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Катедра за Хистологију и ембриологију

Digestive tract 1

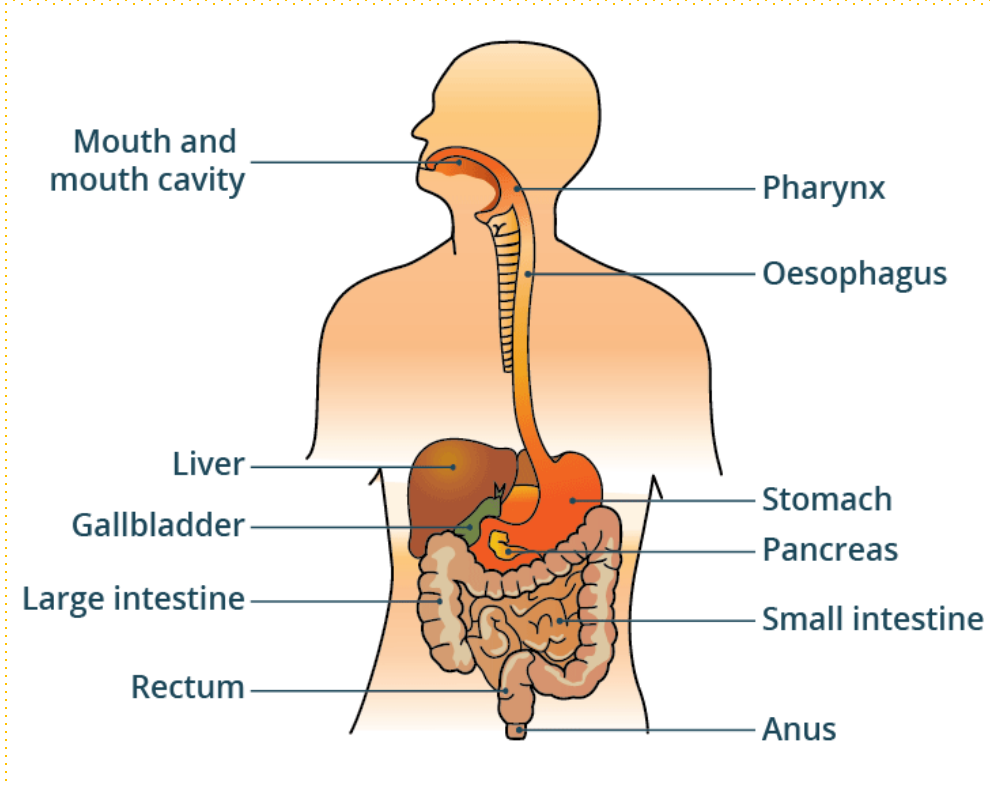
Week 7

Digestive tract (GIT)

- **oral cavity,**
- **esophagus,**
- **stomach,**
- **small intestines**
- **large intestines,**
- **anus**

associated glands

- **salivary glands,**
- **liver**
- **pancreas**



Roles of GIT

- **Ingestion**, or introduction of food and liquid into the oral cavity;
- **Mastication**, or chewing, which divides solid food into digestible pieces;
- **Motility**, muscular movements of materials through the tract;
- **Secretion** of lubricating and protective mucus, digestive enzymes, acidic and alkaline fluids, and bile;
- **Hormone release** for local control of motility and secretion;
- **Chemical digestion** or enzymatic degradation of large macromolecules

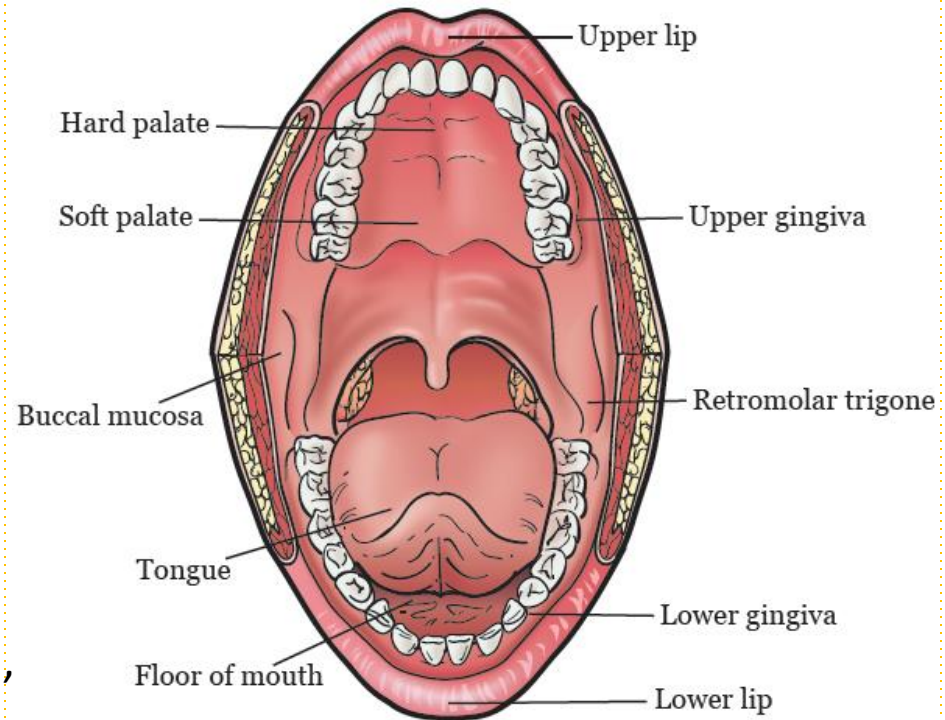
-and more.....

Oral cavity mucosa

The **oral mucosa** is made up stratified **squamous epithelium and lamina propria**.

TYPES

- **Lining mucosa** (lips, cheeks, soft palate, mouth floor) relatively thin epithelium; resistant to stretching;
- **masticatory mucosa** (gingiva and hard palate) the thickest and most resistant epithelium; resembles the epidermis;
- **specialized** (specialized for taste reception, on the dorsal side of the tongue), contains papillae and gustatory cells;



Lips (labia oris)

- Skin outside and oral mucosa inside
- Between there is a **muscle layer** - musculus orbicularis oris.

Skin

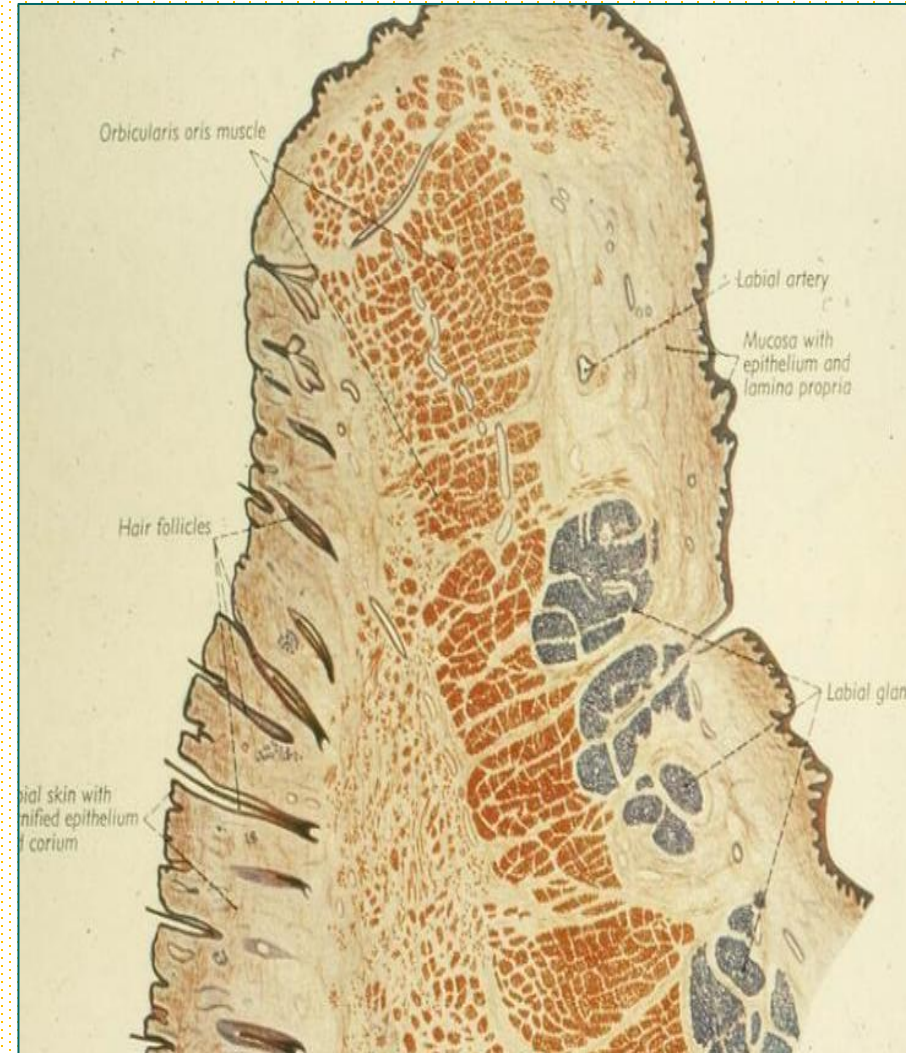
- epidermis
- Dermis

Vermilion - free edge of the lips

- lacks the glands for oil and sweat,
- epithelium does not contain pigment granules;
- epidermis is very thin, lightly keratinized, and transparent
- high papillae with wide blood vessels - red color

Oral mucosa

- epithelium and lamina propria (gll. labiales)



Lip



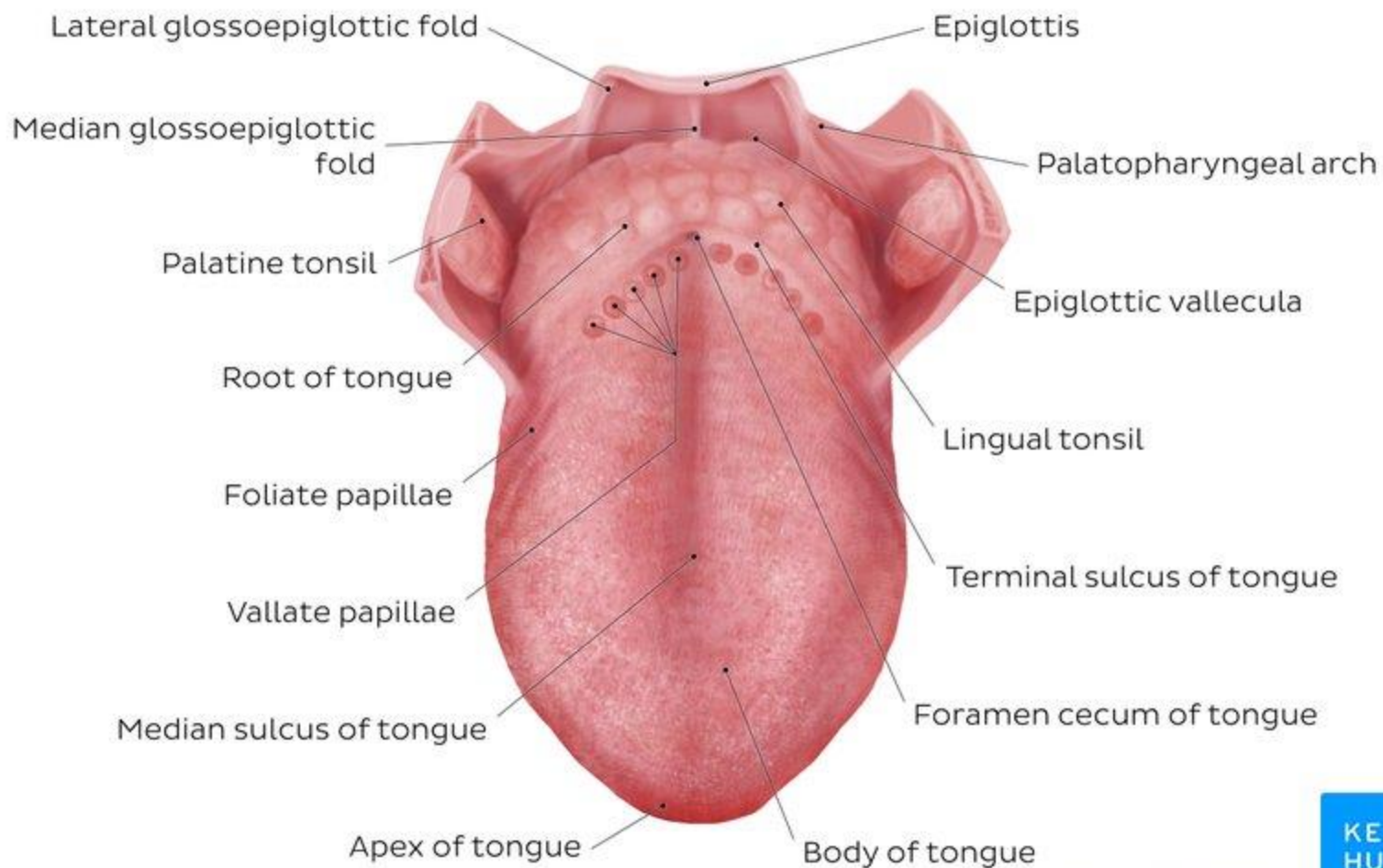
Tongue

The tongue is a mass of striated muscle covered by mucosa, which manipulates ingested material during mastication and swallowing.

- Root of the tongue - radix linguae (back part)
- Body of the tongue - corpus linguae (front, movable part)

The border line is V-shaped line called **sulcus terminalis**.

- The root of the tongue (radix linguae) has a mucosa that is functionally and structurally different from the mucosa of the body of the tongue.
- The surface is uneven due to the presence of numerous lymph follicles **lingual tonsil**. There are **no gustatory papillae** in the epithelium.



The body represents the front, movable part of the tongue.

Two sides

- Dorsal surface
- Lower surface

From the dorsal side of the body of the tongue, the following layers are distinguished:

- Mucosa of the dorsal surface
- Lingual aponeurosis
- Muscularis (striated)
- Submucosa
- Mucosa of the lower surface



Dorsal surface



Mucosa of the dorsal surface
(contains four types of papillae)

- Lamina epithelialis
- squamous-layered epithelium partly with, partly without armature
- Lamina propria is loose connective tissue

Lingual aponeurosis

- fibrous skeleton of the tongue (aponeurosis)

Muscularis

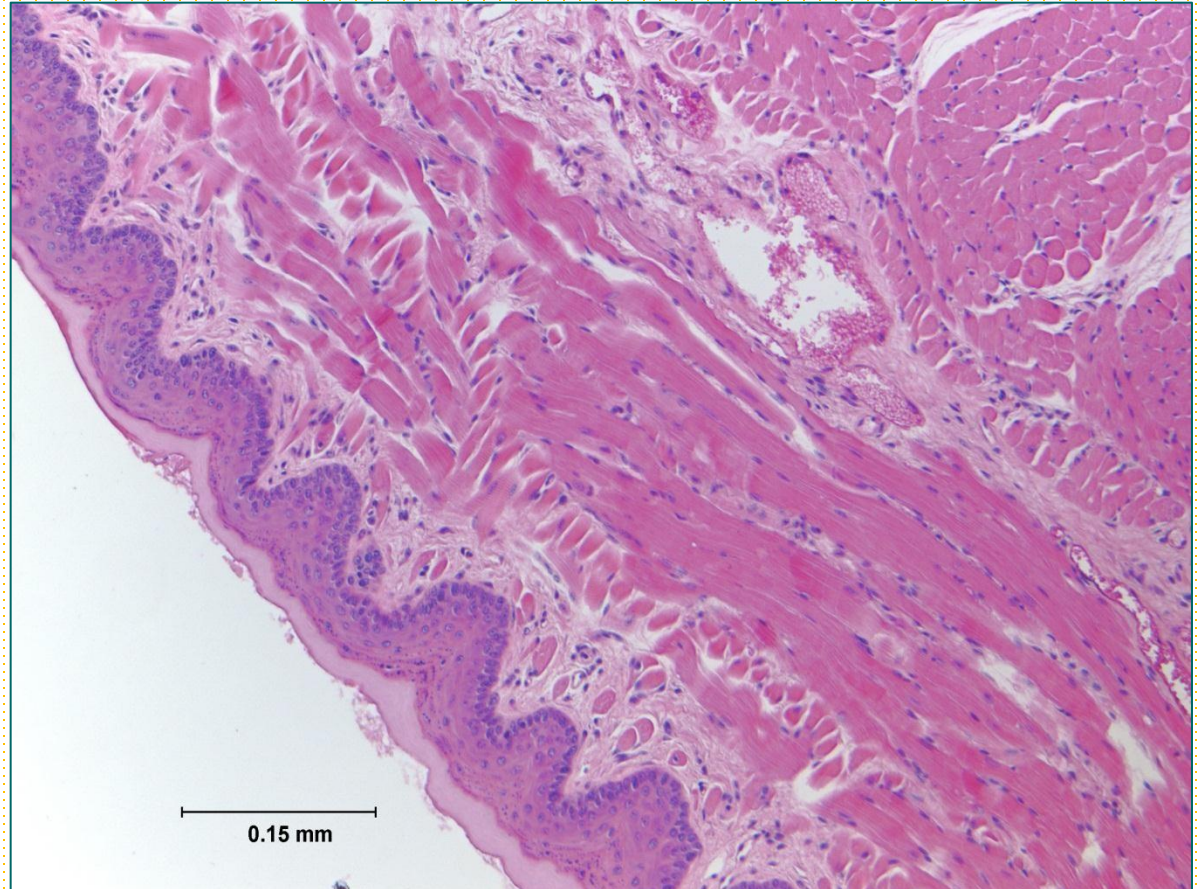
- three layers in three directions at right angles, in between is adipose tissue and mucous glands.

