum: long, broad & leaf-like.

In jejunum: tongue-shaped, slightly shorter.

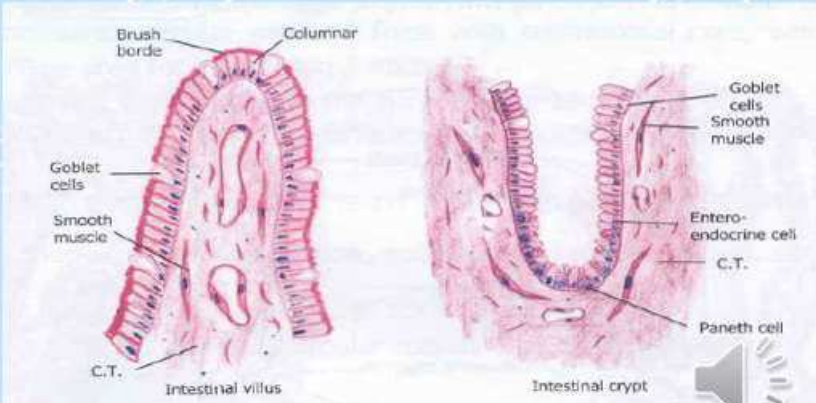
In ileum: thin, finger-like or absent above Peyer's patches.

The cells lining the villi are:

1. Simple columnar absorbing cells

2. Goblet cells

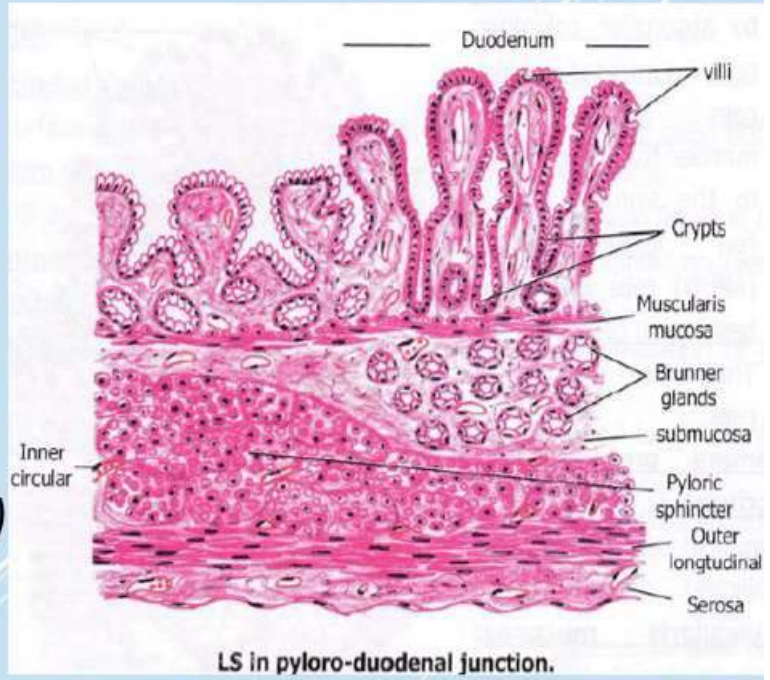
3. Enteroendocrine cells.



Structure of intestinal villi and crypts.

Intestinal Crypts (Crypts of Lieberkühn):

- *Between the bases of the villi, small openings leading to invaginations from the surface.*
- *They are simple tubular glands.*
- *They are lined with 6 types of cells:*



LS in pyloro-duodenal junction.

Changes at the Pyloro-Duodenal Junction:

1. *Appearance of intestinal villi in the duodenum.*
2. *The columnar cells acquire brush border(microvilli)*
3. *Goblet cells start to appear in the duodenum.*
4. *In the corium, the pyloric glands are replaced by intestinal crypts.*
5. *Brunner's glands appear in the duodenal submucosa.*
6. *Musculosa is thinner in the duodenum.*

Epithelial cell lining the interstinal mucosa:

Absorptive columnar cells (enterocytes)

Site: in the villi & crypts

L.M.: Tall columnar cells with basal oval nuclei.

Apical acidophilic brush border(formed a microvilli) to increase area for absorption.

E.M.:

- *Apical Abundant microvilli (brush border)*
- *Interdigitated lateral borders with junctional complexes*
- *Covered by cell coated (glycocalyx) rich in enzymes help terminal absorption as Sucrase , isomaltase & alkaline phosphates*
- *Abundant mitochondria*
- *Well developed sER, rER & Golgi complex*
- *Free ribosomes.*

Function :Terminal digestion of CHO , Proteins

Absorption of amino acids, glucose , monoglyceride and fatty acids

Goblet cells

Site: Interspaced between enterocytes in villi & crypts.

Their number increases from duodenum to ileum why?

L.M.: Expanded, flask shaped clear apical part due to dissolve of mucin in the mucinogen apical granule .

Narrow cylindrical basal part containing triangular dark nucleus.

E.M.:

- *Apical large pale mucus containing granules*
- *Abundant rER in the basal and lateral parts*
- *Supranuclear Golgi.*
- *Some mitochondria.*
- *Few apical microvilli*

Function:

Secretion of mucus at intervals (by exocytosis) for protection lubrication

Paneth cells

Site:

- *At the bases of small intestinal crypts only.*

L.M.:-

- *Columnar pyramidal cells, with basal rounded nuclei.*
- *Basal basophilic cytoplasm with apical acidophilic secretory granules.*

E.M:

Features of active protein forming cells:

- *Well developed basal PER in the form of parallel cisternae studded with Ribosomes*
- *Prominent supranuclear Golgi complex*
- *Many mitochondria.*
- *Apical large electron - dense homogenous granules & lysosomes*

Function: *1.Secrete intestinal enzymes 2.Secrete lysozyme (antibacterial enzymes)*

Undifferentiated (stem or regenerative) cells

Site:

- *Found mainly at the base of each crypt.*
- *They undergo extensive proliferation migrate to repopulate the epithelium of villi & crypts.*

L.M.:

- *Low Columnar cells with basal oval nuclei & prominent nucleoli. pale cytoplasm& Smooth lateral cell membrane , many cells found in mitosis*

E.M.:

- *few mitochondria.*
- *Few rER Small Golgi complex.*
- *More free ribosomes &polysomes*

Function:

- *Stem cells for other cell types.*
- *The cells of villa are renewed every 5-7 days.*

M (Microfold) cells

Site:

- *Specialized squamous-like cells associated with large lymphatic nodules (Peyer's patches).*

L.M.:

- *Squamous like small cells*

FUNCTION:

- *Antigen presenting cells.*
- *Phagocytose & transport antigens present in the intestinal lumen to the underlying macrophages.*

Entero-endocrine (argentaffin, APUD OF DNES) cells

Site:

- *Mainly in the base of crypts.*
- *Few cells (1%) of the cells covering the villi.*
- *Their secretions passes directly to the lamina propria.*

L.M.:

- *Small columnar cells with apical rounded nuclei.*
- *Basal granules appear only with silver (Ag) stain-> called argentaffin cells.*

E.M.:

- *Nucleus is apical with prominent nucleolus.*
- *Basal small electron dense granules.*
- *Many free ribosomes & well developed rER*
- *Elongated numerous mitochondria.*
- *Intranuclear Golgi complex.*
- *Few thin apical microvilli -- serve to monitor the contents of intestinal lumen.*

Function: Many types of cells secrete:

(1) D-cells Somatostatin

(2) I-cells -- cholecystokinin - pancreozymin.

(3) EC-cells serotonin

(4) G-cells gastrin.

(5)Mo-cells motilin.

(6) K-cells - gastric inhibitory peptide (GIP)

(7)N-cells -- neurotensin

(8)S-cells secretin

(9) A -cells entoroglucagon

(10) E -cells endorphin (pain killer)

Large Intestine

- *It is the site of absorption of water and ions, production of mucus for lubrication and formation of fecal mass for elimination.*
- *The ileum joins the large intestine at the junction of the cecum with the ascending colon and the orifice between them is called the ileocecal valve.*
- *It is formed of: cecum, colon (ascending, transverse, descending and sigmoid and rectum)*
- *Vermiform appendix is projecting from the cecum.*
- *The large intestine is connected to the exterior by the anal canal.*

Cecum and Colon

- *They are similar in structure.*
- *They form most of the length of the large intestine.*

Histology of digestive system

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Palestinian board of pathology

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Cecum and Colon

- *They are similar in structure.*
- *They form most of the length of the large intestine.*

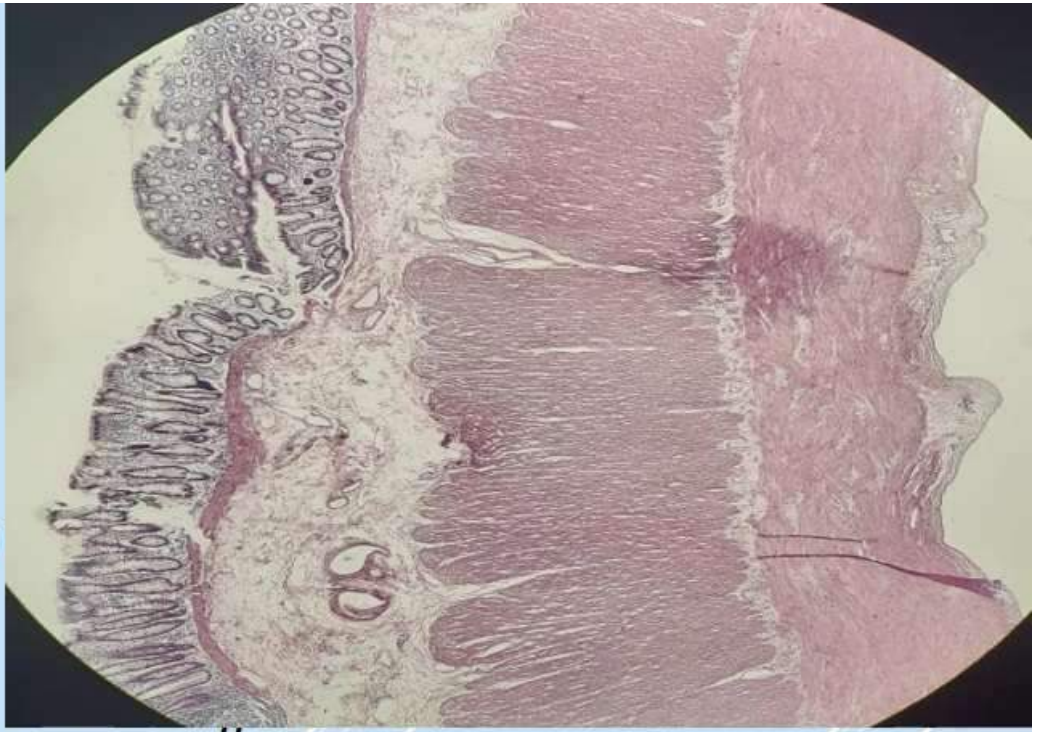
1. MUCOSA:

It has no villi

The crypts are deep and wide.

a) Epithelial lining:

Surface epithelium: consists of tall absorptive columnar cells with striated border and many goblet cells.