Lower surface

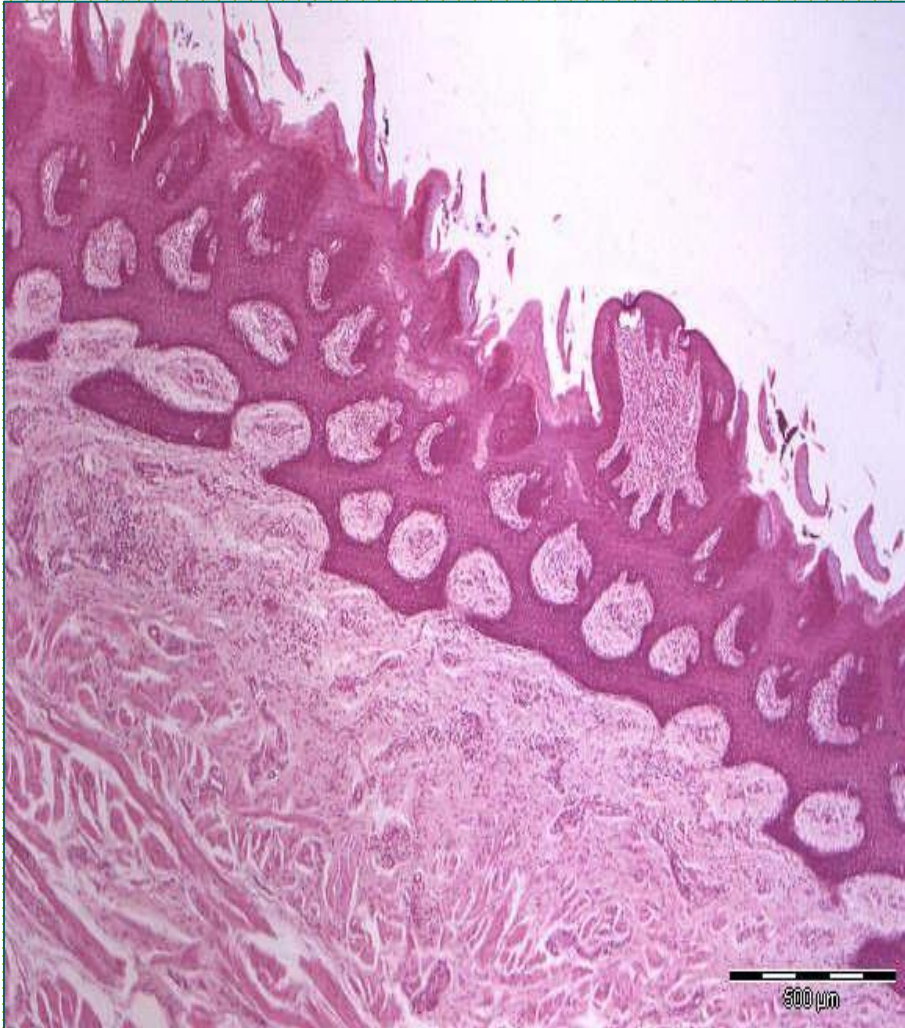
Submucosa (underside)

Mucosa of the lower
surface

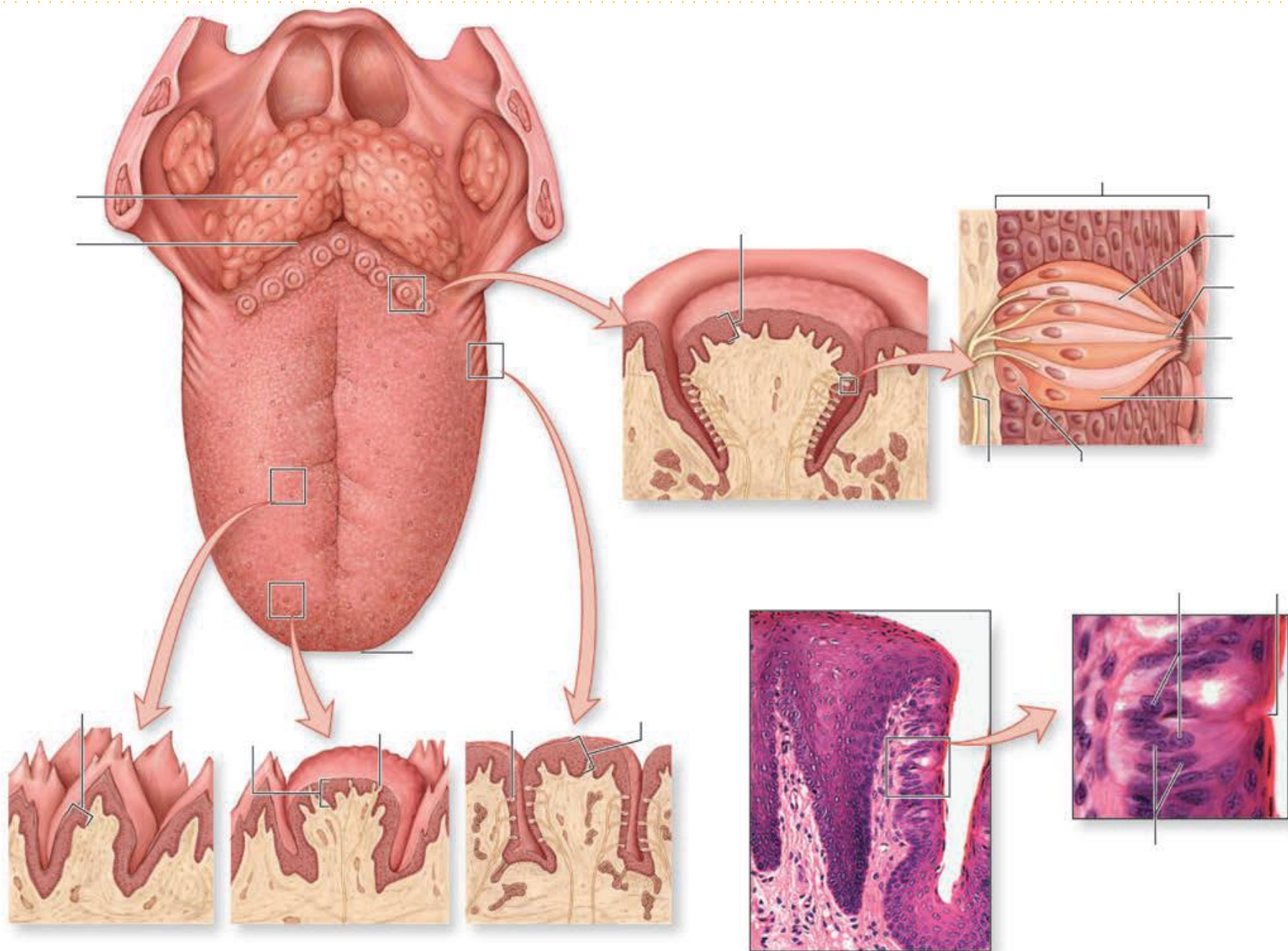
- squamous-stratified
epithelium without
keratinization
- lamina propria



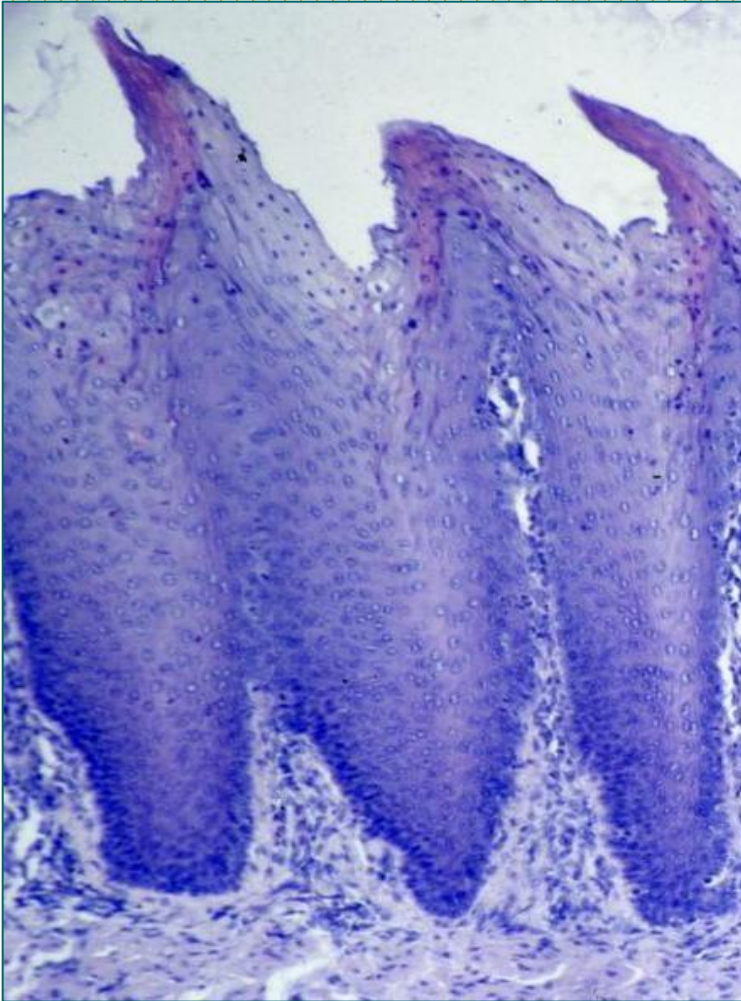
Papillae



- **Filiform papillae**, very numerous, conical shape, and are heavily keratinized, which gives whitish appearance.
- **Fungiform papillae**, much less numerous, lightly keratinized, and interspersed among the filiform papillae, mushroom-shaped
- **Foliate papillae**, several parallel ridges on each side of the tongue, anterior to the sulcus terminalis, but are rudimentary in humans.
- **Vallate (or circumvallate)** papillae are the largest papillae, with diameters of 1-3 mm. Eight to twelve vallate papillae are normally aligned just in front of the terminal sulcus.

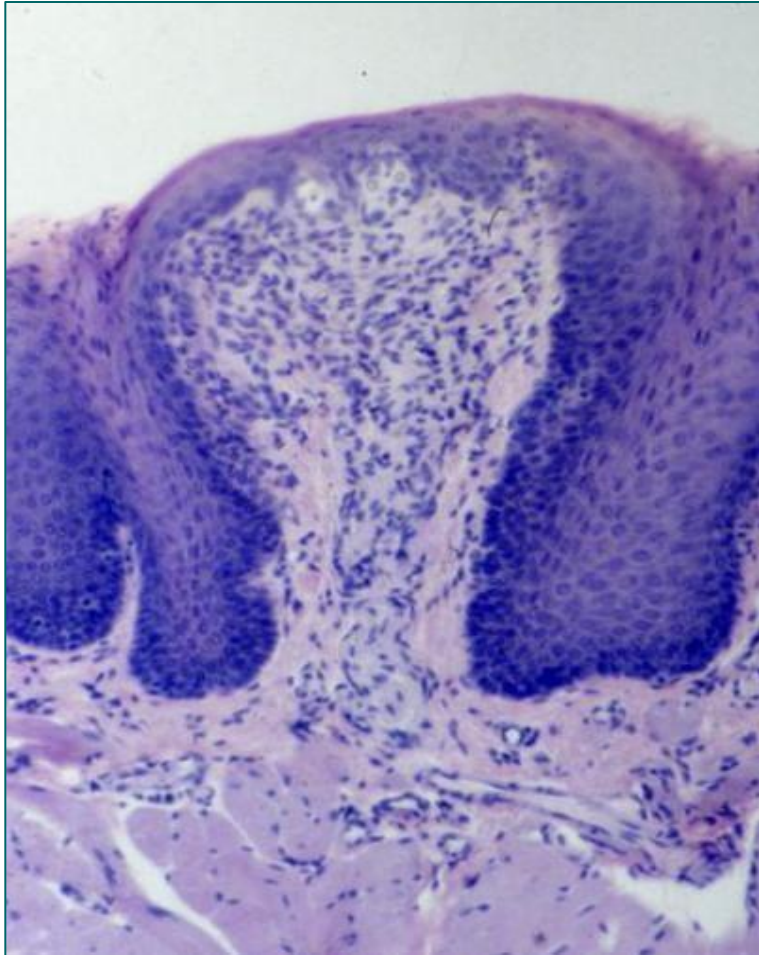


Filiform papillae



- The most numerous and the smallest.
- Diffusely distributed on the dorsal surface of the tongue.
- Squamous stratified epithelium, heavily keratinized
- They do not contain taste buds, represent mechanical papillae.

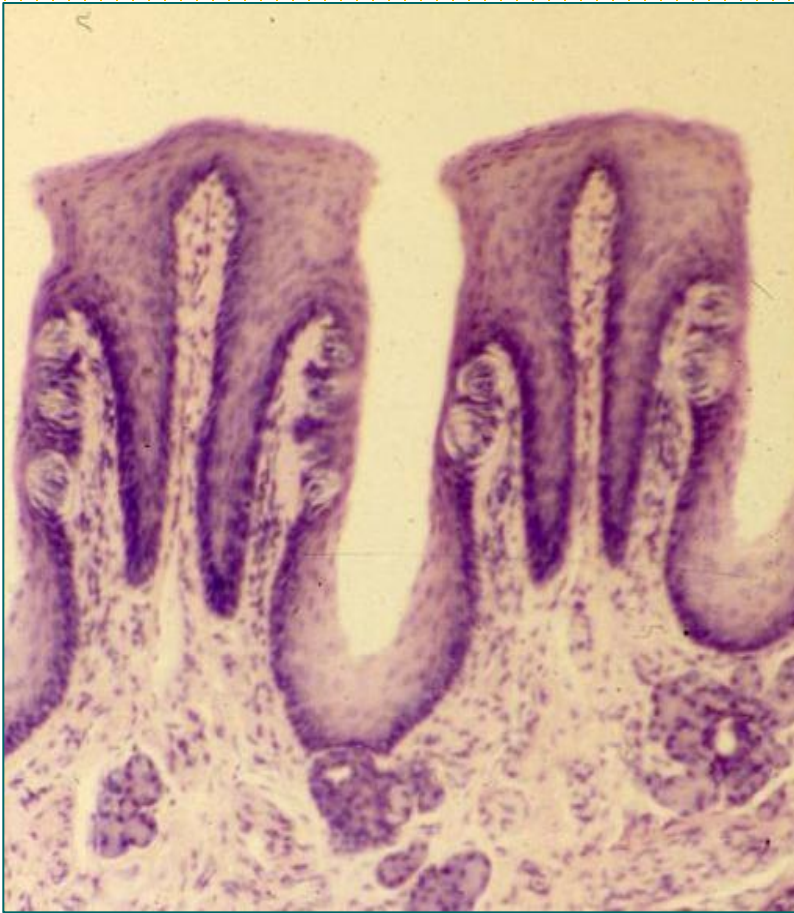
Fungiform papillae



- Covered with thin, partially keratinized epithelium.
- **Red color** - rich blood vessels of the lamina propria under the thin epithelium.
- They are located between the filiform papillae (there are about 200 of them).
- They belong to **mechanical papillae**.

In childhood, they have taste buds localized in the apical part.

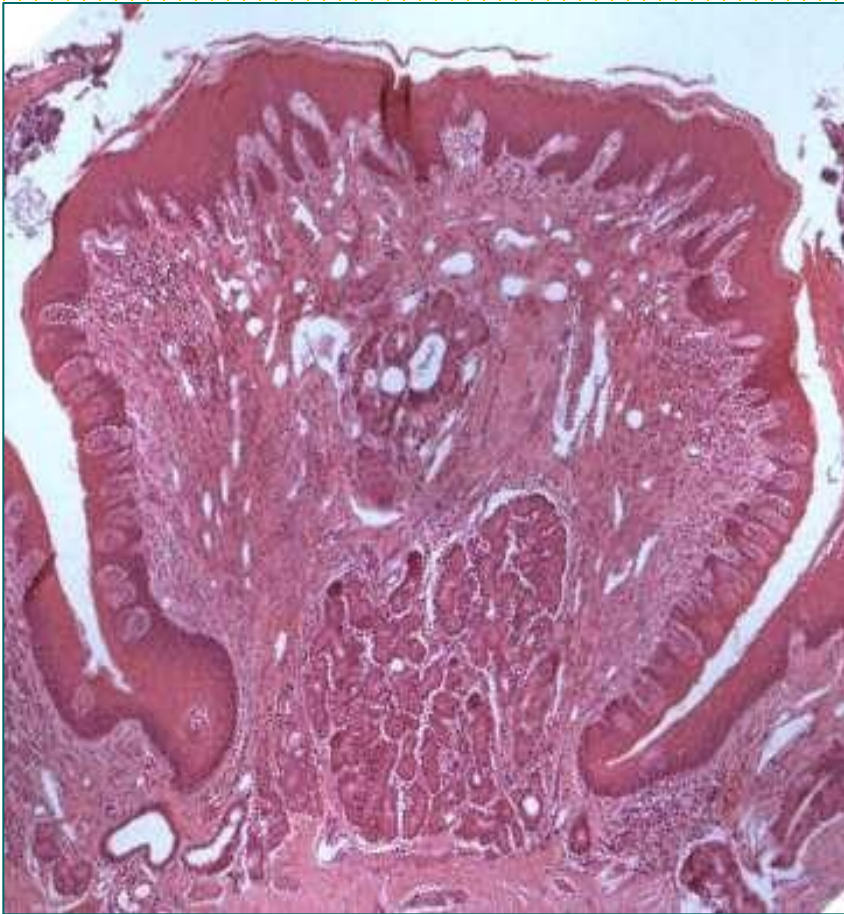
Foliate papillae



- They are separated from each other by grooves into which the drainage channels of the salivary glands flow.
- There are **8 to 10 of them in total**.
- Located at the back he edges of the tongue.
- **Individual taste buds on the sides**

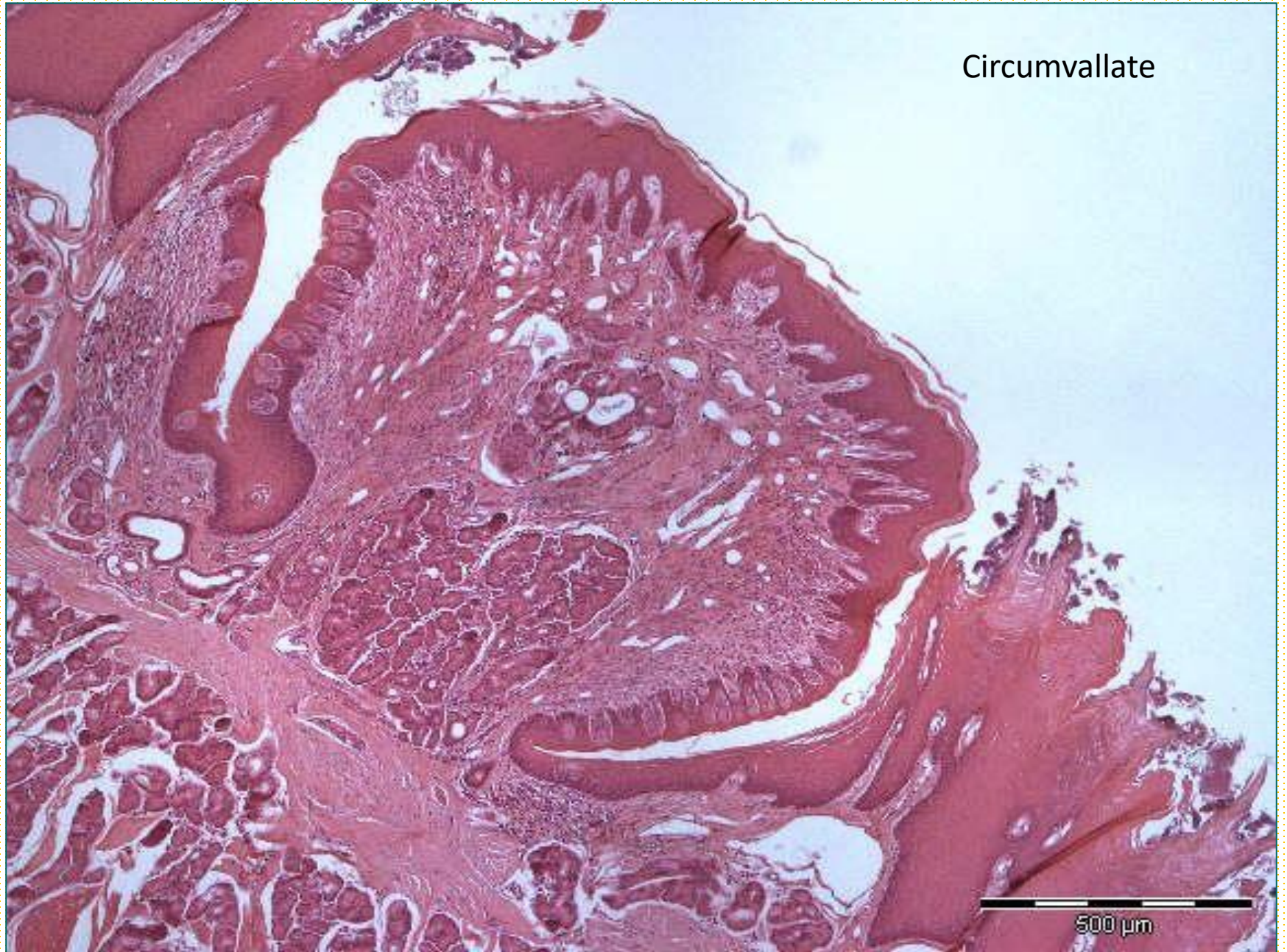
In adults, their involution occurs.

Circumvallate



- Largest papillae.
- There are 6 to 12 of them.
- They are placed in one row in front sulcus terminalis.
- Surrounded by the groove.
- Drainage channels of serous **von Ebner's salivary glands** flow into the ditch.
- The epithelium is keratinized on the upper surface, non-keratinized on the sides.
- A large number (250) of **taste buds** on their sides

Circumvallate

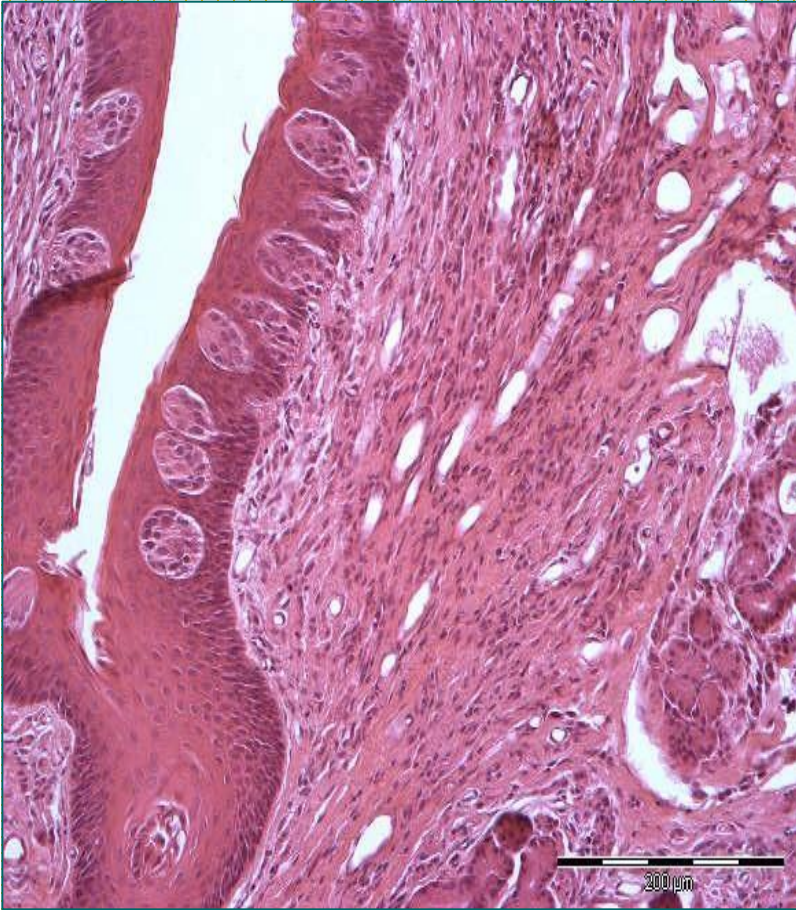


300 μ m

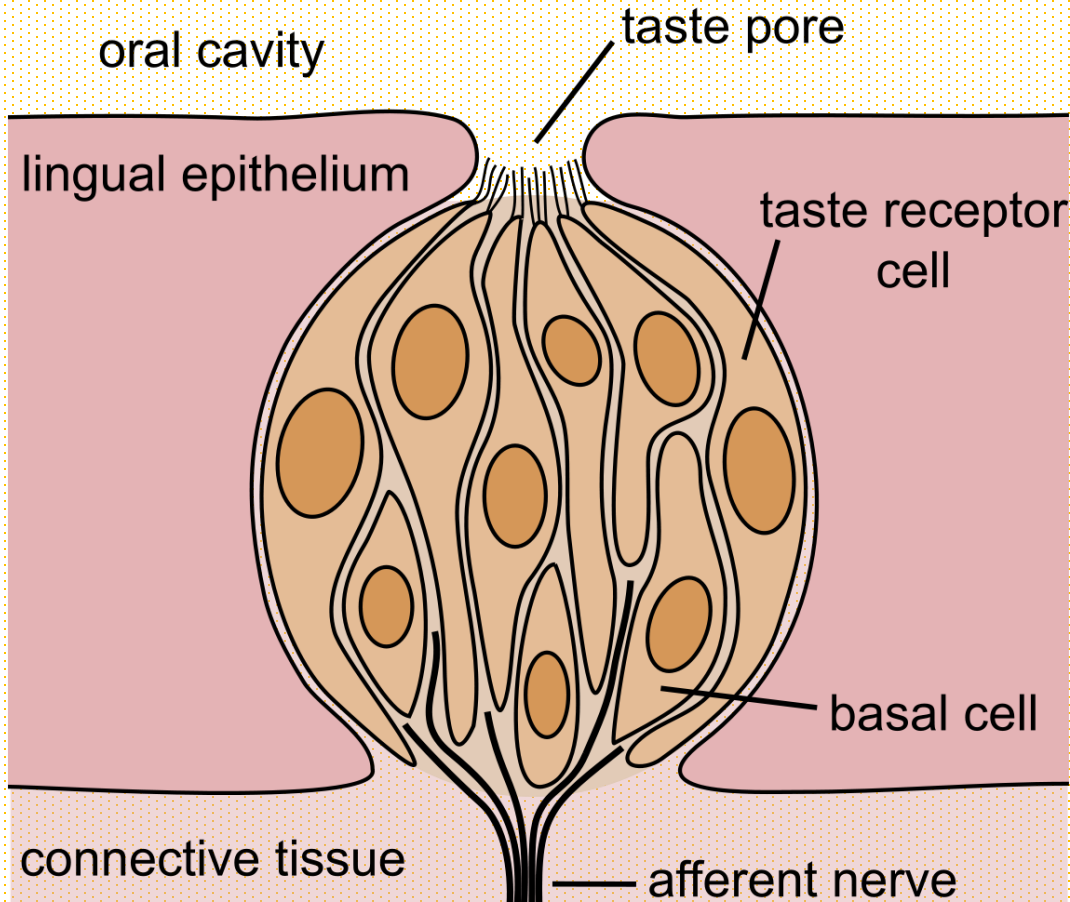
Tongue surface (SEM)



Taste buds

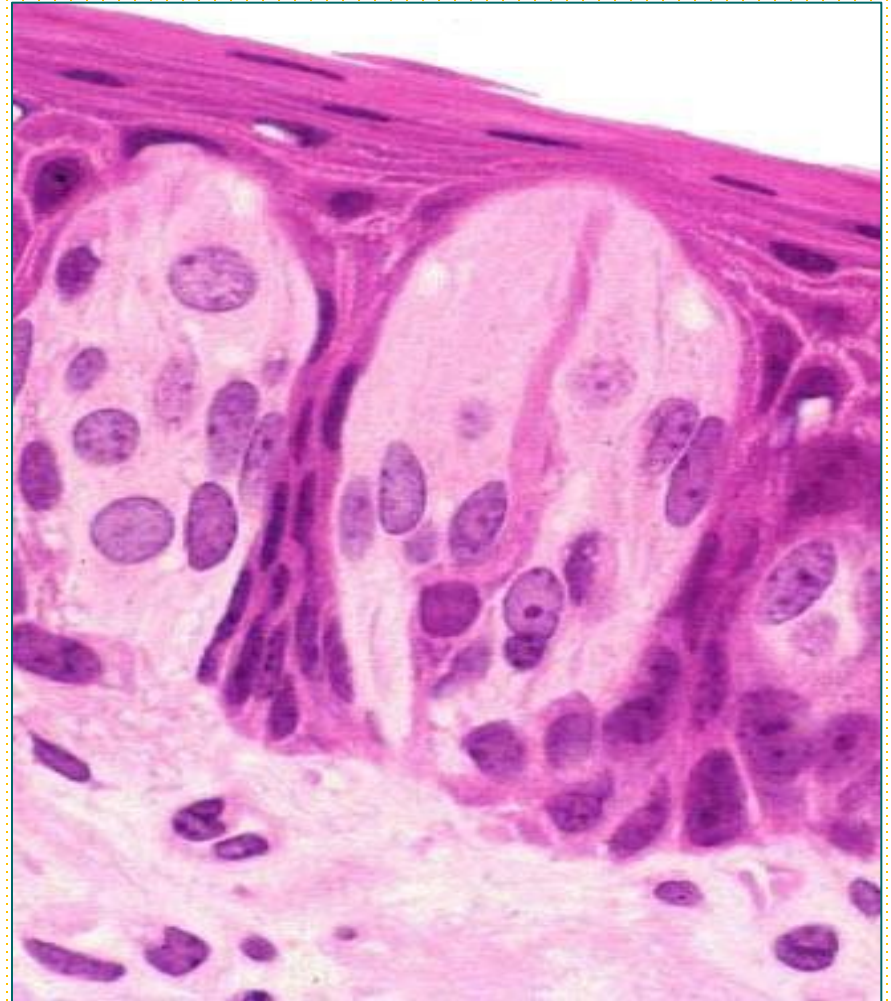
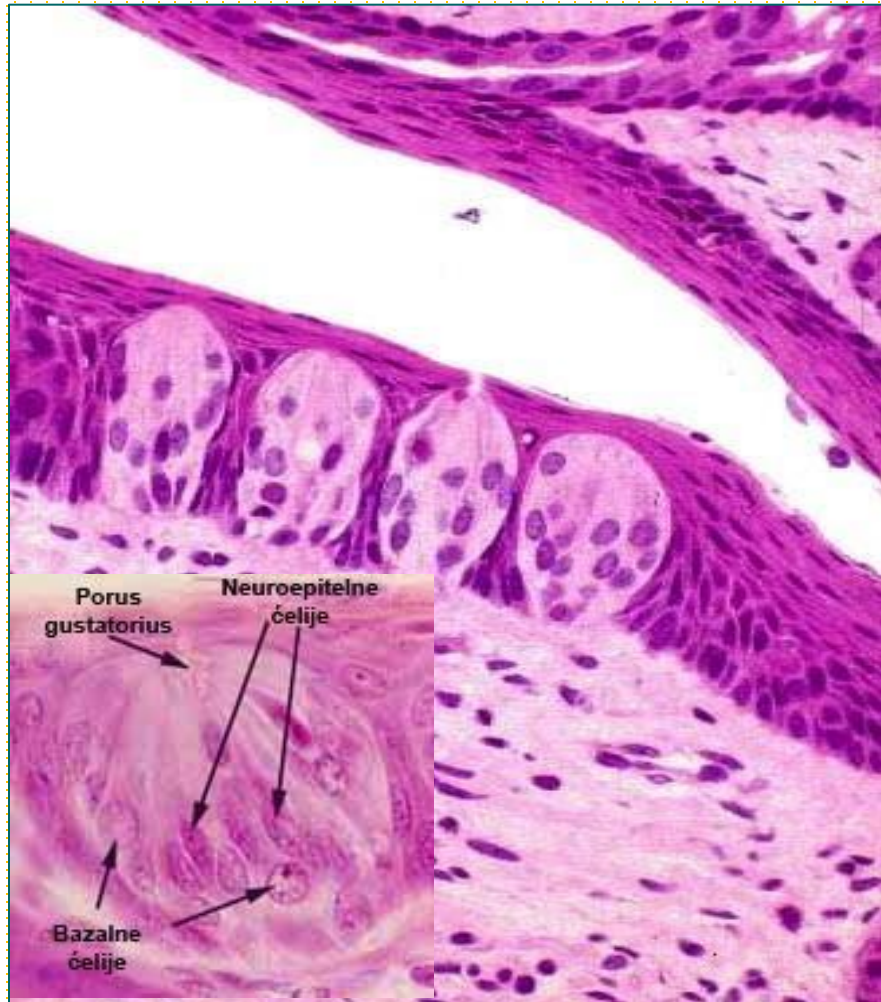


- Ovoid structures within the stratified epithelium on the tongue's surface
- Present in **circumvallate, fungiform and foliate**, and in smaller numbers in the epithelium of the soft palate, pharynx, epiglottis and glossopalatine arch.
- At the basal pole there are **nerve fibers**, at the apical pole there is a **pore** (in contact with the oral cavity).