The crypts: are lined by absorptive columnar cells, numerous goblet cells (increase in number from the cecum to the sigmoid colon),few enteroendocrine (APUD) cells and some basal stem cells.

There are no Paneth cells.

b) Lamina propria (C.T. corium): C.T. layer rich in lymphoid cells and nodules (follicles)

c) Muscularis mucosae: well developed, formed inner circular and outer longitudinal muscle layers.

2. SUBMUCOSA:

- *C.T. layer containing blood vessels, nerves and lymphatics,*

It contains no glands.

3. MUSCULOSA:

Formed of smooth muscles arranged as inner circular and outer longitudinal layers.

- *The outer longitudinal layer is not continuous but present in three bundles or bands called tenia coli*

4. SEROSA:

- *Formed of C.T. rich in fat cells and is covered with peritoneum (simple squamous mesothelium).*
- *Accumulation of adipose cells beneath the peritoneum forms pouches called appendices epiploicae.*

Vermiform Appendix

It is a projection from the cecum.

Two to eight cm in length.

Tts lumen is narrow and stellate shaped that is usually occupied by debris

1. MUCOSA:

a) Epithelial lining:

Surface epithelium consisting of tall absorptive columnar cells, goblet cells stem cells, M-cells and many enteroendocrine (APUD) cells

Villi are usually absent and crypts are irregular, short and fewer in number

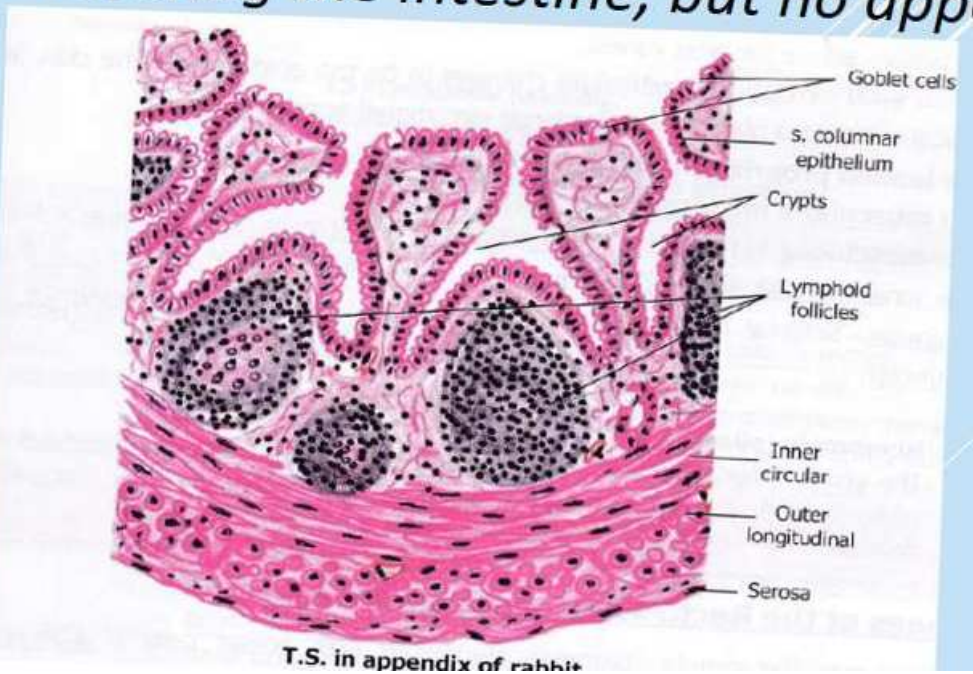
b) Lamina propria (C.T. corium): Loose CT, rich in lymphoid nodules

c) Muscularis mucosae: Poorly developed

2. SUBMUCOSA: Thick C.T. layer containing extensive accumulation of lymphoid follicles

3. MUSCULOSA: Thin, formed of inner circular and outer longitudinal muscle layers.

4. SEROSA: Similar to that covering the intestine, but no appeindices epiploicae



T.S. in appendix of rabbit

Rectum

Itis the terminal part of the gastrointestinal tract

It is about 12 cm in length.

Its histological structure is similar to the colon except. that:

-Its crypts are deeper and fewer in number, containing many goblet cells

There are no tenia coli.

Serosa is replaced by adventitia (no peritoneal covering)

Anal Canal

it is the communicating canal between the intestinal tract and the exterior

It is about 3-4 cm in length.

Its crypts are short and few and are absent in the distal half of the canal.

The mucosa forms longitudinal folds called rectal columns of Morgagni
The columns join each other to form the anal valves separated by anal sinuses. Each column of Morgagni contains an artery , a vein and smooth muscles.

The epithelium of the anal canal is simple columnar epithelium about 2 cm above the anal opening. Then it is transformed into stratified columnar epithelium above the columns of Morgagni and non-keratinized stratified squamous epithelium above the anal valves. At the anal orifice the epithelium changes to the epidermis of the skin, with typical sebaceous glands and also large circumanal apocrine glands

The lamina propria contains a plexus of veins

The muscularis mucosae disappears

The musculosa is formed of inner Circular and outer longitudinal muscle layers

The inner circular smooth muscle layer thickened to form the internal anal Sphincter ,Skeletal muscles of the floor of the pelvis form the external anal sphincter.

Changes at the Recto-Anal Junction:

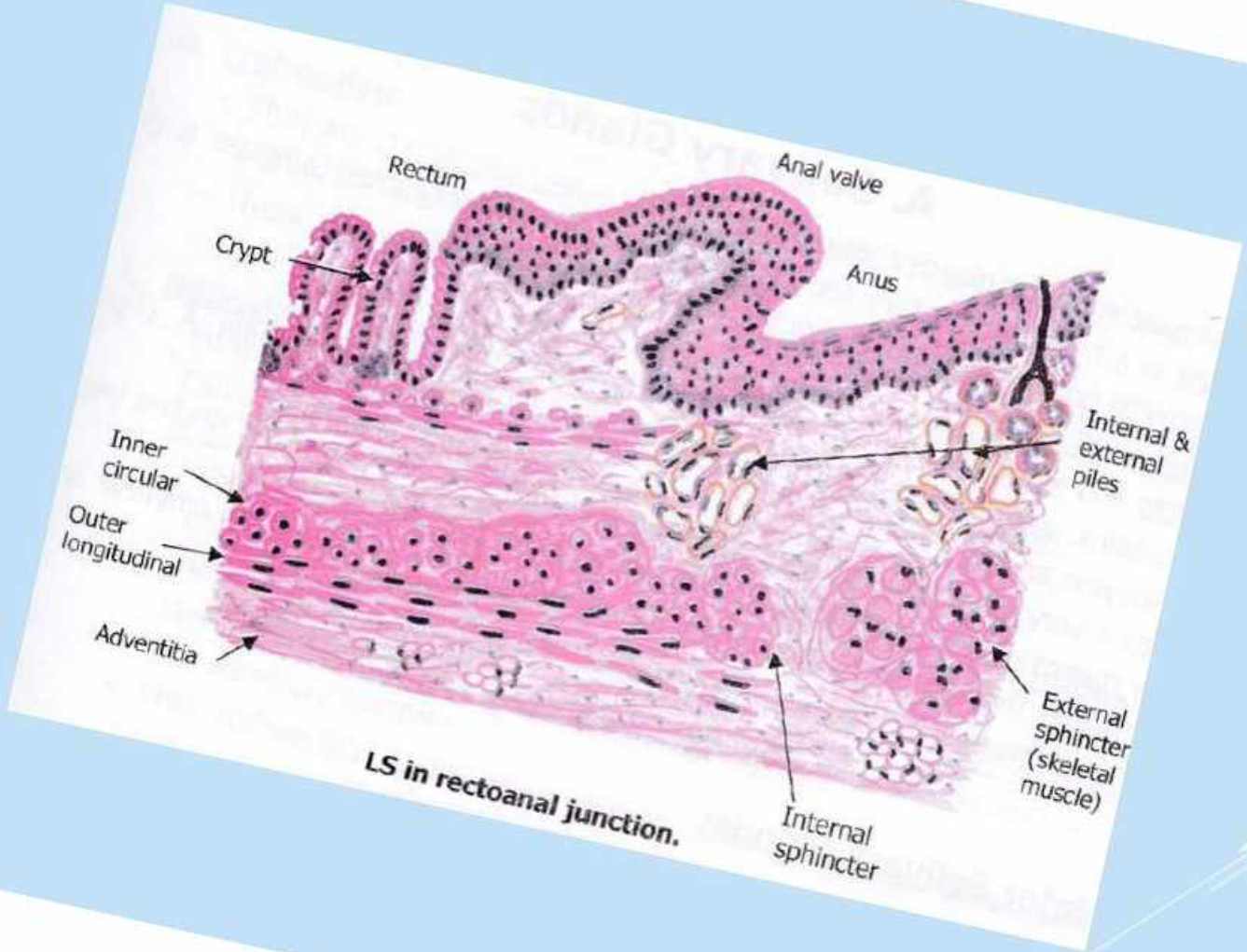
1. Epithelium: The simple columnar epithelium with goblet cells of the rectum changes into stratified columnar epithelium above the columns of Morgagni and non-keratinized stratified squamous epithelium above the anal valves.

2. Muscularis mucosae is broken in the region of the columns of Morgagni and then disappears.

3. Submucosa of the rectum is continuous with the C.T. core of the anal canal.

4. The inner circular smooth muscle layer of the rectum changes into a thick layer internal anal sphincter).

5. The outer longitudinal smooth muscle layer of the rectum extends between the internal and external anal sphincters.



LS in rectoanal junction.

II. GLANDS ASSOCIATED WITH THE DIGESTIVE TRACT

The glands associated with the digestive tract include the salivary glands, the pancreas and the liver.

A. Salivary Glands

They are exocrine glands that produce saliva.

Saliva is a hypotonic watery secretion containing mucus, enzymes (amylase & the antibacterial enzyme lysozyme), antibodies and inorganic ions.

Functions of saliva:

1. Wets and lubricates the oral mucosa, lips and ingested food.

2. Contains germicidal protective substances such as immunoglobulin A (IgA), lysozyme and lactoferrin.

3. Has a very important buffering function and forms a protective layer on the teeth by means of calcium-binding protein-rich salivary proteins.

4. Initiates the digestion of carbohydrates and lipids (by means of amylase and lingual lipase activities).

Types of Salivary Glands

A. Major Salivary Glands:

They are compound tubulo-alveolar exocrine glands.

They secrete 90% of the total volume of the saliva in humans.

They are connected to oral epithelium by branching systems of ducts.