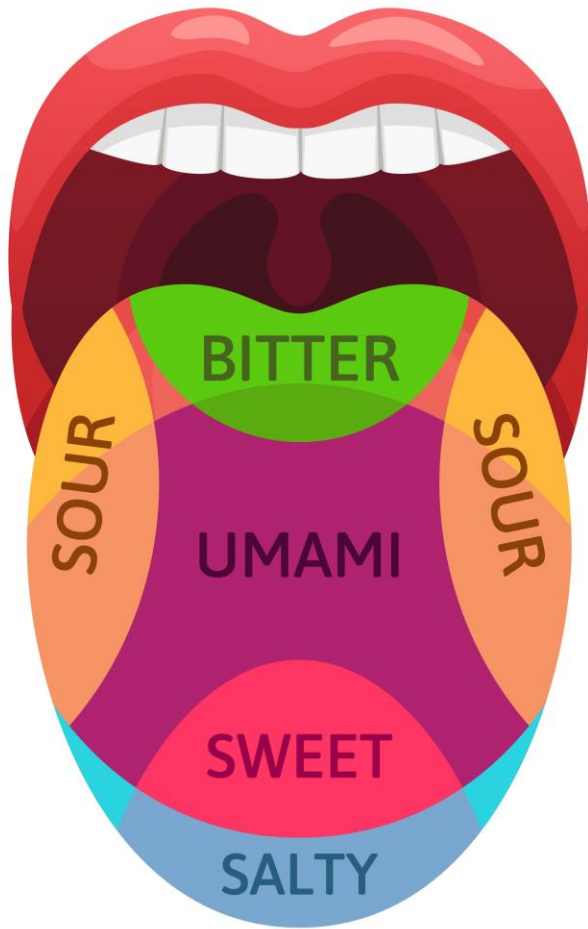


- They contain **stem, receptor and supporting (dark) cells**. Overall 50-100 cells.
- Gustatory cells are tall, contain microvilli with chemoreceptors **for sweet, salty, sour and bitter**.
- At the basal pole, they are in contact with the fibers of the VII, IX and X cranial nerves

Taste buds



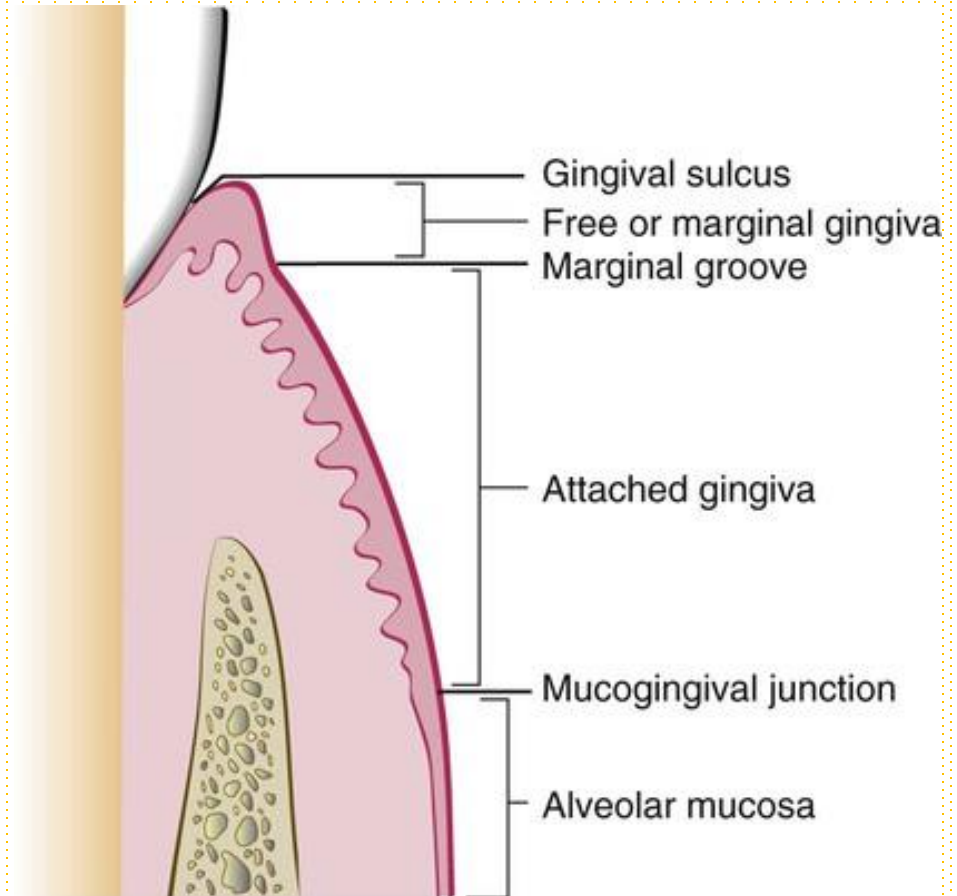
Distribution of the taste



- Umami, which is also known as monosodium glutamate is one of the core fifth tastes including sweet, sour, bitter, and salty.
- Taste is often described as the *meaty, savory deliciousness that deepens flavor*.
- Precisely umami represents the taste of the amino acid L-glutamate, aspartate and 5'-ribonucleotides such as guanosine monophosphate (GMP) and inosine monophosphate (IMP).

Gingiva

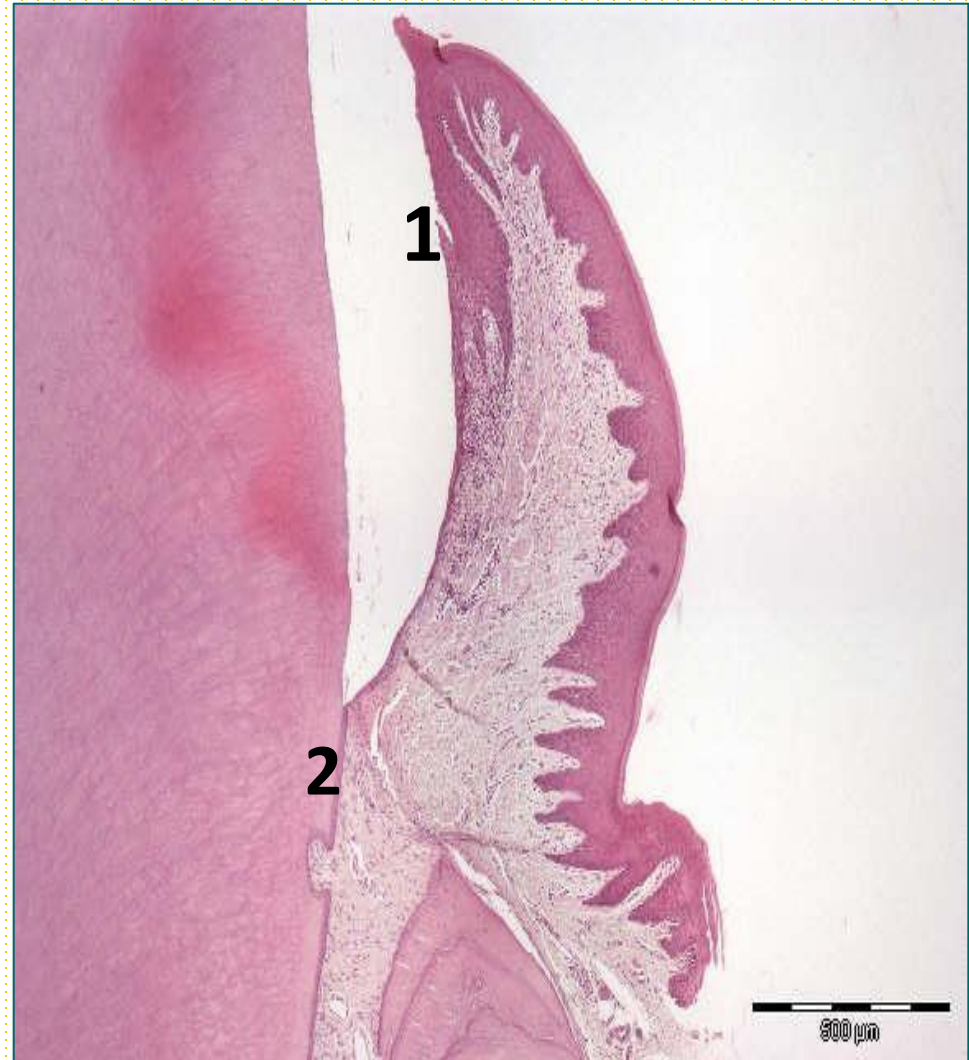
- **Gingiva** is firmly bound to the periosteum of the maxillary and mandibular bones, attaching around the neck of the tooth.
- Between the tooth enamel and the gingival epithelium is a groove, **gingival sulcus**.
- The gingiva is made of squamous epithelium and lamina propria.



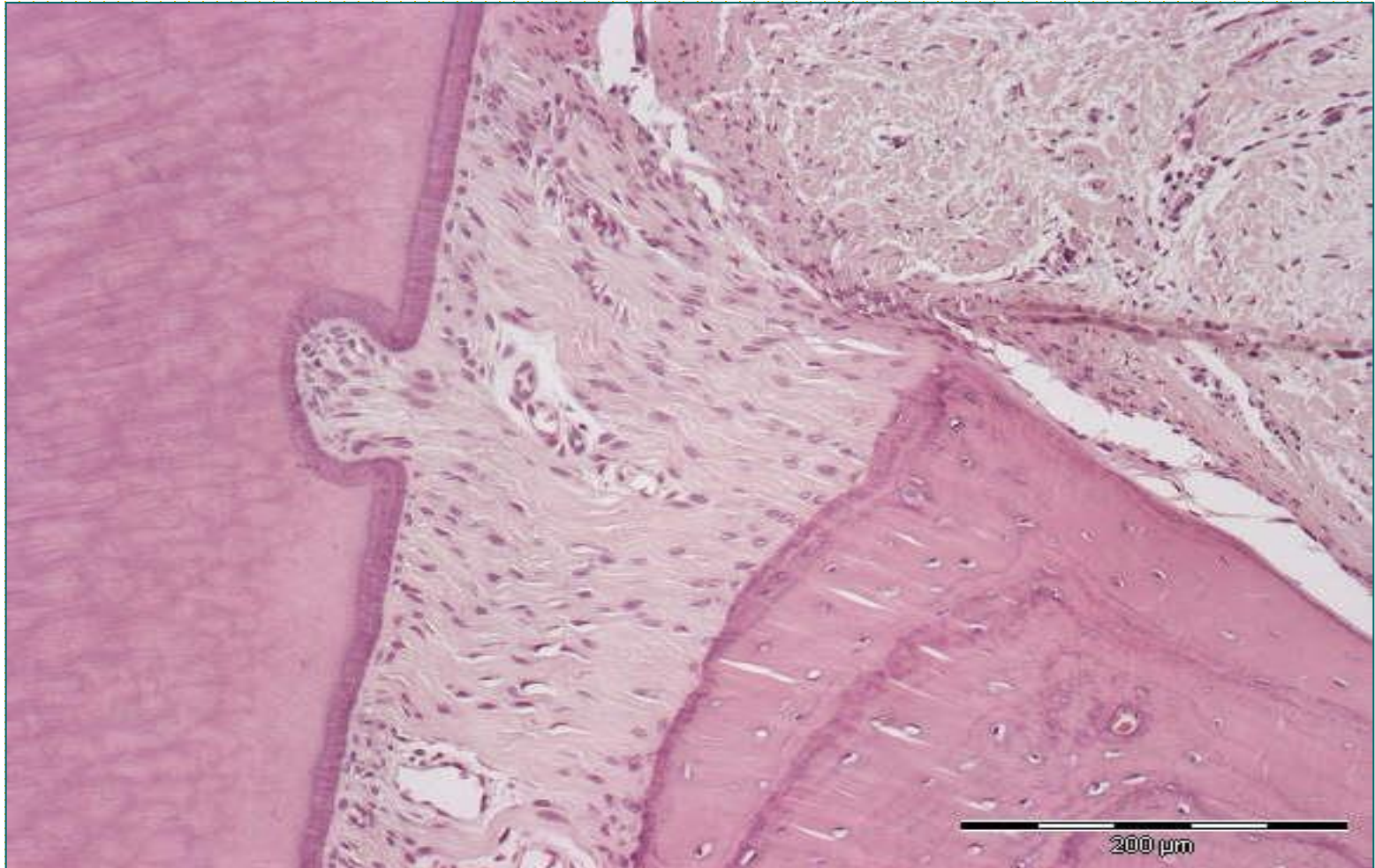
Gingiva

Two types of epithelia

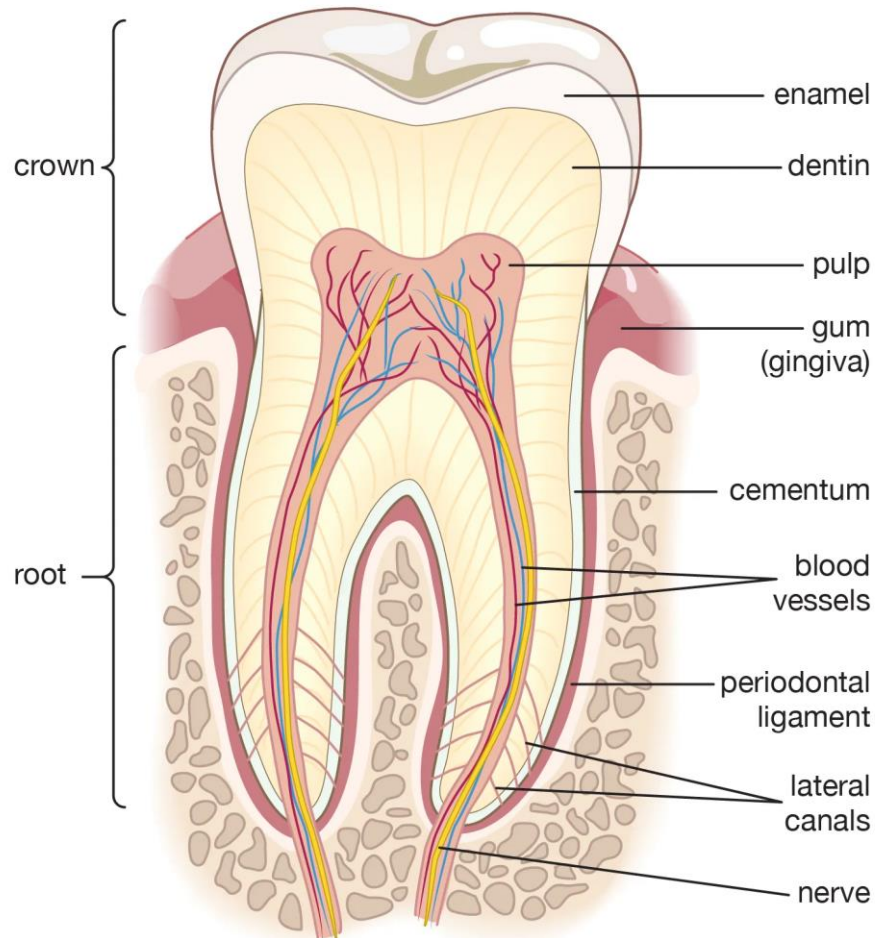
1. **Sulcus epithelium** – squamous-stratified epithelium with low or absent dermal papillae.
2. **Junctional epithelium** - a unique epithelium in the human body. It is thinner than the oral and sulcus ones. Contains a basal and suprabasal layer of cells. High mitotic activity of cells (renew in 6 days). Bonding to the tooth surface - epithelial insertion.



Junctional epithelium



Teeth



➤ **Crown** (corona dentis)

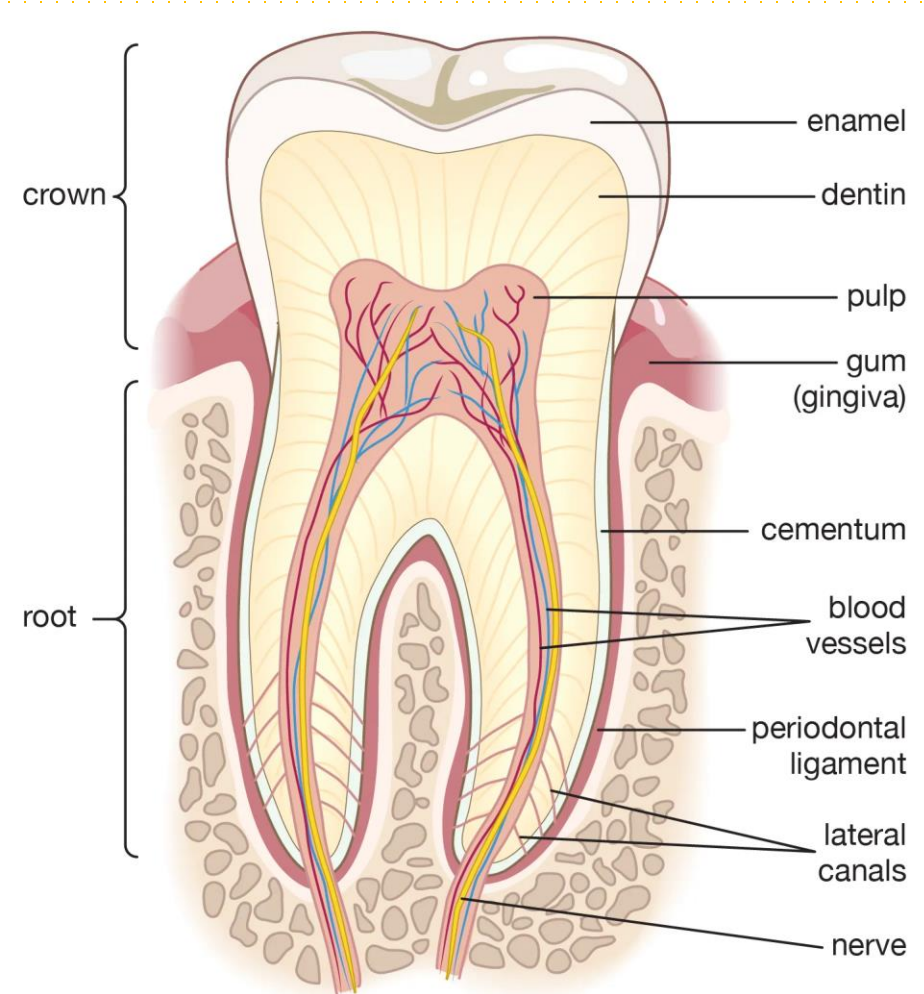
➤ **Neck** (collum dentis)

➤ **Root(s)** (radix dentis)

- The central cavity forms the **pulp cavity**
- In the root of the tooth, the cavity is narrowed – **root canal** which extends to an **apical foramen** at the tip of each root for the blood vessels, lymphatics, and nerves of the pulp cavity.
- The tooth cavity is filled with **dental pulp**.

Dental pulp is highly vascular and well-innervated loose connective tissue.

Teeth

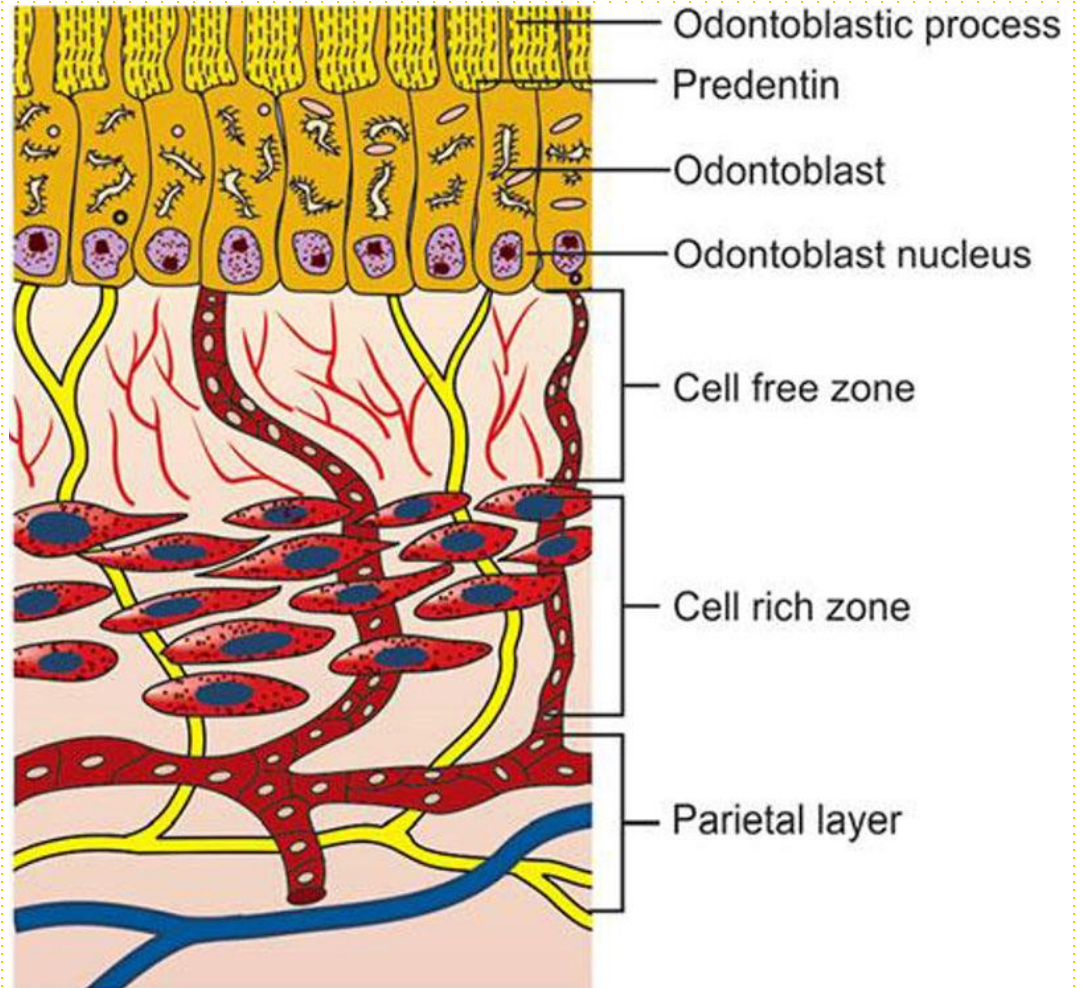


- The crown is covered by very hard, acellular **enamel** and the roots by a bone-like tissue called **cementum**. These two coverings meet at the neck of the tooth. The bulk of a tooth is composed of another calcified material, **dentin**, which surrounds an internal pulp cavity.
- **Periodontal ligaments** are fibrous connective tissue bundles of collagen fibers inserted into both the cementum and the alveolar bone.

Dental pulp zones

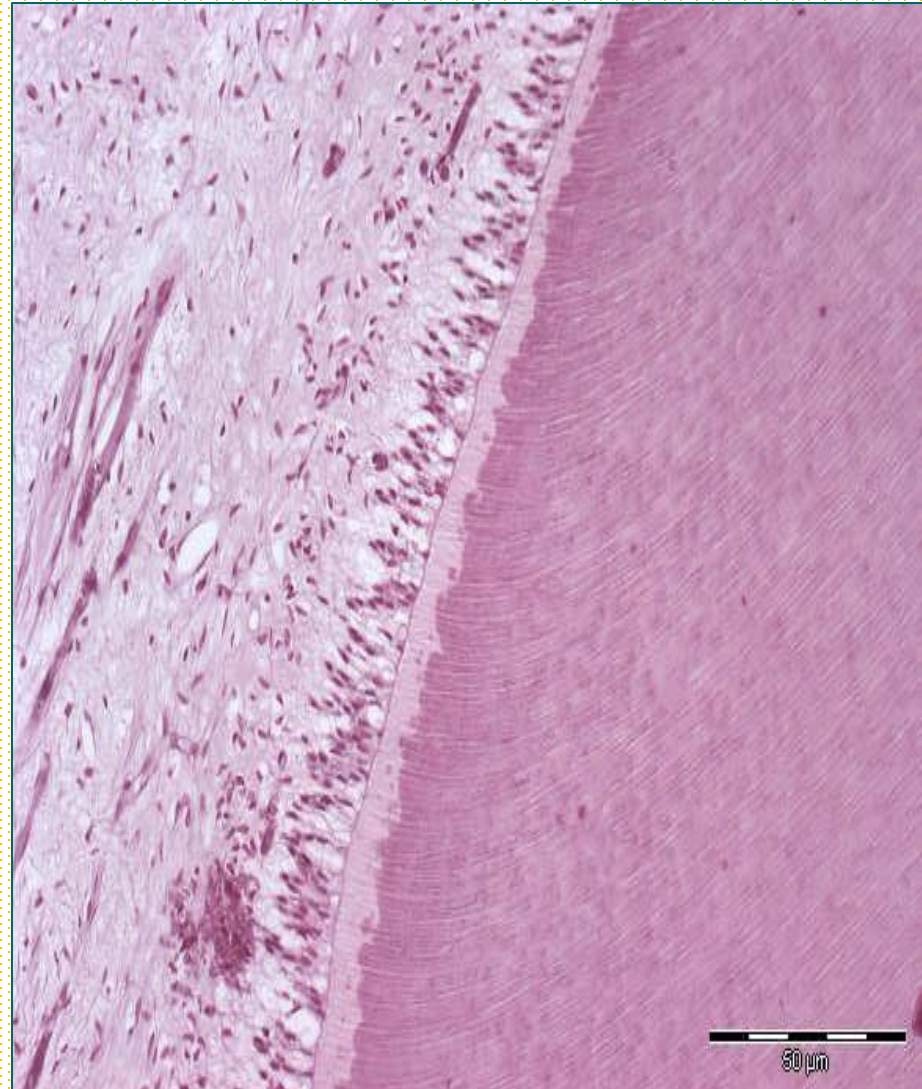
From dentin side

- **Odontoblast zone**
- **Cell free**
- **Cell-rich**
- **Central (parietal)**

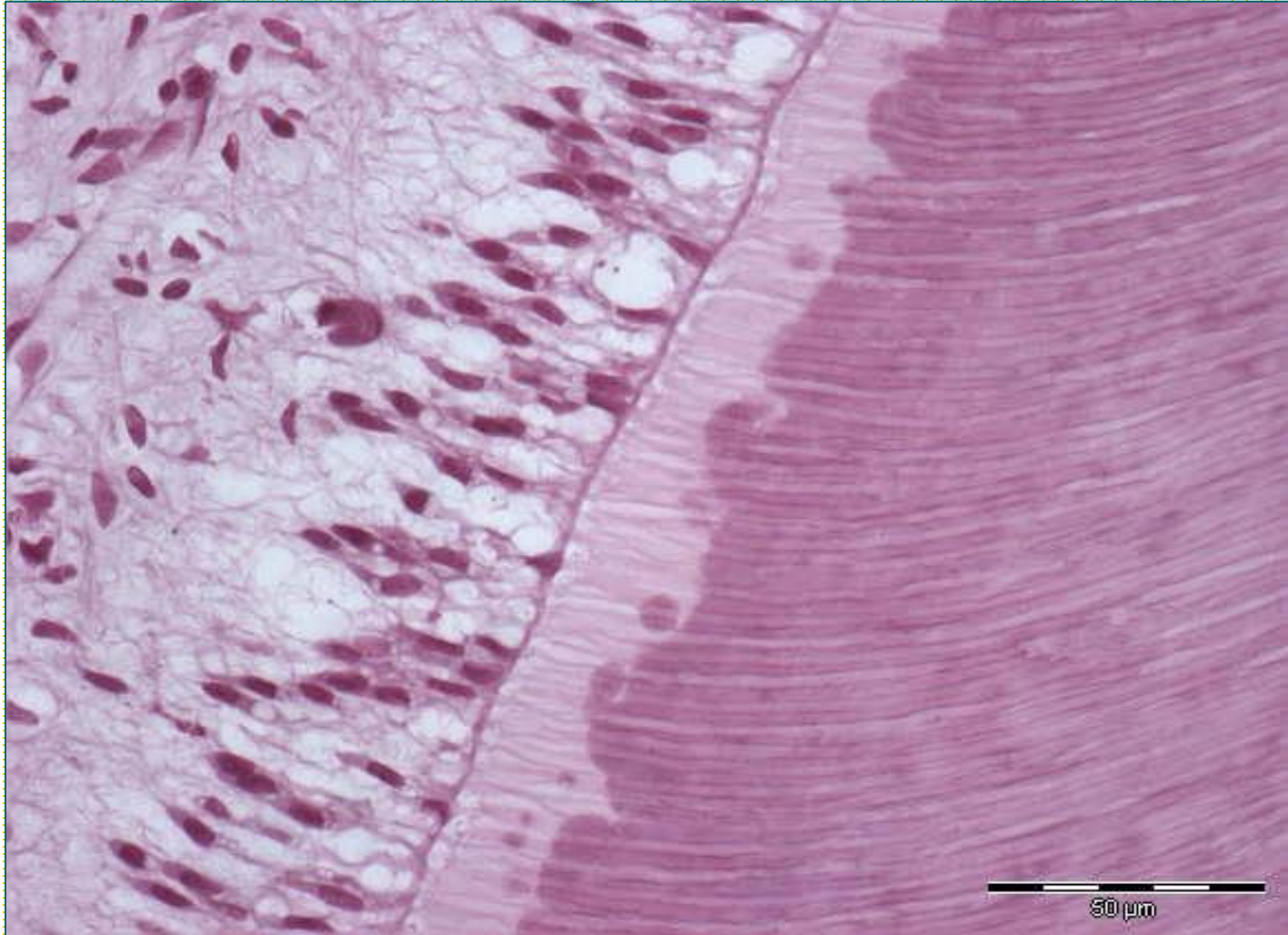


Odontoblast zone

- **Odontoblasts** are tall, cylindrical cells in a palisade array in the superficial layer of the pulp.
- They synthesize **predentin** (the organic part of dentin).
- They do not have the ability to divide (regenerate from deeper preodontoblasts)
- Long apical odontoblast processes extend from the odontoblasts within **dentinal tubules**, which penetrate the full thickness of the dentin.
- Mineralization of predentin results in **dentin** (happens one day after predentin deposition)
- With the formation of new layers of dentin, the odontoblasts move towards the center of the pulp