They produce their secretions (saliva) in response to parasympathetic activity which is induced by physical, chemical and psychological stimuli.

Major salivary glands include:

1. The parotid glands: in front of both ears.

2. The submandibular glands: lie against the inner aspect of the mandible.

3. The sublingual glands: lie under the oral mucosa of the floor of the oral cavity.

B. Minor Salivary Glands:

They are scattered in the oral mucosa (in the lamina propria under the oral epithelium).

They open directly, or via short ducts, onto the surface of the oral epithelium.

They secrete 10% of the total volume of saliva. Most of their secretion is mucus, so they account for approximately 70% of the mucus secreted.

They are present throughout the oral mucosa of the lips, cheeks, palate, tonsils, tongue and tongue papillae (labial, buccal, palatine, lingual & von Ebner's).

General Architecture of Major Salivary Glands

Each gland is formed of stroma & parenchyma.

I STROMA: Connective tissue (capsule, trabeculae and reticular C.T.).

A. Capsule: A connective tissue capsule rich in collagen fibers surrounds the large salivary glands.

B. Trabeculae: They are connective tissue septa (formed of C.T. cells & fibers) dividing the glands into numerous lobes and lobules.

These trabeculae radiate from the capsule between the lobes and lobules and convey blood vessels, nerves and large excretory ducts.

C. Reticular Stroma:

Formed of reticular fibers forming the background of the glands. Can be demonstrated with silver (Ag).

N.B.

The connective tissue of large salivary glands contains many plasma cells and lymphocytes

Plasma cells secrete IgA, which forms with a secretory_component (synthesized by serous cells, intercalated ducts & striated ducts) an IgA- rich secretory complex,

- This IgA secretory complex released into the saliva is resistant to enzymatic digestion and constitutes an immunologic defense mechanism against pathogens in the oral cavity.

II. PARENCHYMA: It consists of secretory end pieces (secretory portion) and a branching duct system.

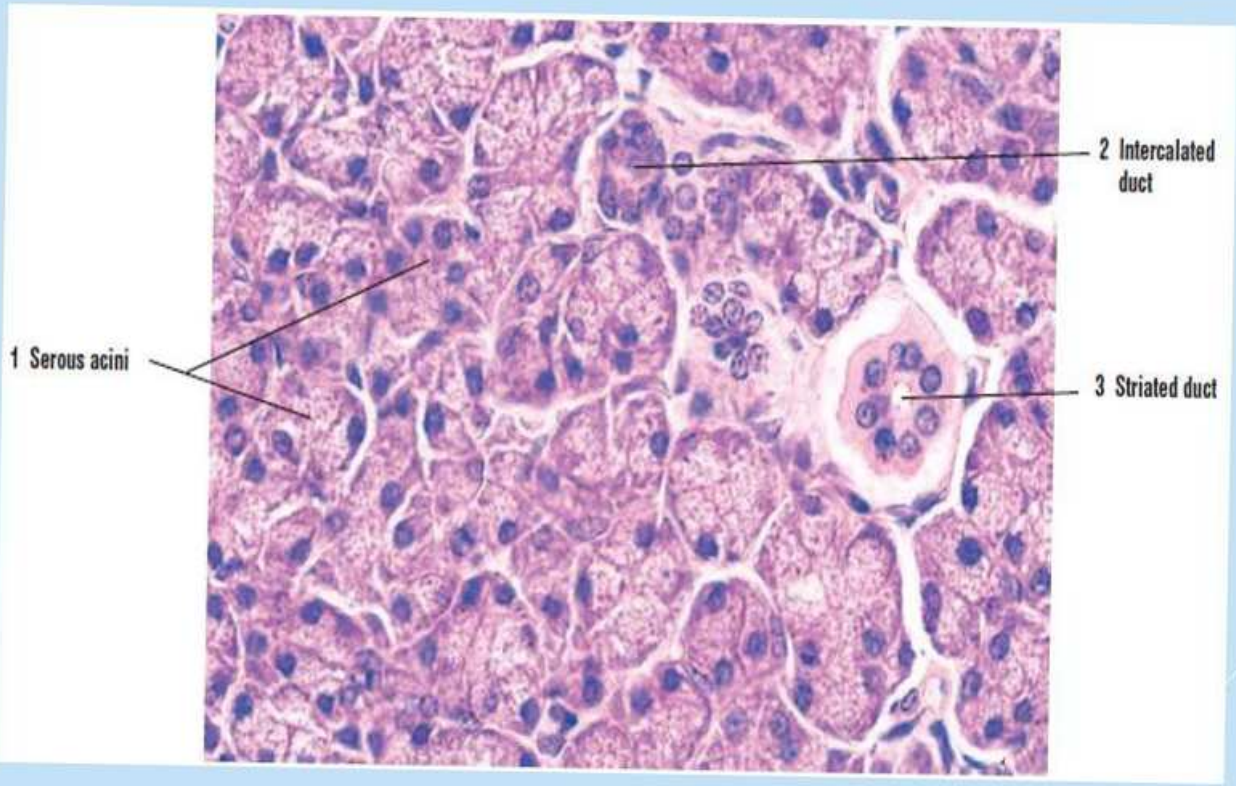
A. The Secretory End Pieces (Secretory Portion): It is formed of two types of secretory cells (serous and mucous) as well as the non-secretory myoepithelial cells. These three types of cells of the secretory portion are organized to form spherical masses of cells called acini. There are three types of acini: serous, mucous and mucoserous.

1. Serous acini:

- They are alveolar structures which are small in diameter with narrow lumens.
- Formed of serous cells:

I. Pyramidal in shape with broad base resting on the basal lamina and a narrow apical surface with short, irregular microvilli facing the lumen.
II. Their nuclei are single, rounded and central.
III. Their cytoplasm is basophilic containing well developed rER, Golgi apparatus, numerous mitochondria and apical acidophilic zymogen granules
IV. Adjacent cells are joined together by junctional complexes (they appear with indistinct cell boundaries).
V. Intercellular canaliculi are seen apical to the junctional complexes and extending to the lumen.

- They serete serous secretion.
- They are surrounded by few myoepithelal (basket) cells.



2 Mucous acini:

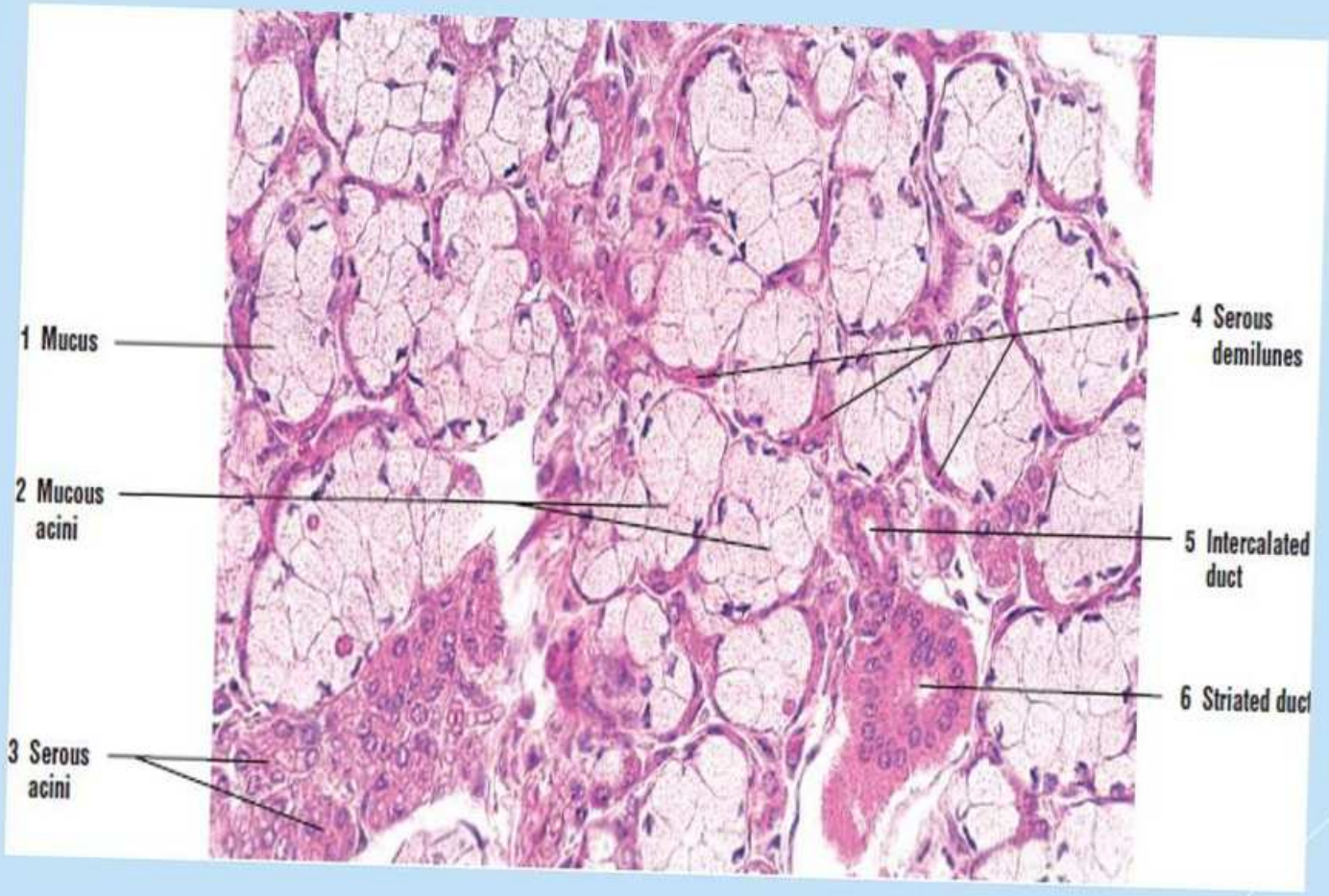
They have large diameters with wide lumens.

They formed of mucous cells:

I. They are cubical to columnar in shape.
II. They have pale vacuolated cytoplasm due to the presence of abundant secretory granules containing mucins (glycoprotein in nature) which dissolve during preparation. Golgi complex, few mitochondria and basal rER are also demonstrated.
III. Their nuclei are flat and basal.
IV. Intercellular canaliculi are few and less clear.

They secrete mucous secretion.

They are surrounded by many myoepithelial (basket) cells


1 Mucus
2 Mucous acini
3 Serous acini
4 Serous demilunes
5 Intercalated duct
6 Striated duct

3. Mucoserous acini:

- They are mixed secretory acini containing both serous and mucous cells,
- The mucous cells are organized as a mucous acinus. Serous cells cap the mucous part appearing as a crescent cap of basophilic cells called Serous demilune or crescent of Gianuzzi.
- They secrete mucoserous secretion.

Myoepithelial cells (basket cells):

They are non-secretory cells.

- They are branching stellate or spindle-shaped cells.