Odontoblast

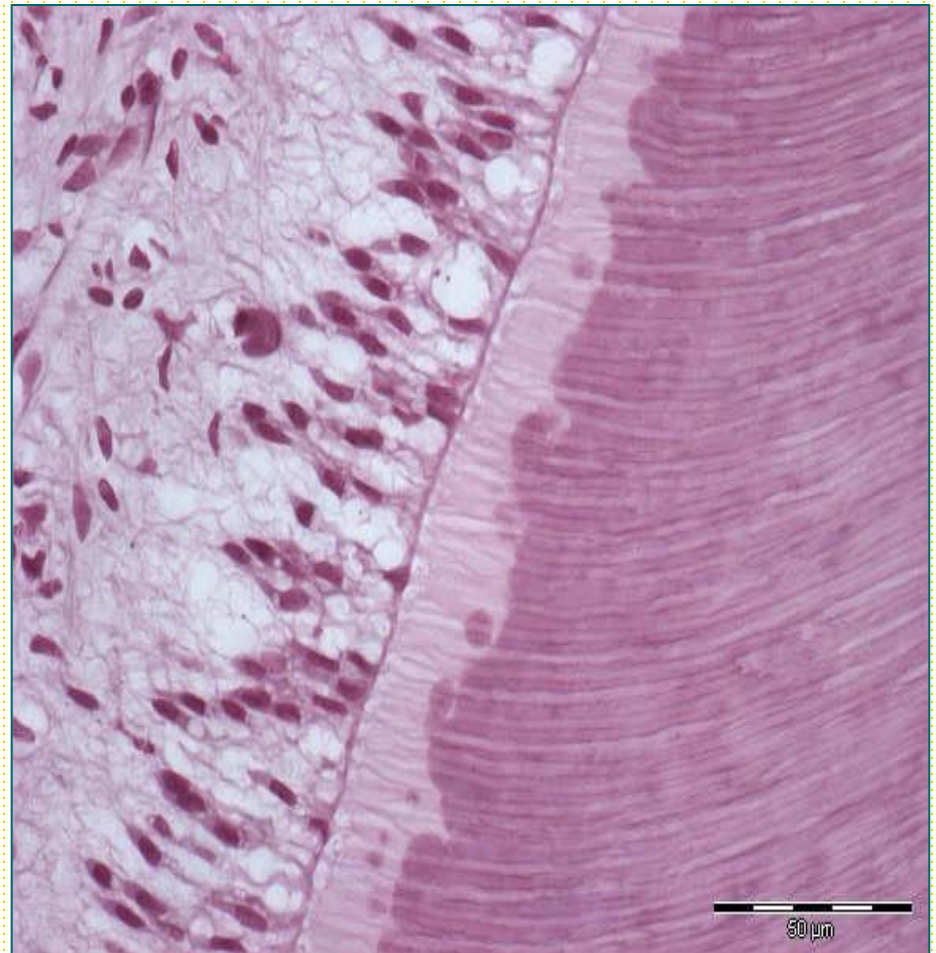


Odontoblasts



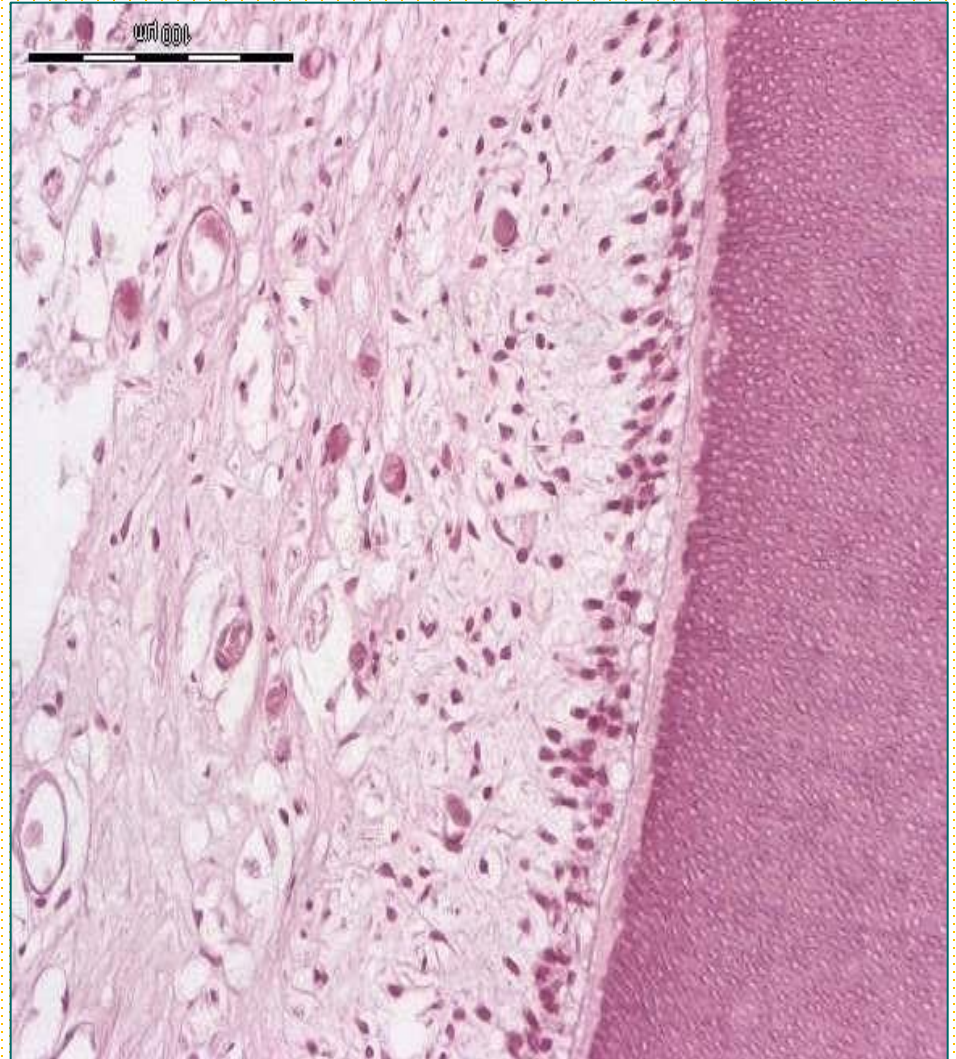
Cell free

- It is located below the odontoblast.
- It contains a subodontoblastic bundle of nerve fibers.
- Myelinated nerve fibers enter the pulp through the apical opening together with blood vessels.
- In the subodontoblast cell-free zone, the **myelin sheath is lost**.
- They represent **pain receptors**.



Cell-rich

- It contains **fibroblasts**, **undifferentiated cells** and **preodontoblasts**.
- Apart from these cells, **lymphocytes**, **plasma cells**, **macrophages**, **eosinophils** and **mast cells** are also present.



Central (parietal)

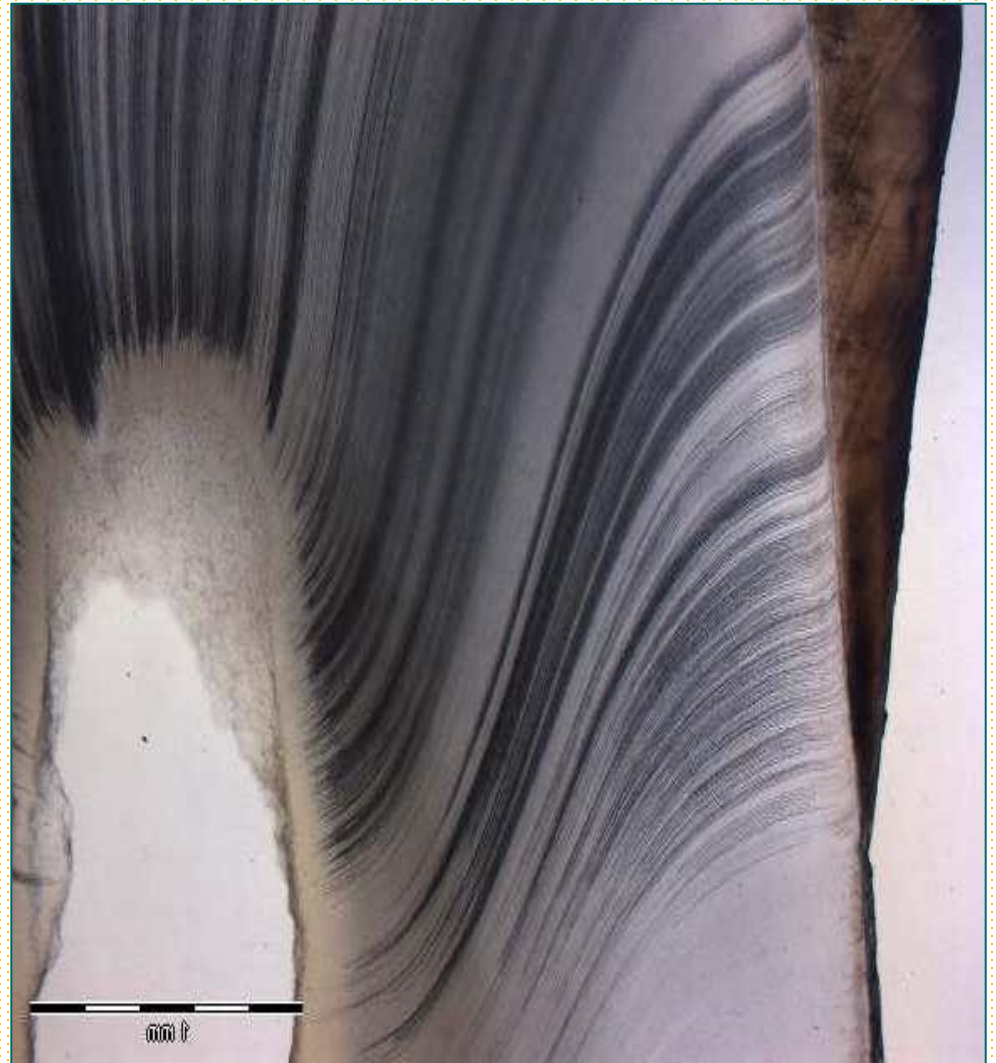
- The most numerous cells are **fibroblasts** - secrete collagen fibers and ground substance.
- Hyaluronic acid dominates in the ground substance.
- Blood vessels and nerves are located in the central zone



Dentin

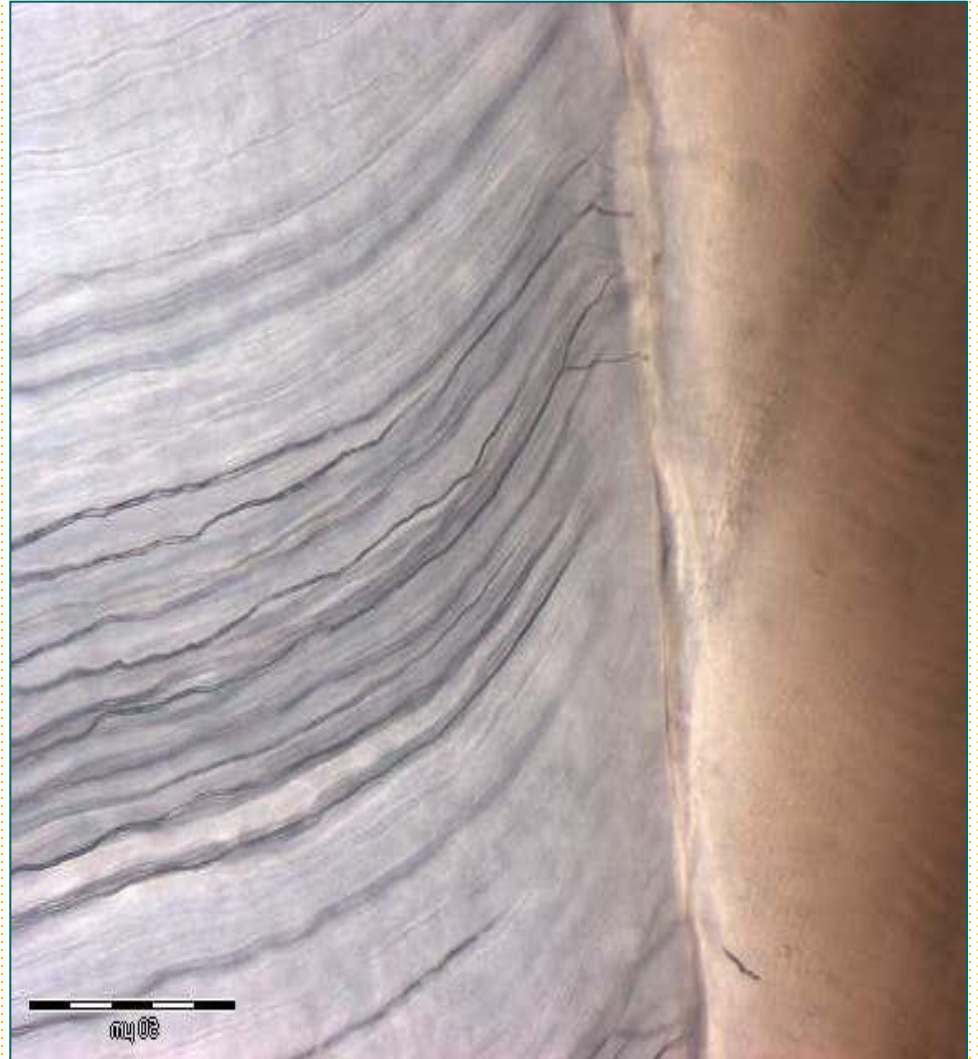
- Mineralized connective tissue (inorganic substances make up about 70% of dentin).
- It does **not contain cells** or blood vessels.

In the tubules there are **odontoblast processes, collagen fibers, unmyelinated nerve fibers and dentinal fluid (H_2O , ions).**

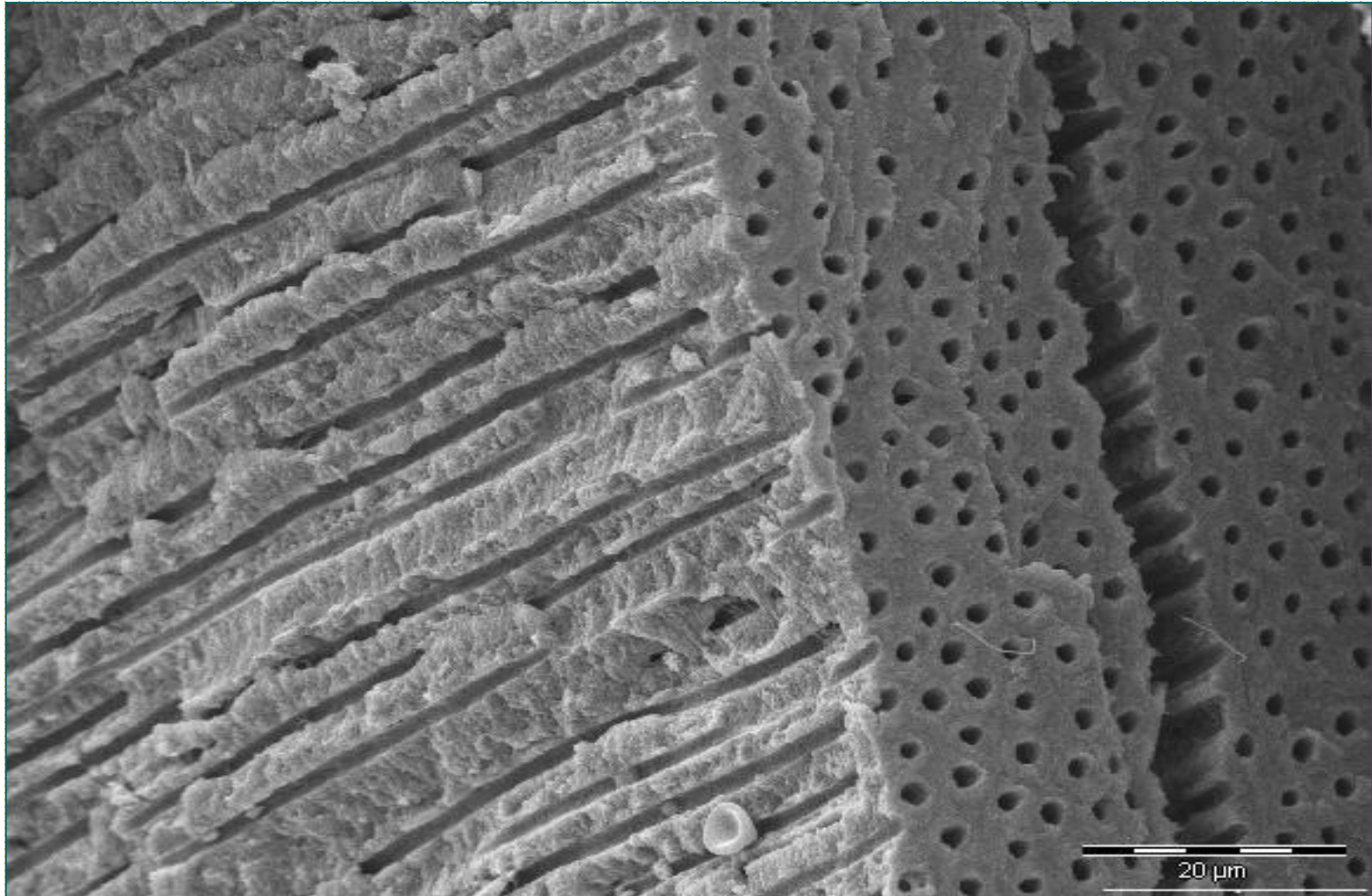


Dentin

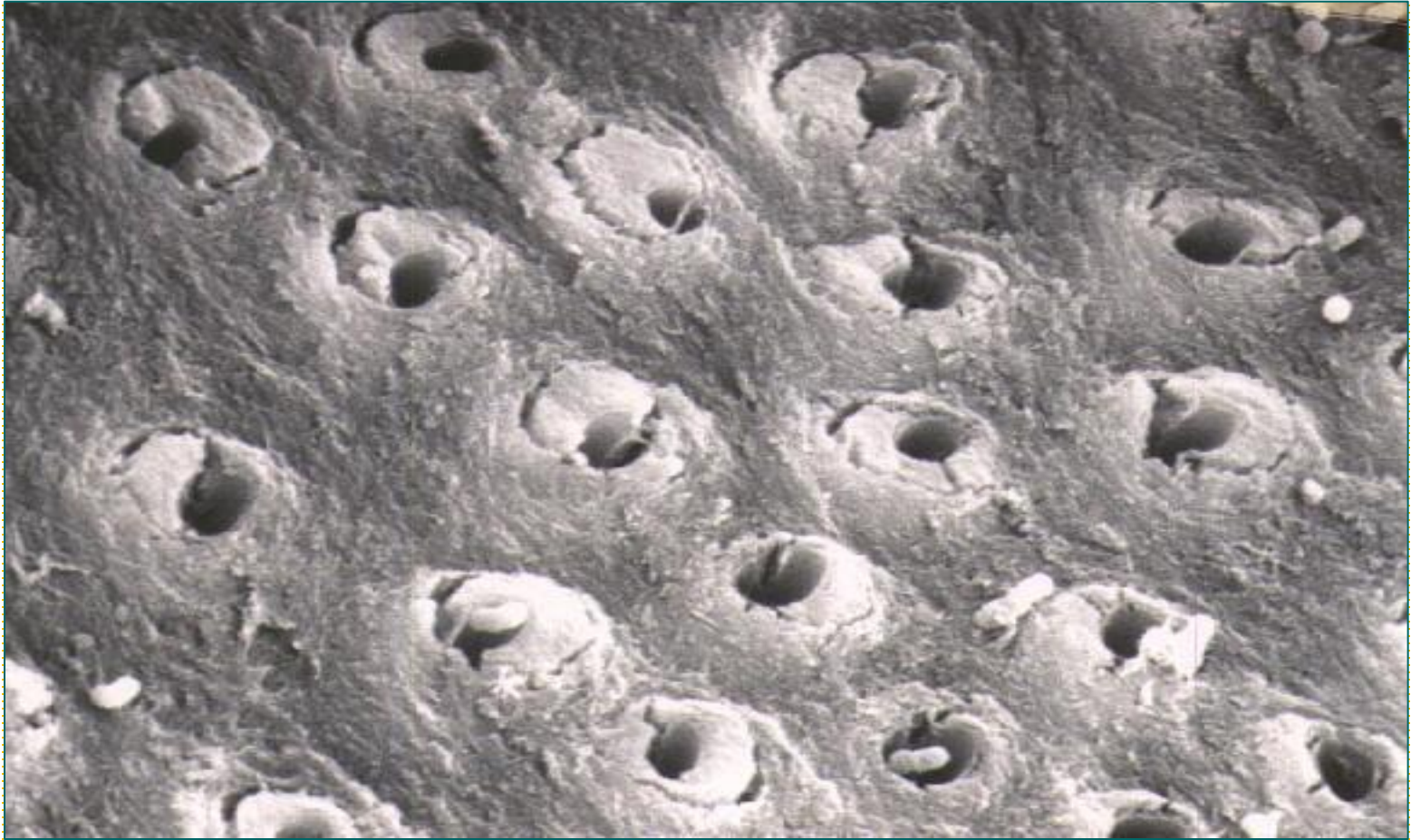
- The wall of the dentinal tubule forms a thin ring of highly mineralized dentin - **intratubular dentin**.
- **Intertubular dentin**, which lies between the tubules, is a less-calcified
- The main part of the dentine mass is made up of **intertubular dentin**.



Dentinal tubules (SEM)



Dentinal tubules (SEM)



Intratubular and intertubular dentin

Dentinogenesis

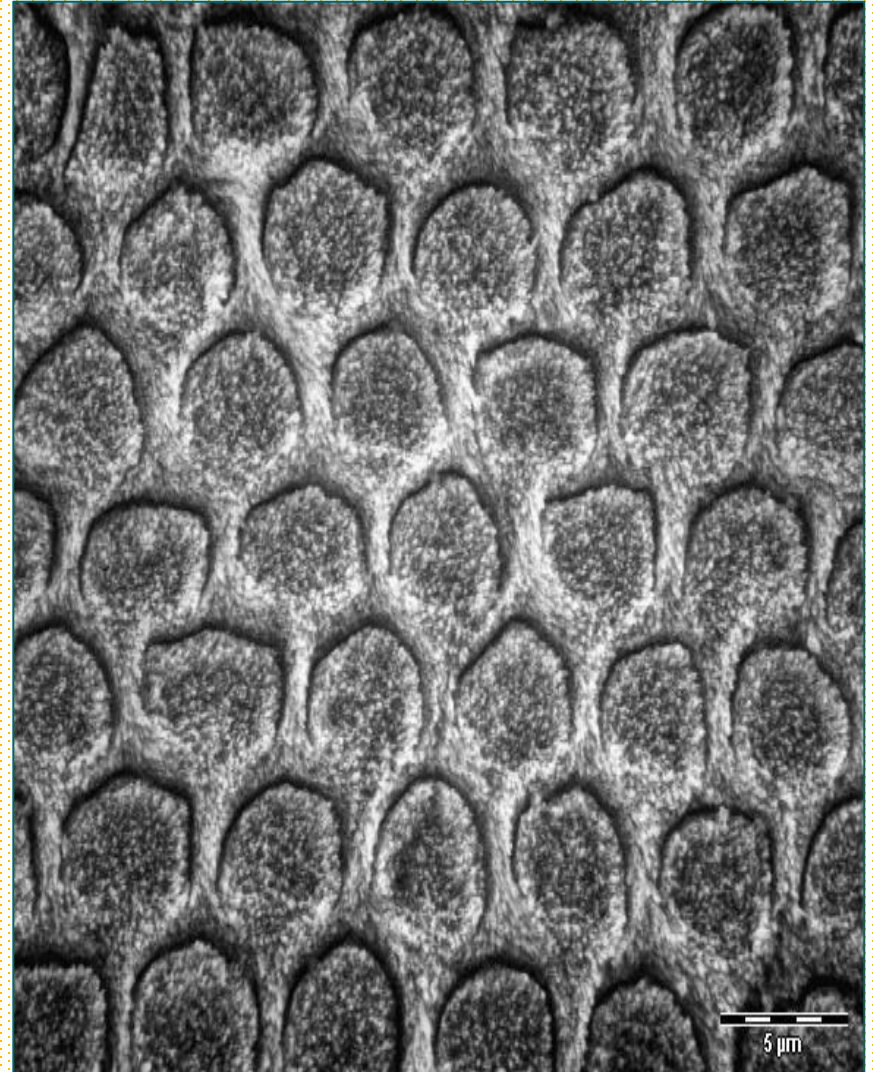
- It takes place **throughout life**, as long as the tooth is vital.
- At the moment of tooth eruption, dentin is formed in the crown, while its formation has just begun in the root.
- Dentin that is formed before and during tooth eruption is called **primary dentin**.
- When root growth is completed and the tooth reaches the plane of occlusion, dentinogenesis slows down and the deposited dentin represents the **secondary dentin**.
- In pathological conditions, **tertiary or reactive dentin** is formed in response to odontoblast stimulation.

Enamel

- It covers the dentin in the crown.
- The hardest substance in the body (**between steel and titanium**)
- Enamel consists of 96% inorganic salts (hydroxyapatite), 2% organic matter (proteins: **amelogenins, ameloblastins, enamelins and tuftelins**) and 2% water.
- Enamel **does not contain collagen**.
- During tooth development, enamel is produced by **ameloblasts** (activated by the formation of dentin).
- An apical extension from each ameloblast, the ameloblast (or Tomes) process, contains numerous secretory granules with the proteins of the enamel matrix.
- After the formation of the enamel, the **involution of the ameloblast** occurs and only a thin covering remains on the surface - the enamel cuticle (protective function).

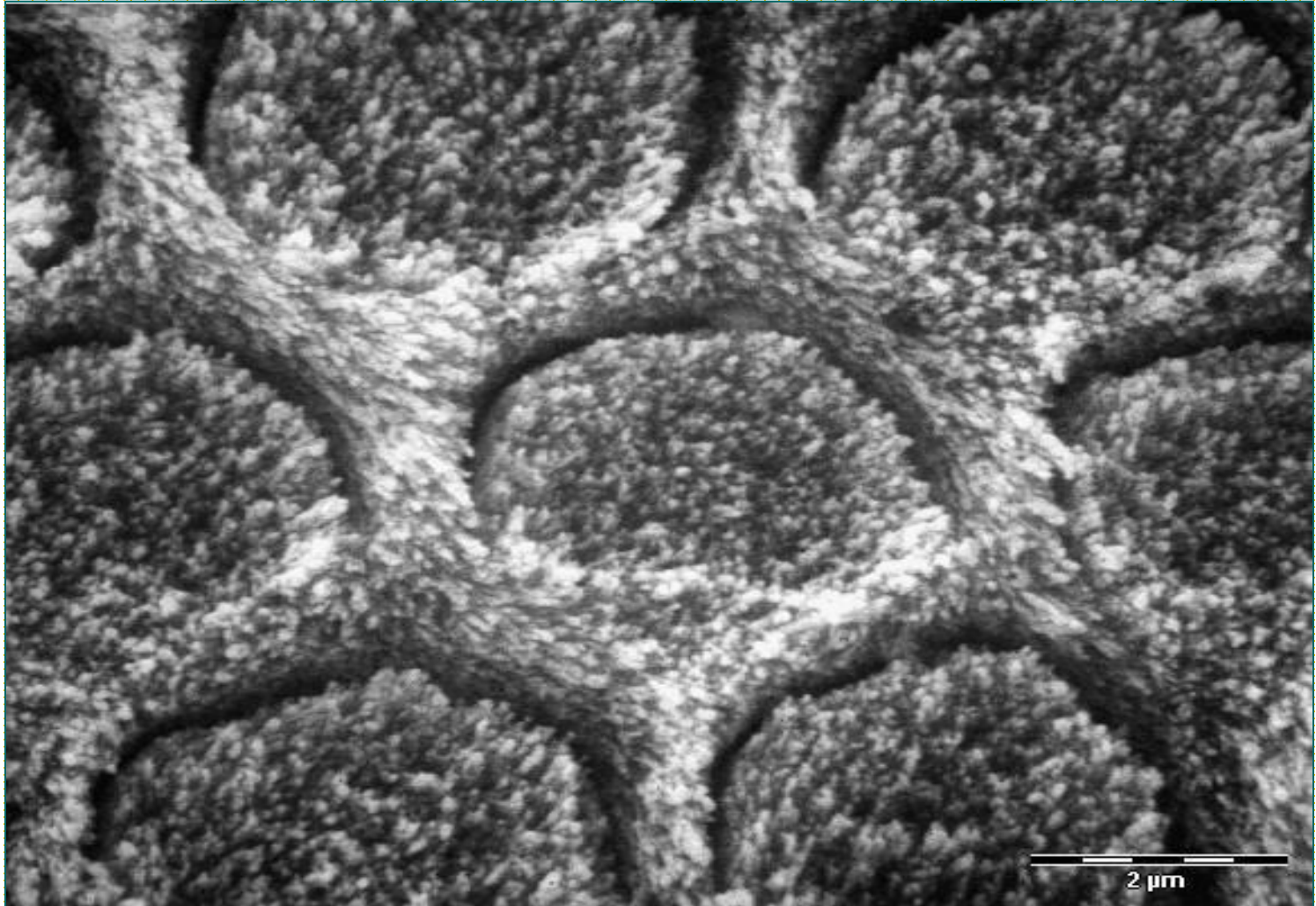
Enamel rods

- Enamel consists of **enamel rods** and **interrod enamel**.
- The **enamel rods** are composed of hydroxyapatite.
- From dentine borders to enamel surface (up to 2 mm).
- The head of the rod, the tail of the rod, fit together.
- **Interrod enamel** is in between rods and is less mineralized.

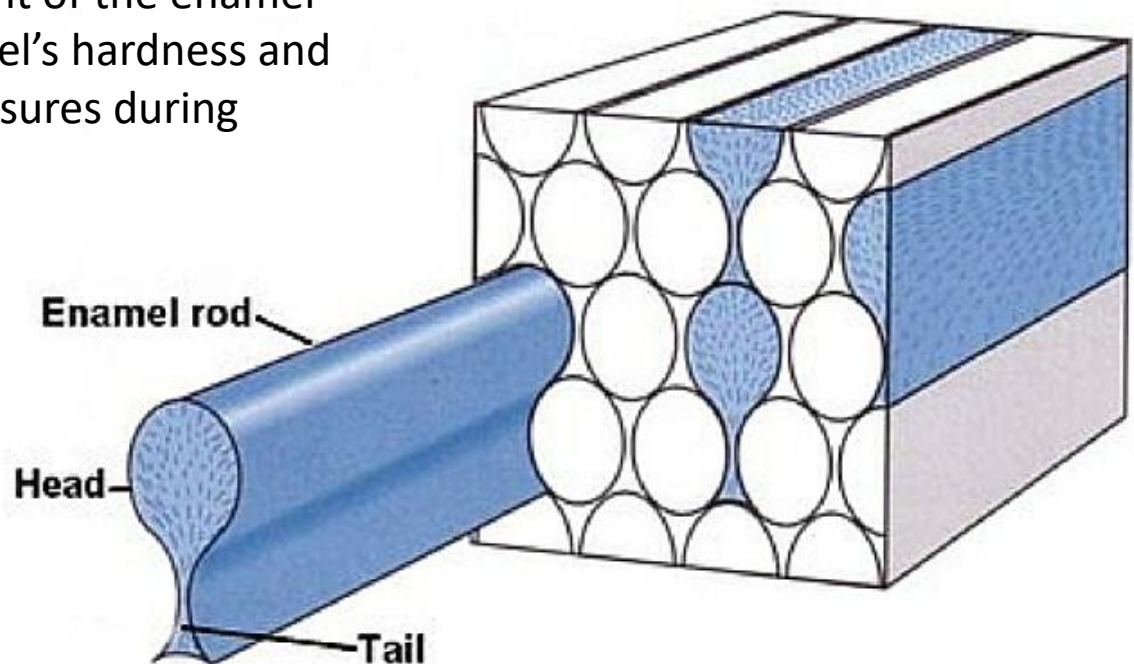


Enamel rods

Enamel rods and interrod enamel.

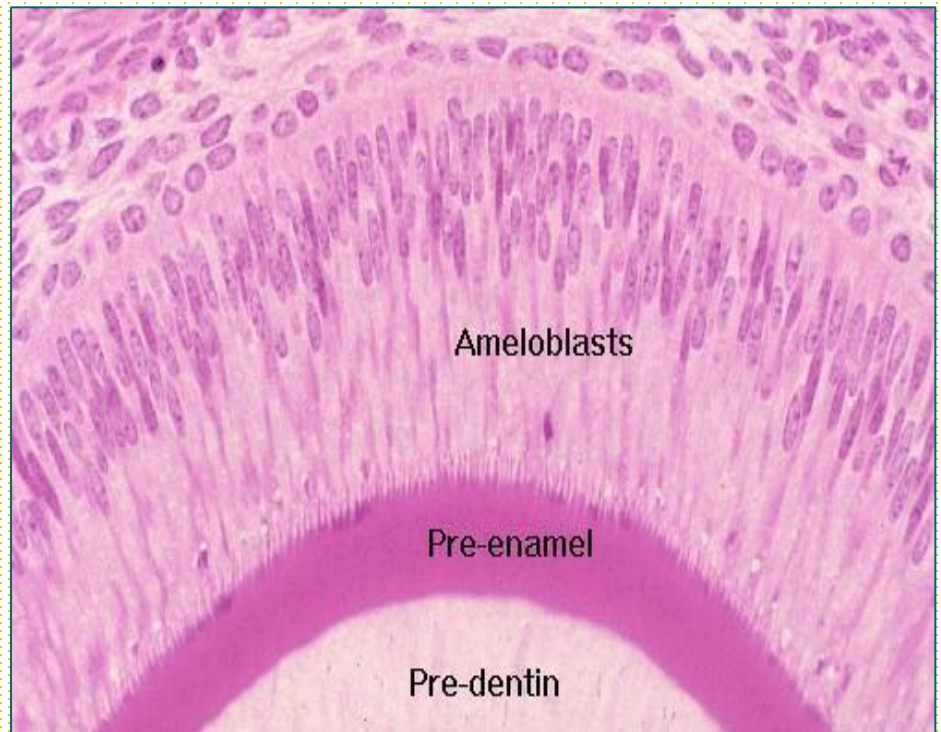


- Interlocking enamel rods (or prisms), each about 5 μm in diameter and surrounded by a thinner layer of interrod enamel
- The precise arrangement of the enamel rods is crucial for enamel's hardness and resistance to great pressures during mastication.