They embrace (surround) secretory acini & ducts as an octopus.

- They are located between the basal lamina and the basal pole of secretory cells.
- Their cytoplasm contains numerous actin and myosin filaments.
- Their function:

Contract around the secretory cells to release their secretions to the duct system.

Prevent distension of secretory acini during secretion due to increased intraluminal pressure.

B. The Duct System: It is a branching duct system present in all the major salivary glands. It is formed of:

1. Intercalated ducts:

- They are found inside the lobules.

They are linked to the secretory acini.

- The acini empty their secretions in these short ducts.
- They are lined with simple cubical epithelium.
- They have acidophilic cytoplasm
- Several of these short ducts join to form striated ducts.

2. Striated (intralobular) ducts:

- They are located inside the lobules
- They are lined by cuboidal or low columnar cells with central rounded nuclei.
- Their cytoplasm is acidophilic with basal acidophilic striations.
- By EM: the basal striations are seen to consist of infolding of the basal cell membrane with numerous elongated mitochondria parallel to the membrane infoldings.

They have a secretory function.

- The striated ducts of each lobule converge and drain into ducts located in the connective tissue septa separating the lobules to become interlobular or excretory ducts.

3. Interlobular (excretory) ducts:

Large ducts found in the C.T. septa separating the lobules.

- They are lined with columnar cells.
- The excretory ducts drain into larger ducts in the C.T. septa between the lobes to become interlobar ducts

4. Interlobar ducts:

- Present in the C.T. septa separating the lobes.
- They are lined with pseudostratified columnar epithelium. They collect to drain in the main duct.

5. Main duct:

- It empties the secretions in the oral cavity.
- At its beginning, it is lined by stratified columnar epithelium and by stratified squamous epithelium at its end in the oral cavity

The Parotid Gland

It is the largest major salivary gland

- A pair of glands situated in front of both ears.
- **The stroma (well developed):**

The parotid gland has a well developed C.T. capsule rich in fat cells.

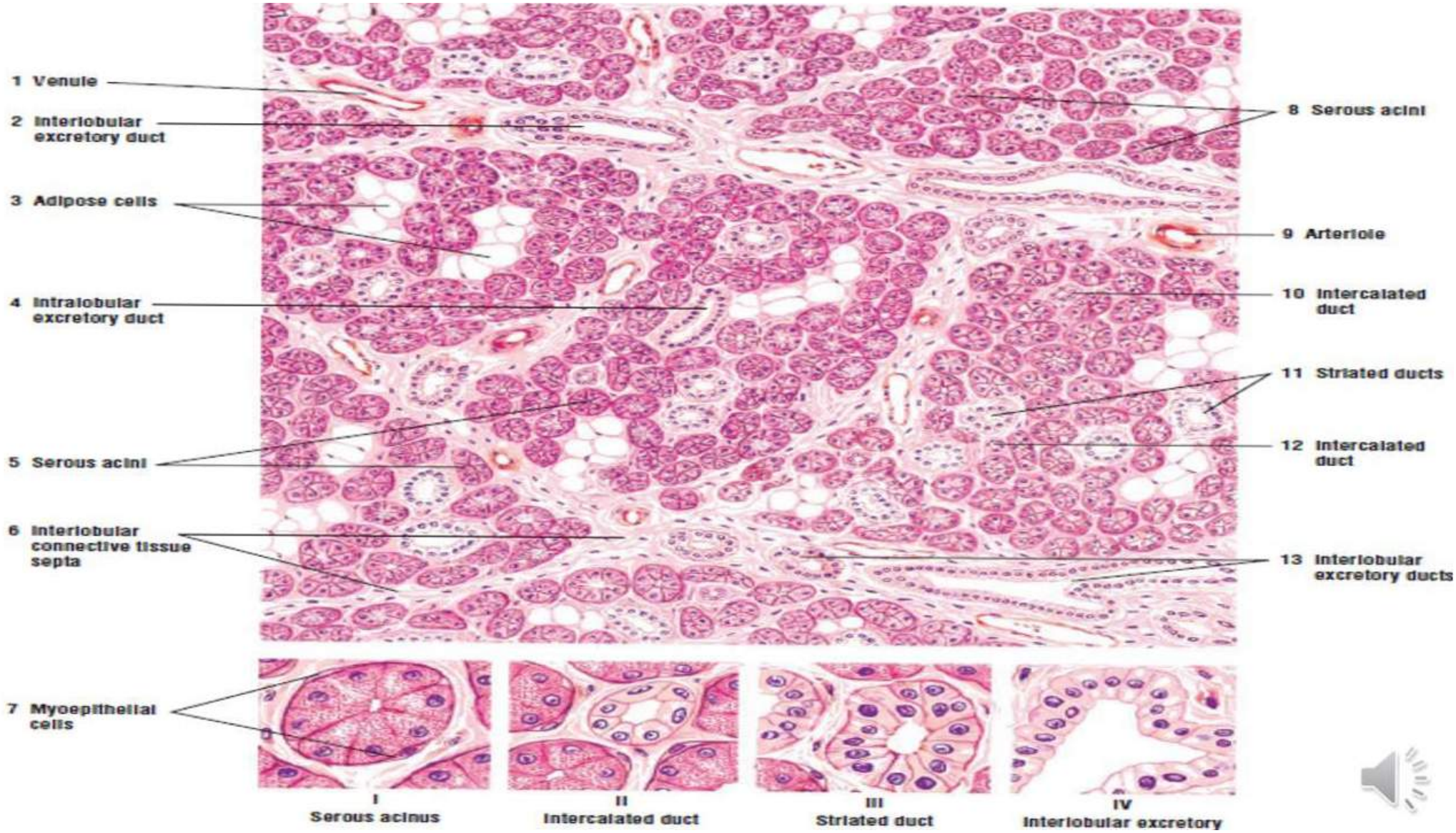
The trabeculae (septa) are thick formed of C.T. fibers and C.T. cells mainly fibrocytes & adipocytes (fat cells). They divide the gland into lobes & lobules.

- **The parenchyma:**

The parotid gland is a purely serous gland; formed almost of serous acini.

The serous cells contain secretory granules rich in proteins that have high amylase activity. This activity is responsible for most of hydrolysis of ingested carbohydrates.

• The duct system of the parotid is similar to that of all large salivary glands. The main duct (Stenson's duct) opens in the inner surface of the cheek opposite the second upper molar tooth.


1 Venule
2 Interlobular excretory duct
3 Adipose cells
4 Intralobular excretory duct
5 Serous acini
6 Interlobular connective tissue septa
7 Myoepithelial cells
8 Serous acini
9 Arteriole
10 Intercalated duct
11 Striated ducts
12 Intercalated duct
13 Interlobular excretory ducts
I Serous acinus
II Intercalated duct
III Striated duct
IV Interlobular excretory

The Submandibular Gland

- A pair of glands situated against the inner aspect of the mandible.

The stroma (well developed):

The capsule is thick

The C.T. trabeculae (septa) are abundant dividing the gland into lobes & lobules.

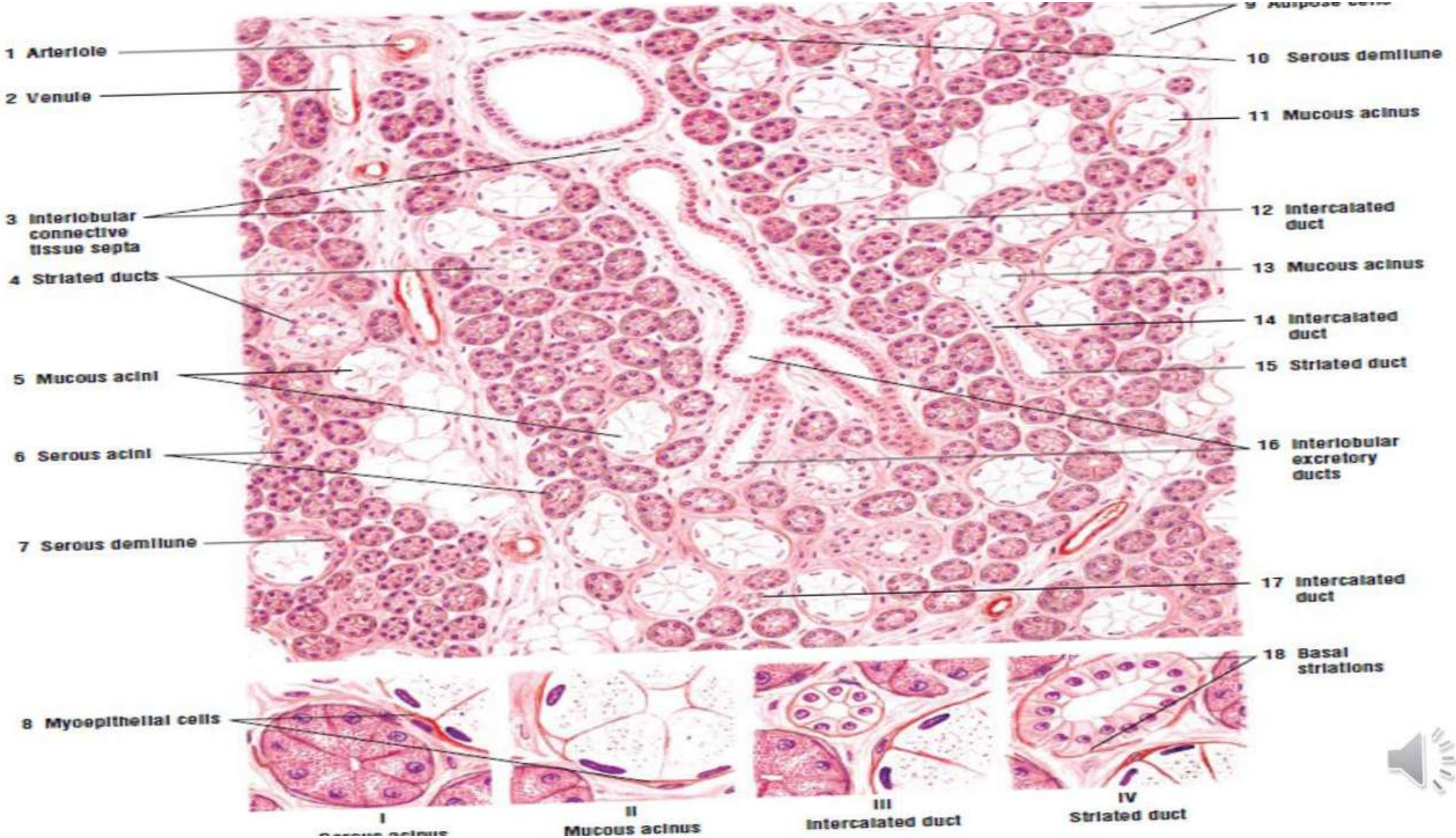
The parenchyma:

The submandibular gland is a seromucous gland. In humans, 90% of its acini are serous acini and the remaining 10% are mucous & mucoserous acini, while in the dog mucous acini predominate.

The serous cells contain granules containing the enzyme lysozyme, whose main activity is to hydrolyze the walls of certain bacteria.

The duct system is the same as that of all major salivary glands. The main duct (Wharton's duct) opens on the floor of the mouth cavity opposite to lower middle incisors at the sides of the frenulum.

In dogs the submandibular glands are formed mostly of mucous acini.


1 Arteriole
2 Venule
3 Interlobular connective tissue septa
4 Striated ducts
5 Mucous acini
6 Serous acini
7 Serous demilune
8 Myoepithelial cells
9 Adipose cells
10 Serous demilune
11 Mucous acinus
12 Intercalated duct
13 Mucous acinus
14 Intercalated duct
15 Striated duct
16 Interlobular excretory ducts
17 Intercalated duct
18 Basal striations
I
II
Mucous acinus
III
Intercalated duct
IV
Striated duct

The Sublingual Gland

A pair of glands present under the oral mucosa of the floor of the mouth.

It is the smallest major salivary gland.

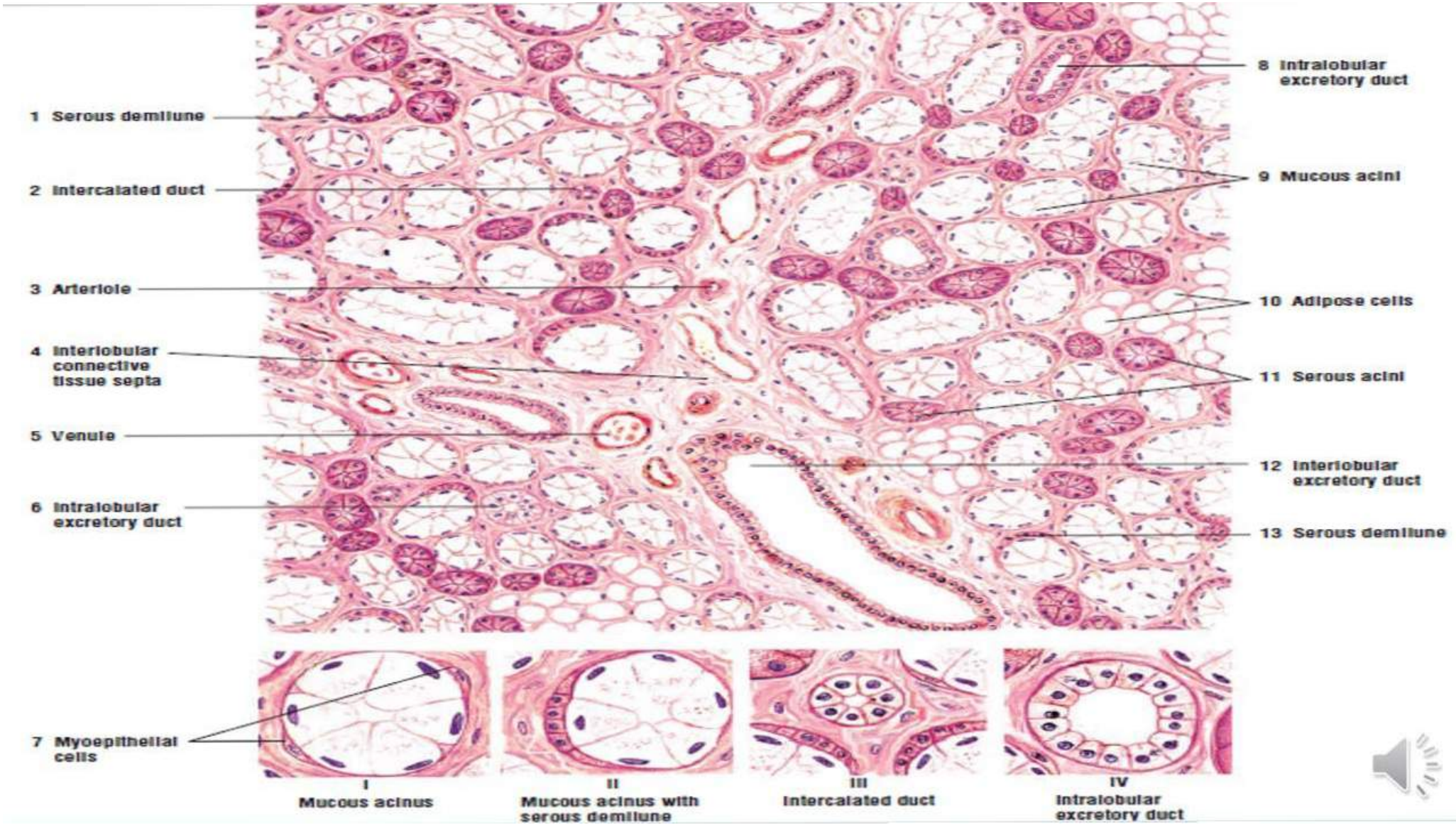
The stroma: It has a thin C.T. capsule with prominent C.T. septa dividing the gland into lobes & lobules.

The parenchyma:

The sublingual gland is a mucoserous gland. Mucous acini predominate with mixed mucoserous acini.

The gland has no pure serous acini.

The main duct often joins the submandibular main duct or may open separately on the floor of the mouth,


1 Serous demilune
2 Intercalated duct
3 Arteriole
4 Interlobular connective tissue septa
5 Venule
6 Intralobular excretory duct
7 Myoepithelial cells
8 Intralobular excretory duct
9 Mucous acini
10 Adipose cells
11 Serous acini
12 Interlobular excretory duct
13 Serous demilune
I
Mucous acinus
II
Mucous acinus with serous demilune
III
Intercalated duct
IV
Intralobular excretory duct

Histology & Pathology of The liver

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Liver

- The most important and the largest metabolic organ (1.5 kg).
- The accessory gland of the GIT.
- The interface between the blood and the digestive system, as all nutrient materials that are absorbed from the small intestine reach the liver via the portal vein.
- Most of its blood supply (70-80%) comes from the portal vein (O_2 poor & nutrient rich), and about 25% by hepatic artery (O_2 rich).
- It is situated in the upper quadrant of the abdomen, its rounded upper surface confirming to the dome of the diaphragm.
- From its lower surface blood vessels & nerves enter and hepatic duct leaves from deep transverse recess (the porta hepatis).

• It is the largest compound tubular gland.
• It is also considered as a mixed gland, as it has:
- exocrine secretion (bile), which pass to the intestine by bile duct to emulsify fat.
- endocrine secretion: many substances that pass directly to the blood, e.g. glucose, plasma proteins & lipids.

Functions:

1. Protein synthesis: albumin Fibrinogen prothrombin amino acids, uric acid & urea
2. Storage: of carbohydrates in the form of glycogen minerals as fe & ou, and Vitamins (A, B, D & K)
4. Detoxification of drugs, hormones and toxins.
5. Phagocytosis of unwanted materials in the blood stream as cell debris and fragments of RBCs.
6. Secretion of immunoglobulins (IgA, IgM).

Histological Structure of the Liver

Formed of stroma & parenchyma.

I. STROMA: formed of:

A. Capsule (Glisson's capsule): thin, strong, partially surrounded by peritoneum, formed of collagenous fibers and fibrocytes.

B. Trabeculae: formed of collagenous fibers & fibrocytes, demarcate lobules, condensed at the corners surrounding blood vessels & bile ducts. Very delicate in human, so lobulation is not clear. It is thicker in pig and in man it becomes very thick in liver cirrhosis (fibrosis).

C. Reticular network: formed of fine reticular fibers which support the liver cells & blood sinusoids. It can be demonstrated with (Ag).

II. PARENCHYMA: the basic structural component is the liver cells (hepatocytes), which are arranged to form classic hepatic lobules, portal lobules and liver acini.

1. Classic Hepatic Lobule

• Hexagonal mass of liver tissue drained with a central vein at its center. It is demarcated by thin C.T. trabeculae, which is thickened at the corners, forming the portal tracts portal canals).

• Each portal tract contains:

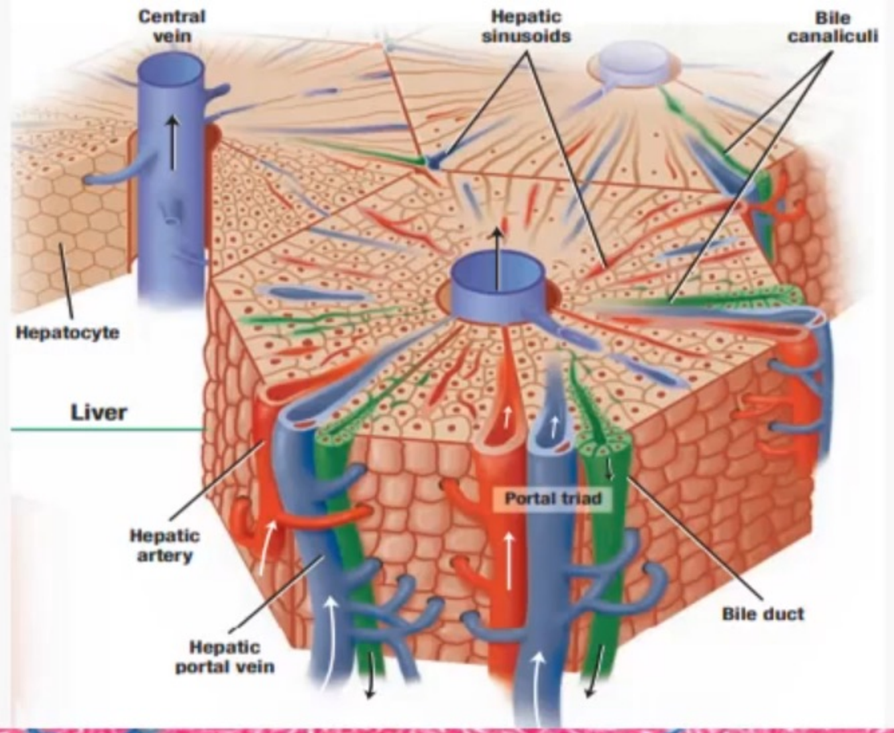
1- A branch of the portal vein: widest, with thin wall.

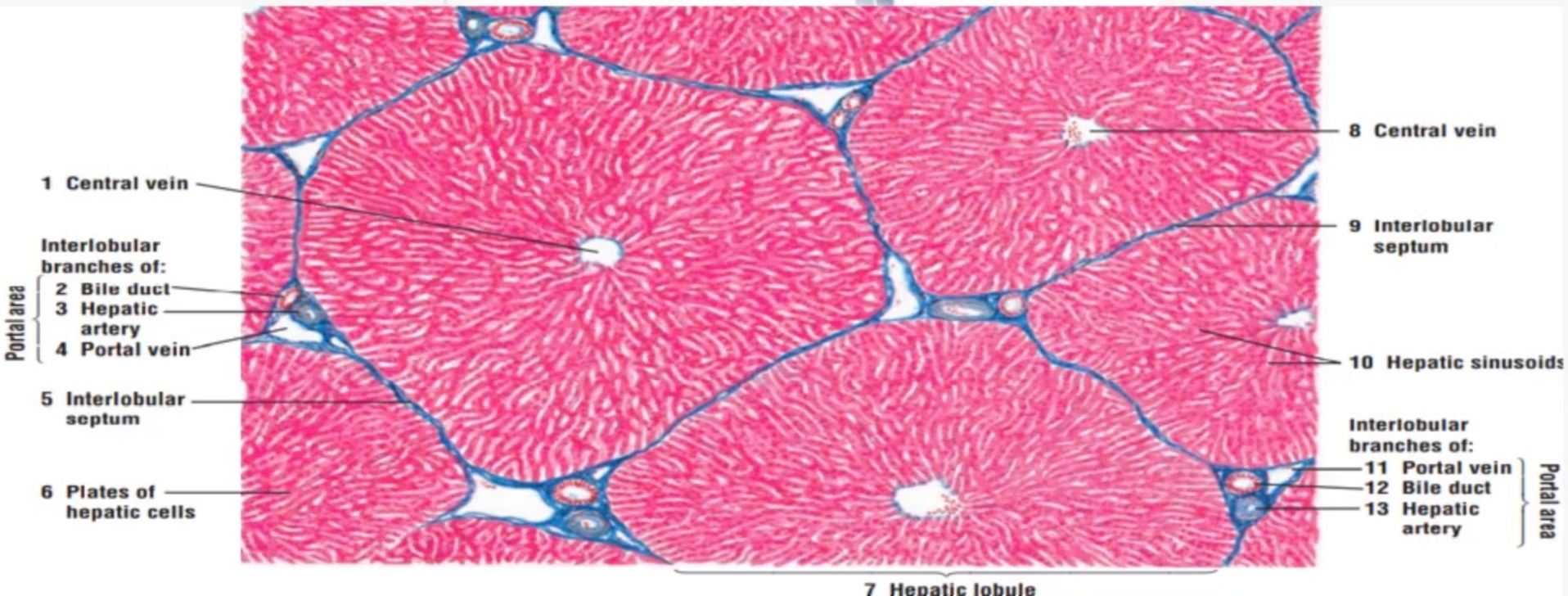
2- A branch of the hepatic artery rounded, with narrow lumen.

3- A branch of the bile duct: lined with cubical epithelium.

4. Lymph vessel.

• The liver cells (hepatocytes) are interconnected in cords or plates.
• Each cord is formed of 2 cell thickness (2 rows) enclosing a bile canaliculus in-between.
• The cell cords radiate from the center of the lobule to the periphery and anastomose together forming a sponge-like structure.
• Cords of liver cells are separated with blood sinusoids.
• The endothelial lining of the blood sinusoids are separated from the hepatocytes by the space of Disse. The fenestrated character of the sinusoids, termed sieve plates, allow the exchange of materials between blood & liver cells.


Central vein
Hepatic sinusoids
Bile canaliculi
Hepatocyte
Liver
Portal triad
Hepatic artery
Bile duct
Hepatic portal vein


1 Central vein
Interlobular branches of:
Portal area
2 Bile duct
3 Hepatic artery
4 Portal vein
5 Interlobular septum
6 Plates of hepatic cells
8 Central vein
9 Interlobular septum
10 Hepatic sinusoids
Interlobular branches of:
11 Portal vein
12 Bile duct
13 Hepatic artery
Portal area
7 Hepatic lobule

Liver cells (Hepatocytes)

LM:

-They are large(20-30 pm),polygonal in shape, with one or two nuclei (binucleated).

-Nuclei: are rounded, pale & centrally located, vesicular with prominent one or two nucleoli.

-Cytoplasm:

· Acidophilic (due to mitochondria & SER), vacuolated in H & E (due to dissolved glycogen).

Glycogen can be specially stained with PAS or Best's Carmine.

EM:

A. The cell membrane:

1. Facing the blood sinusoids shows long microvilli (to help the transfer of materials to and from hepatocytes & blood).
2. Facing the bile canaliculus shows short microvilli.
3. Facing neighboring hepatocytes shows junctional complexes

B. The Cytoplasm:

Hepatocytes are very active cells, so they are very rich in organelles & inclusions:

Organelles:

1. Mitochondria: very numerous (1000-2000/cell), the site for energy production.
2. rER & ribosomes: abundant to synthesize plasma proteins.

3. sER: also abundant for synthesis of cholesterol & phospholipids. It contains enzymes involved in drug & poison detoxification. It contains also enzymes that break down glycogen.
4. Golgi Apparatus: well developed, concerned with secretion (plasma proteins), turnover of the cell membrane & formation of lysosomes.
5. Lysosomes: also numerous to destroy worn out cellular components, and to digest & eliminate waste products.
6. Microbodies (peroxisomes): very numerous concerned with metabolism of H_2O_2, lipid degradation into glucose & alcohol metabolism.

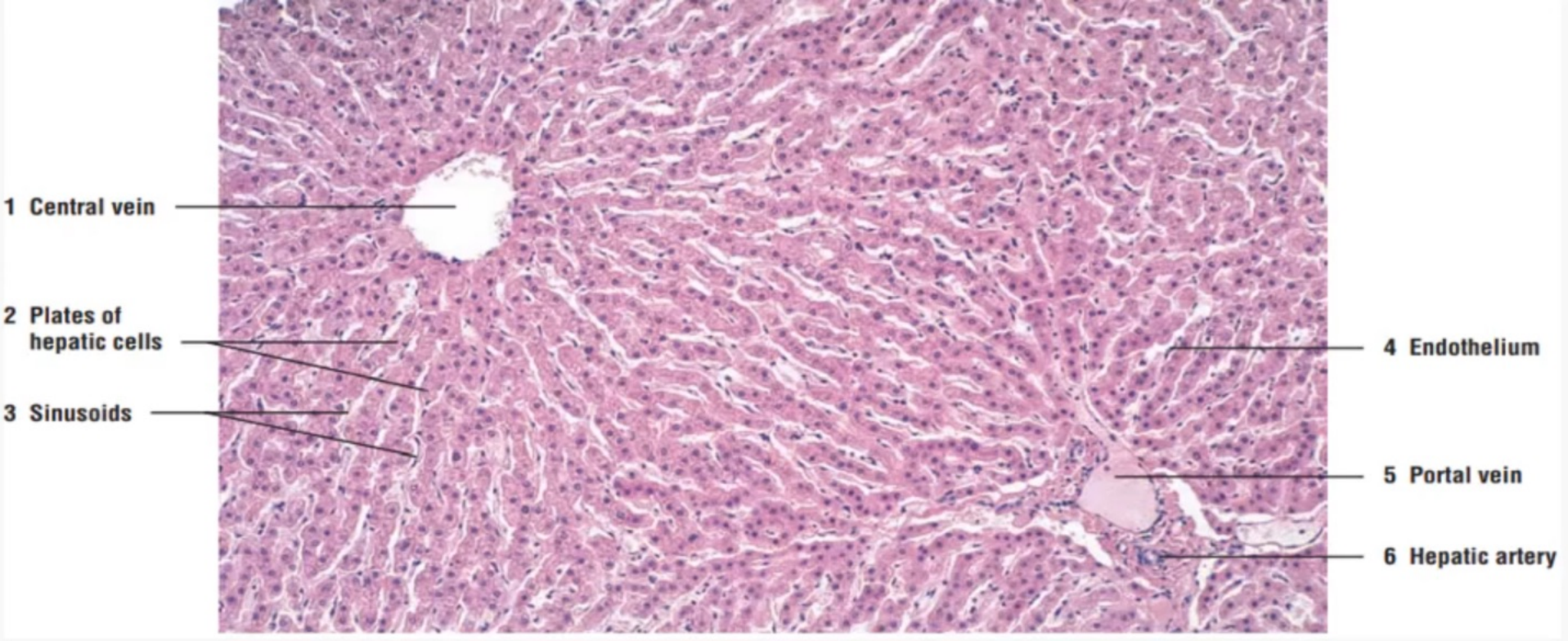
Inclusions:

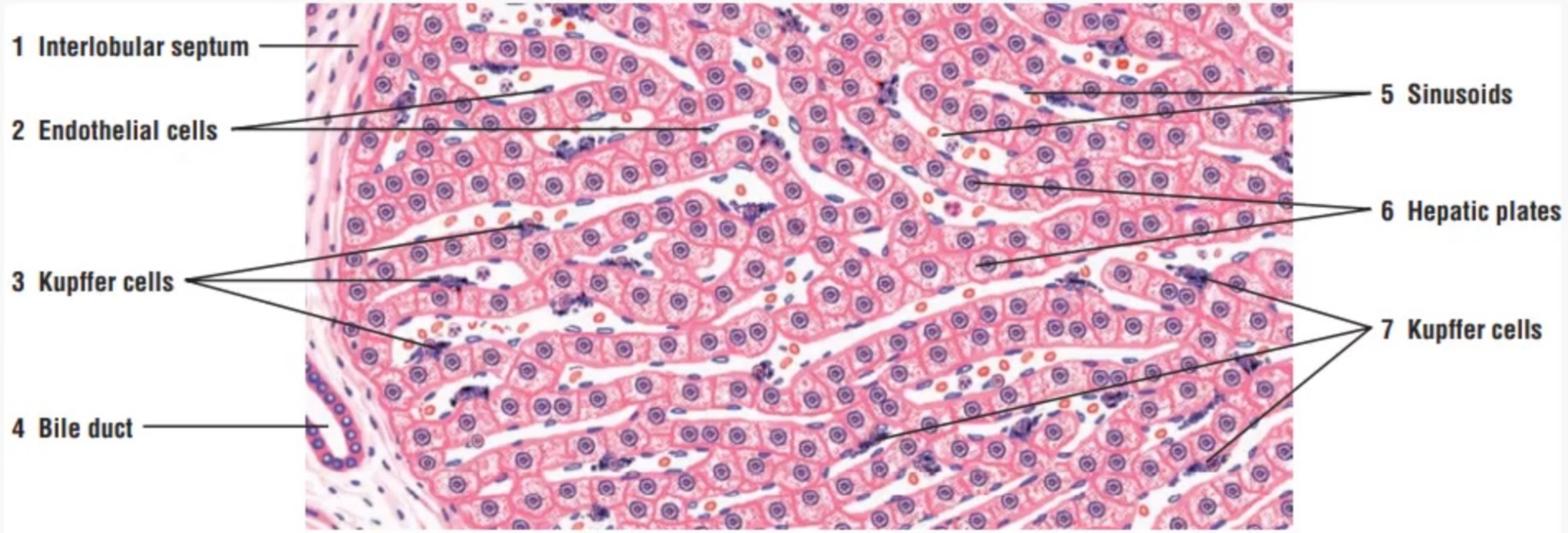
1. Glycogen granules: are found in abundance. They appear as electron dense granules
2. Fat droplets.

Blood Sinusoids:

They are wide irregular blood spaces, radially arranged in the hepatic lobules, in- between hepatic plates (can be demonstrated by injection of gelatin carmine).

They are lined by 2 types of cells: (1) fenestrated endothelial cells that are surrounded by (2) a special type of macrophages (von Kupffer) cells. They form a discontinuous layer of fenestrated epithelium (sieve plate).


1 Central vein
2 Plates of hepatic cells
3 Sinusoids
4 Endothelium
5 Portal vein
6 Hepatic artery


1 Interlobular septum
2 Endothelial cells
3 Kupffer cells
4 Bile duct
5 Sinusoids
6 Hepatic plates
7 Kupffer cells

von Kupffer Cells:

• Large branched phagocytic cells, with microvilli & pseudopodia, lining the liver sinusoids.

• There cytoplasm is vacuolated, rich in lysosomes & phagocytic particles.

• They can be stained with vital stains (Trypan blue).

• Their origin is from blood monocytes.

• Their main functions:

1. Clearing the blood passing slowly from the hepatic artery and portal vein in the direction of the central vein from any unwanted materials to prevent obstruction.
2. Destruction of senile RBCs & formation of bile pigments.
3. Phagocytosis of bacteria & microorganisms coming from the intestine.

The Space of Disse (Perisinusoidal Space):

- It is the space between hepatocytes & the wall of the blood sinusoids.
- It contains:

1. Long microvilli projecting from the surface of hepatocytes (to increase contact between liver cells and plasma in space of Disse).
2. Reticular fibers that support the wall of the sinusoids.
3. Blood plasma containing all the nutrients
4. Lipocytes (Ito cells); branching lipid storing cell that store the fat soluble vitamin A in the form of retinyl ester in lipid droplets.

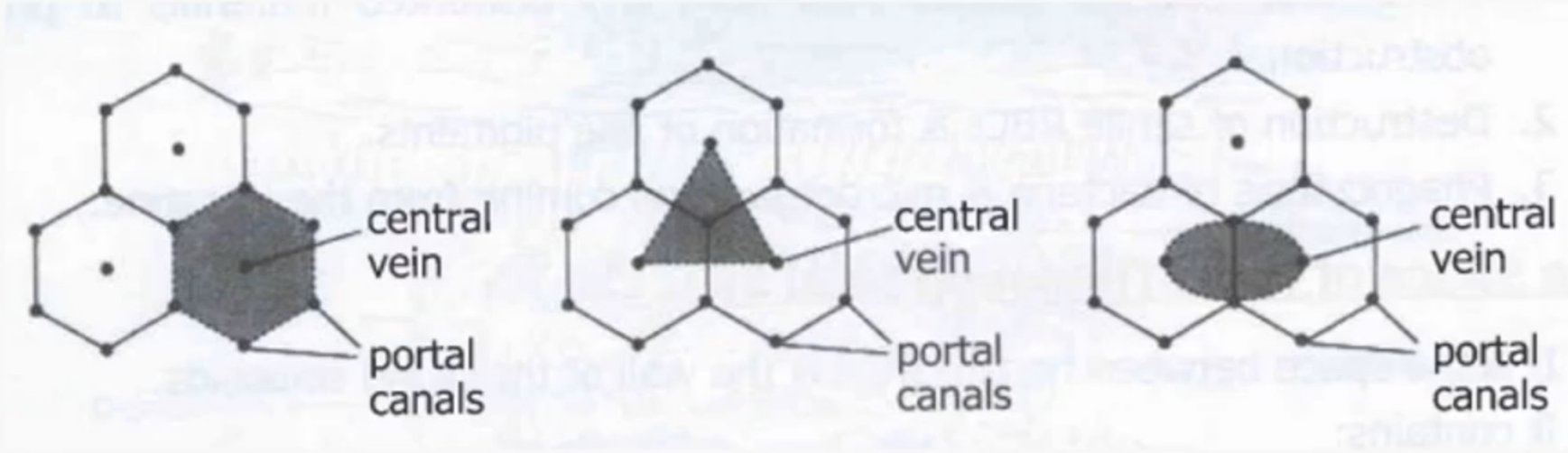
2. Portal Lobule

• It is a triangular area of liver tissue the apices of which are formed by three central veins. (the three apices of the triangle).

• It contains parts of three adjacent classic hepatic lobules.

In the center of each portal lobule there is a portal tract.

. All the cells of this lobule drain their bile to the bile duct in the center of the triangle (in the portal tract).



3. Liver Acinus

It is a diamond shaped mass of liver tissue surrounding a central vascular core (formed of terminal branches of the hepatic artery, portal vein and bile duct that arise at right angles from the vessels in the portal area).

It is formed of parts of two adjacent classic hepatic lobules.

It is divided into three zones:

a. Zone I: lies close to the vascular core. It is rich in blood supply (first to receive glucose & oxygen).

b. Zone II: intermediate zone, less blood supply than zone I.

c. Zone III: at the periphery of the liver acinus. It is far from the vascular core and the nearest to the central veins. It is the poorest in blood supply (least amount of glucose & oxygen).

N.B: the zone arrangement of the liver acinus explains the variation in liver cell damage in response to hypoxia and toxins. Cells of zone III (the poorest in blood supply) are more liable to damage, while cells of zone I (the nearest to the vascular core) are less liable to damage due to their rich blood supply.

The Biliary Tract

Bile is produced by hepatocytes and passes to be drained by the biliary passages through the following ducts:

1. Bile Canaliculi:

• It is the first portion of the bile duct system.

• They are tubular spaces, 1-2 pm in diameter, limited by the cell membranes of two hepatocytes in the rows of liver cells. Microvilli project from the plasma membranes of hepatocytes into the bile canaliculi. The canaliculi are sealed from the intercellular spaces by tight junctions.

• Bile is secreted from hepatocytes into these bile canaliculi.

• The canaliculi anastomose to form an anastomosing network along the plates of liver cells to terminate in the portal canal.

• Bile flows in a direction opposite to that of blood (from the center of hepatic lobules to the periphery).

• The canaliculi empty in the canals of Hering (bile ductules).

2. Canals of Hering (Bile Ductules):

- Lined by simple cubical epithelium.
- They receive bile from bile canaliculi and then drain into the interlobular ducts in the portal canal.

3. Interlobular Bile Ducts:

- They are present in the portal canal.
- They are lined by simple cubical epithelium.
- They fuse together to form right and left hepatic ducts.

4. Right and Left Hepatic Ducts:

- They begin inside the liver (intrahepatic parts) as small ducts lined by simple cubical epithelium.
- Their extrahepatic parts are larger than the intrahepatic ducts and are lined by simple columnar epithelium.
- They unite outside the liver to form the common hepatic duct.

5. Common Hepatic Duct:

• It is found outside the liver.

• It is lined by simple columnar epithelium surrounded by CT. & smooth muscle cells.

• It is joined by the cystic duct forming the common bile duct.

6. Cystic Duct:

• It arises from the gall bladder

• It is lined by simple columnar epithelium surrounded by C.T. & smooth muscle cells.

7. Common Bile Duct:

• It drains bile into the duodenum.

• It is lined with simple columnar epithelium surrounded by C.T. & smooth muscle cells.

• Mucous glands are present in the CT, under the epithelium.

• The muscle layer becomes thicker near the duodenum and in the intramura portion to form a sphincter that regulates bile flow (sphincter of Oddi).

Gall Bladder

• It is a hollow, pear-shaped organ attached to the lower surface of the liver.

• It stores and concentrates (absorbs its water) bile and releases it into the duodenum.

• Its wall consists of:

1. Mucosa:

• Highly folded (more clear in empty gall bladder).

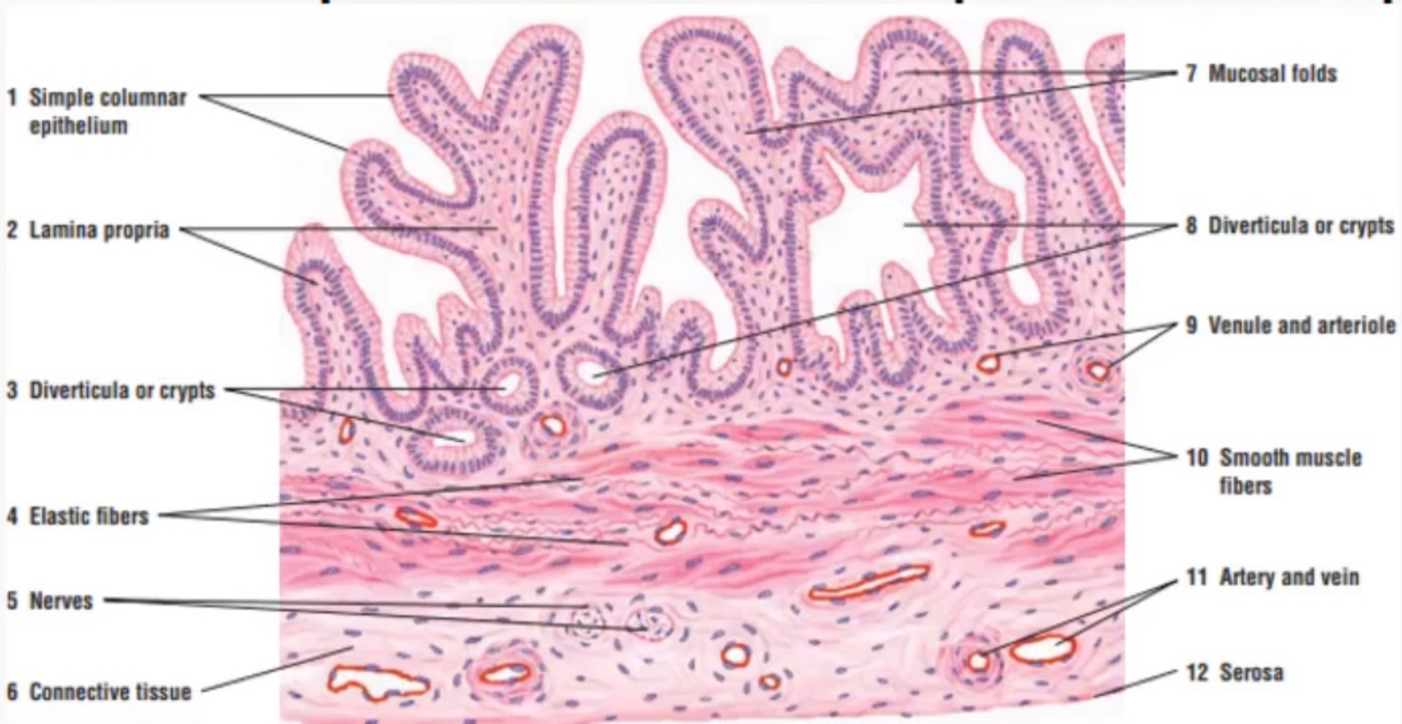
• Lined with simple columnar epithelium with basal oval nuclei. The cytoplasm is acidophilic (rich in mitochondria). The apical surface has microvilli,

• The epithelial cells are capable of secreting mucus.

• Lamina propria: C.T. rich in blood vessels. It contains tubulo alveolar mucous glands near the cystic duct responsible for the production of most of the mucus present in bile.
No muscularis mucosae.

2. Musculosa: Formed of irregularly arranged smooth muscle fibers with elastic and collagenous fibers in-between

3. Serosa: it is covered with peritoneum except at the hepatic surface.



Histology & Pathology of The pancreas

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Histology of Pancreas

It is a mixed gland that produces digestive enzymes & hormones.
Its exocrine part is formed of compound tubulo-alveolar gland, which is responsible for secretion of pancreatic juice.
Its endocrine part is the Islet of Langerhans, which is responsible for release of pancreatic hormones.

Histological Structure:

It is formed of stroma & parenchyma:

I-STROMA:

A. Capsule: thin, of delicate C.T.
B. Trabeculae: are thin, delicate loose C.T., divide the gland into ill-distinct lobes & lobules.
C. Reticular stroma: forms the background of the gland and can be stained with silver.

II. PARENCHYMA:

A. Exocrine Portion: (acini&ducts)

1. Acini:

• *LM:*

- Small spherical structures with narrow lumens.
- The lining cells are pyramidal with ill-distinct cell boundaries.
- The nuclei are rounded & basal.
- Cytoplasm shows basal basophilia and apical acidophilic zymogen granules.
- Centroacinose cells: flat squamous cells found lining the lumen of the acini. They represent the continuation of the intercalated duct (the beginning of the duct system that invaginate or is telescoped inside the acinus).

• *EM:*

- The cell membranes show tight junctional complexes.
- The basal basophilia is due to rER.
- Intercellular canaliculi are found between acinar cells.
- Golgi apparatus is supranuclear.
- Apical membrane-bound electron dense zymogen granules.

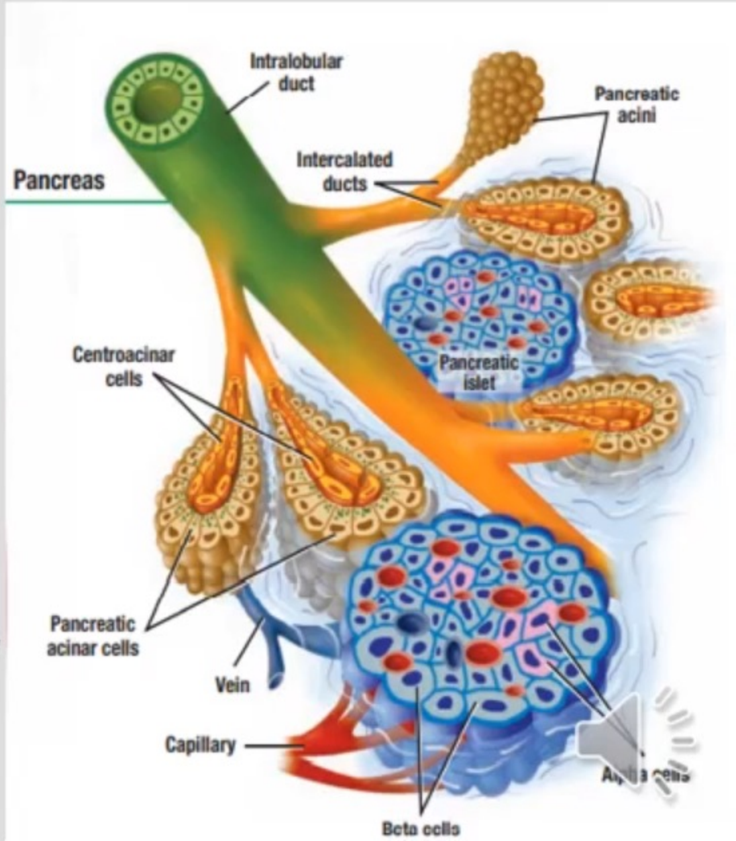
• The pancreatic exocrine secretion is controlled by hormones that are secreted from the entero-endocrine cells of the GIT:

Cholecystokinin stimulates the acinar cells to secrete pancreatic enzymes.

Secretin stimulates the intercalated duct to secrete alkaline fluid to neutralize the acidic chyme that enters the duodenum.

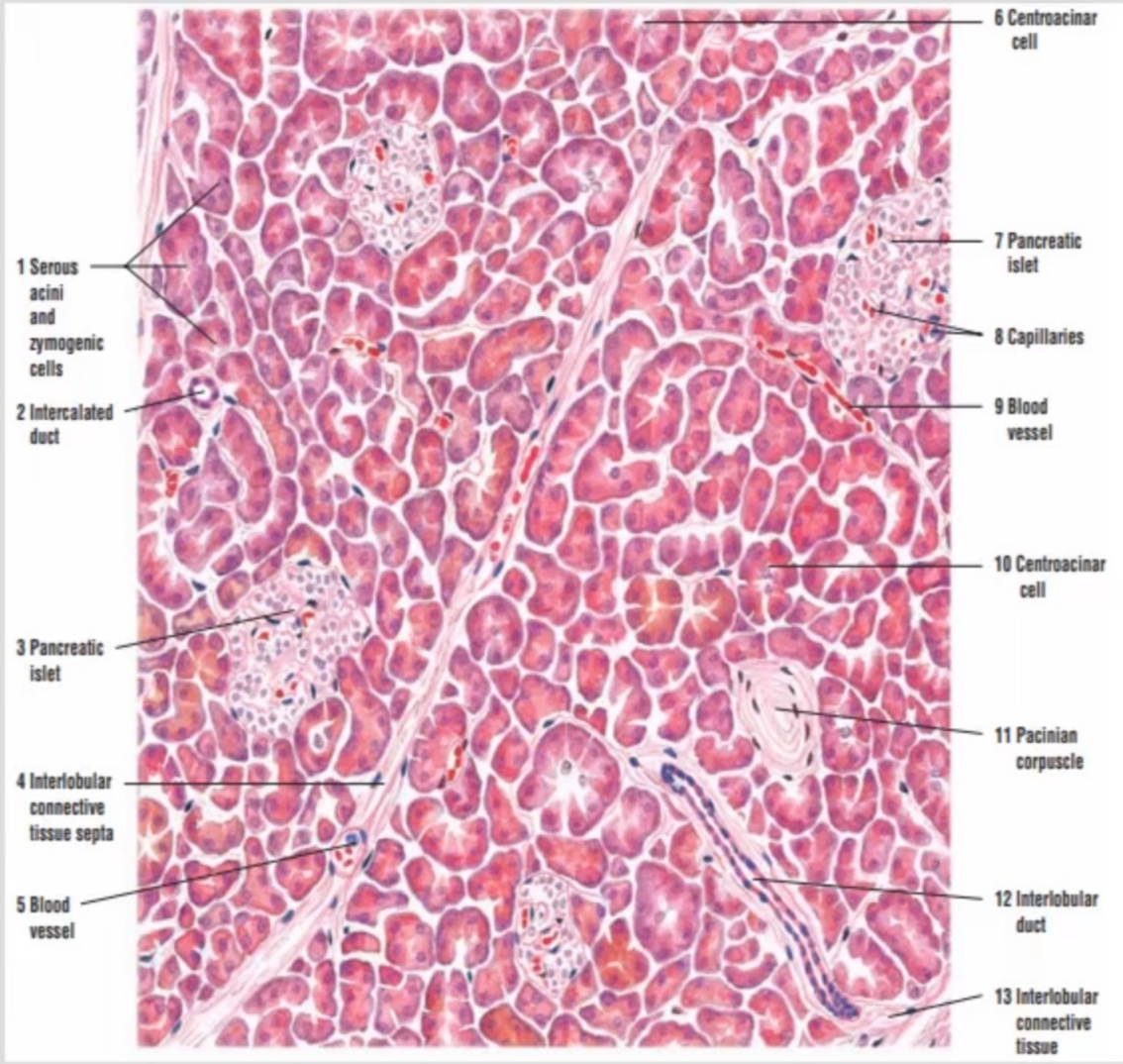
2. Duct system: The pancreas has a small number of ducts:

- **Intercalated ducts:** they are small and narrow, lined with simple squamous epithelium, originate from the acinus, they telescope into the acinar lumen, so in transverse section they appear as if they line the lumen with flat cells (the centroacinose cells).
- No apparent intra-lobular ducts.
- **Inter-lobular ducts:** are lined with simple cubical epithelium.
- **Inter-lobar ducts:** are lined with simple columnar epithelium.
- **Main pancreatic duct:** lined with columnar cells, goblet cells & few entero- endocrine cells.



B. Endocrine Portion (Islets of Langerhans):

- They are multiple pale areas scattered between the darkly stained pancreatic acini.
- Their number is about one million, more numerous at the tail region.
- They are surrounded with delicate reticular fibers, but not capsulated.
- They are formed of cell masses & cords of secreting cells, separated with fenestrated blood capillaries.
- They are supported with reticular stroma.



Cells of Islets of Langerhans:

1. Alpha cells (A) or (a):

- They are less numerous (15% of islet cells).
- Larger cells (15-25 pm).
- Situated at the periphery of the islets.
- Have acidophilic granular cytoplasm (granules are water soluble, but alcohol Resistant)
- Cytoplasm contains rER, well developed Golgi & membrane-bound secretory granules.

Function: They secrete glucagon hormone which increases blood sugar level.

2. Beta cells (B):

- They are more numerous (70% of islet cells).
- Smaller cells (10-15 pm).
- Centrally located in the islets.
- Have basophilic granular cytoplasm (granules are alcohol soluble, but water resistant)
- Cytoplasm contains rER, well developed Golgi, rounded membrane bound electron-dense secretory granules.

Function: They release insulin hormone which lowers the blood glucose level and helps glycogenesis.

3. Delta cells (D):

- They represent 10% of islet cells.
- Located at the periphery of the islets
- They contain membrane bound granules which stain only with silver.
- **Functions:** They secrete somatostatin which controls the release of insulin & glucagon.

4. C-cells:

- Very few (3%), contain few organelles & few secretory granules.
- **Function:** unknown yet, but they may represent immature or degranulated cells.

5. PP (F):

- Very few.
- They contain few organelles & few granules.
- **Function:** They secrete a polypeptide hormone, which reduces pancreatic secretion.

6. G-cells: secrete gastrin.

7. Ganglion cells: aggregated nerve cells, for autonomic nervous control of the islets.