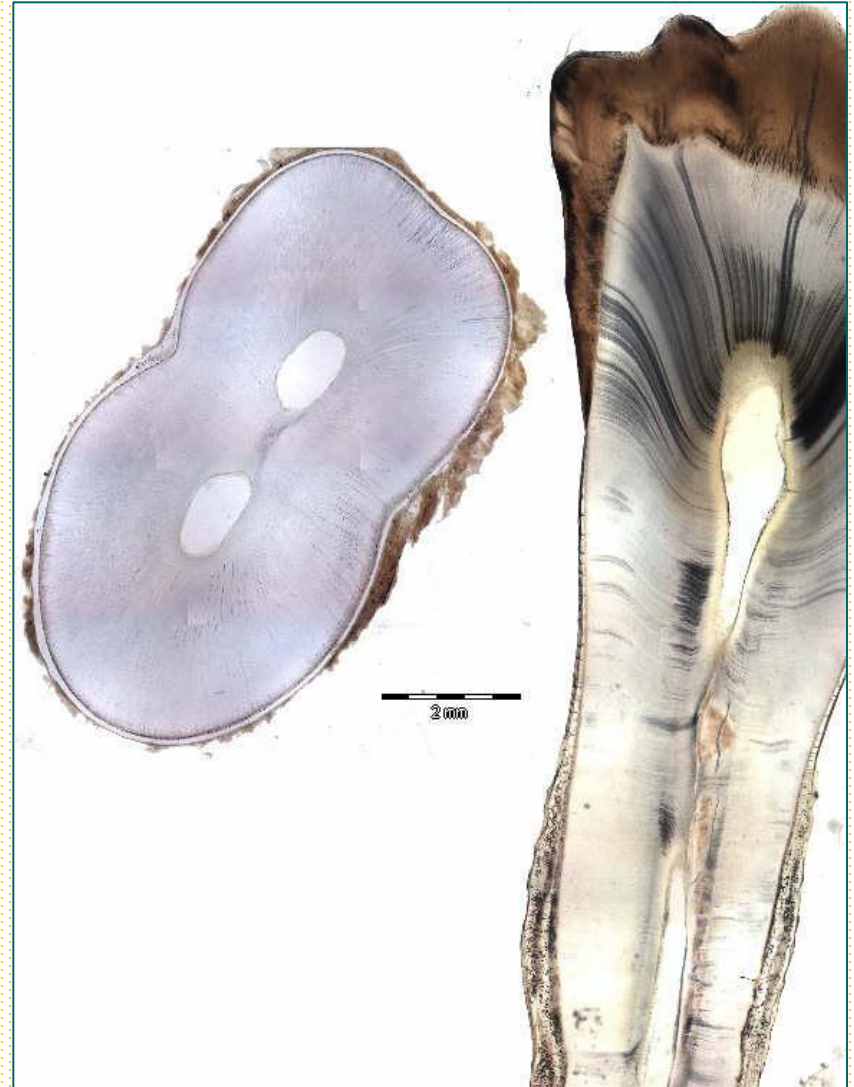
Forming the enamel

- Ameloblasts are derived from the **ectodermal lining** of the embryonic oral cavity.
- They tissues produce a series of 52 tooth buds in the developing oral cavity, 20 for the primary teeth and 32 for the secondary or permanent teeth. Primary teeth complete development and begin to erupt about 6 months after birth.
- Secondary tooth do not erupt until about 6 years of age.

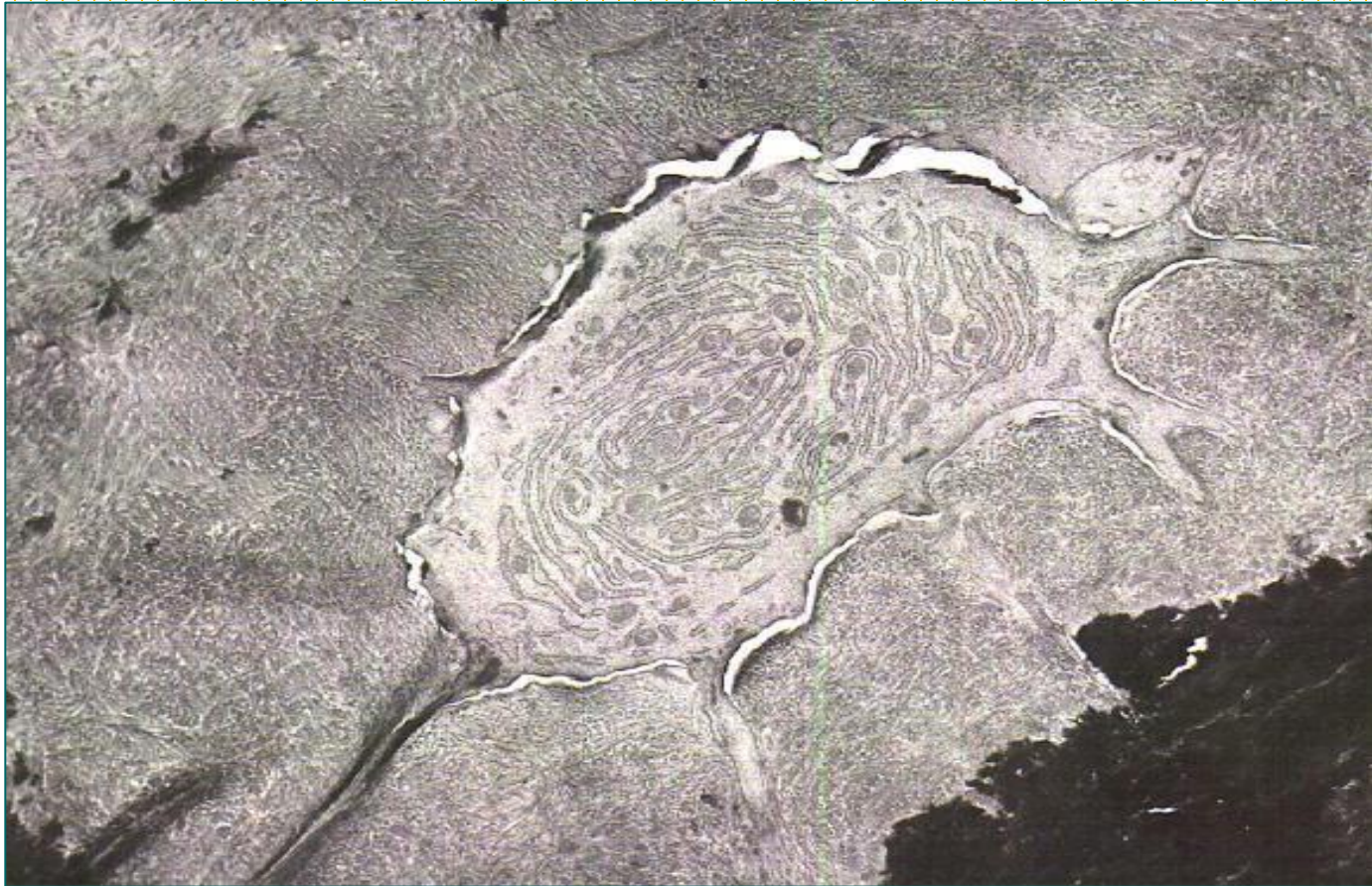


Cementum

- Mineralized connective tissue that covers the dentin in the root produced by **cementoblasts**.
- In the neck of the tooth in 60% of cases cementum covers the enamel (they overlap), in 30% of cases they touch, in 10% of cases the dentin is exposed.
- The thickness of the cement increases towards the root.
- Structures **similar to bone, but softer**.

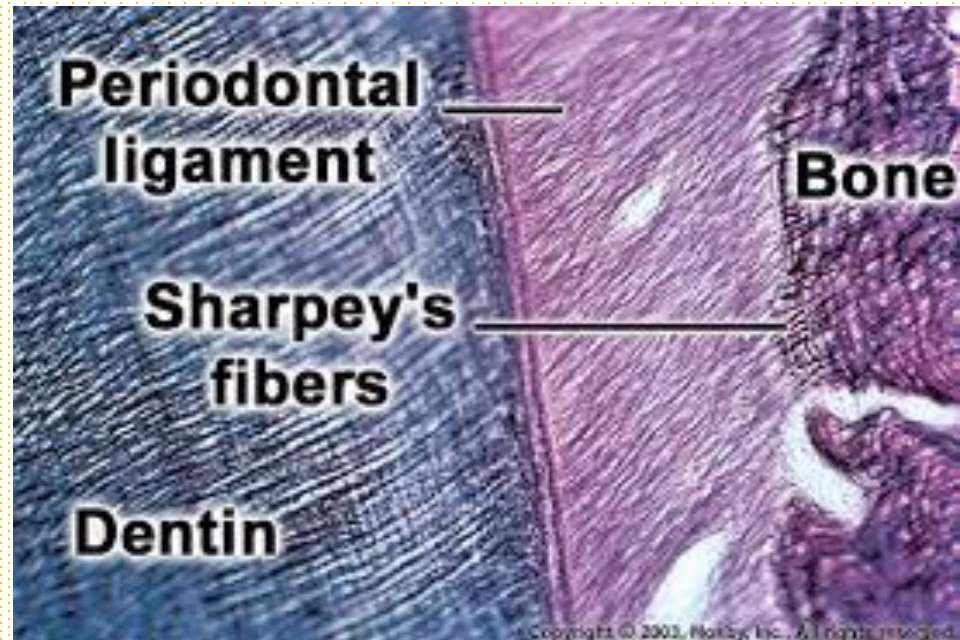


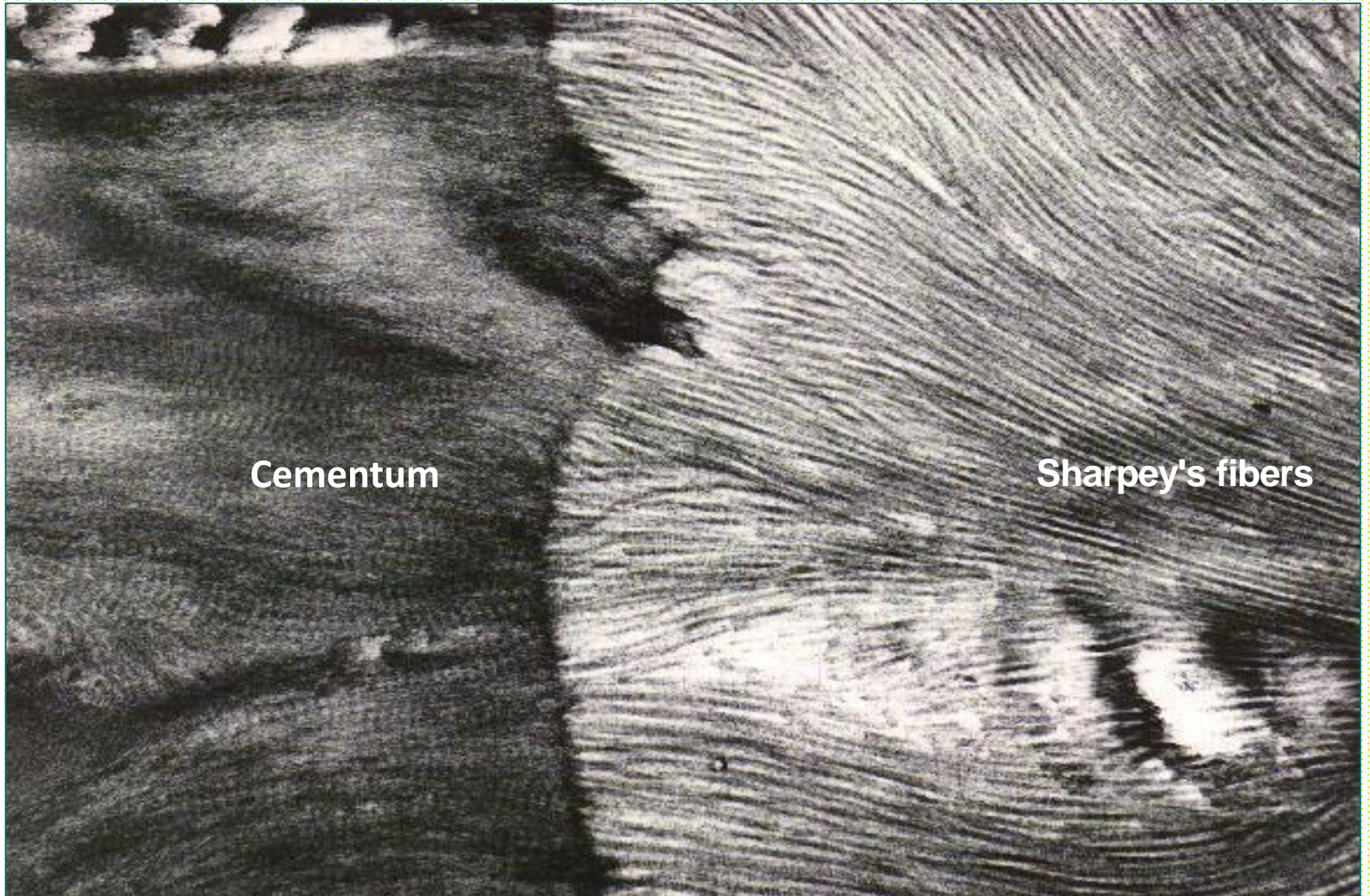
Cementoblasts

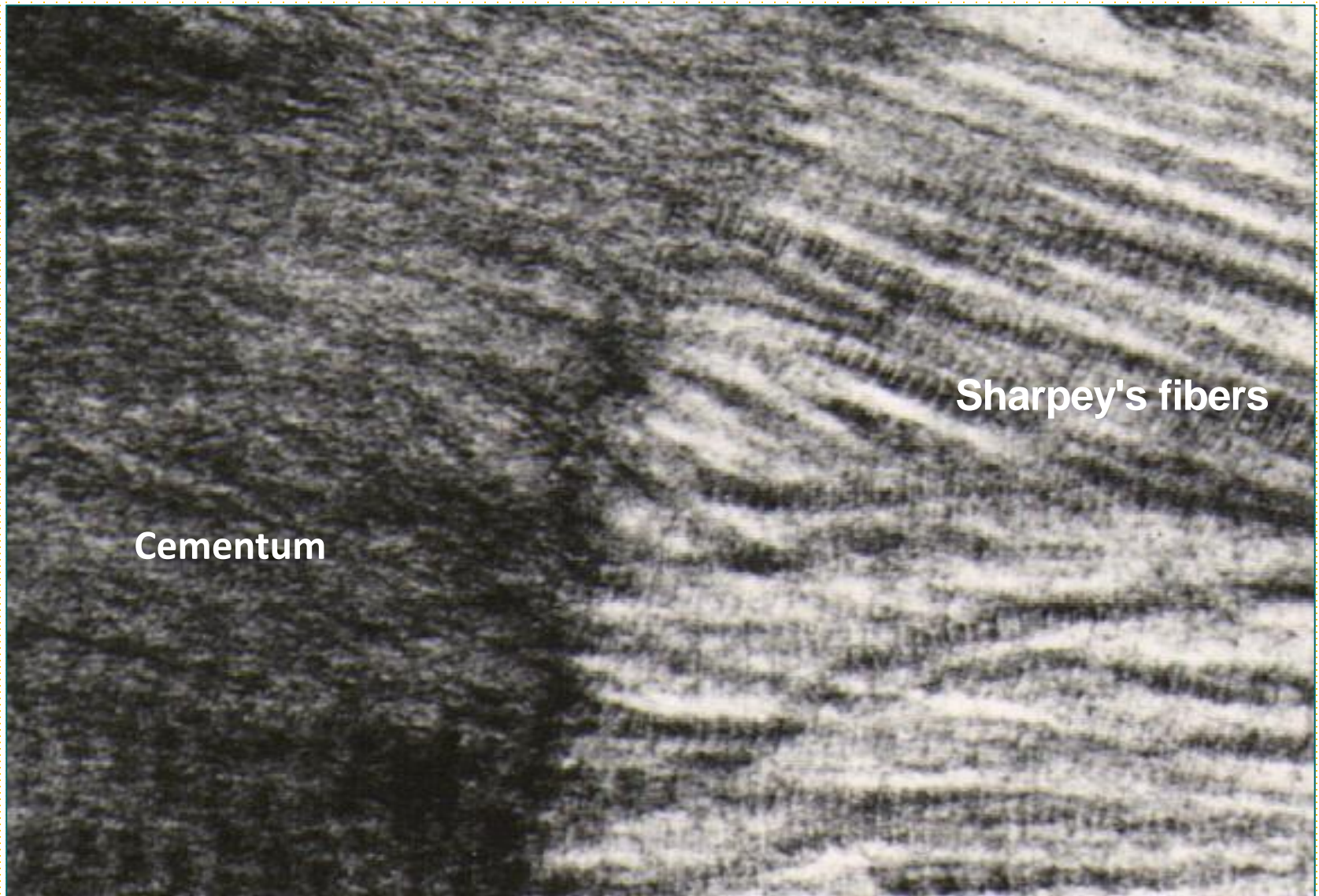


Periodontal ligament

- Cell-rich dense connective tissue between the cementum and the alveolar bone.
- The main content is **Sharpey's fibers**
- They enable a **firm and elastic** bond between the bone and the teeth.
- Cementum, periodontium, alveolar bone and gums represent a morphological and functional whole - **periodontium**.





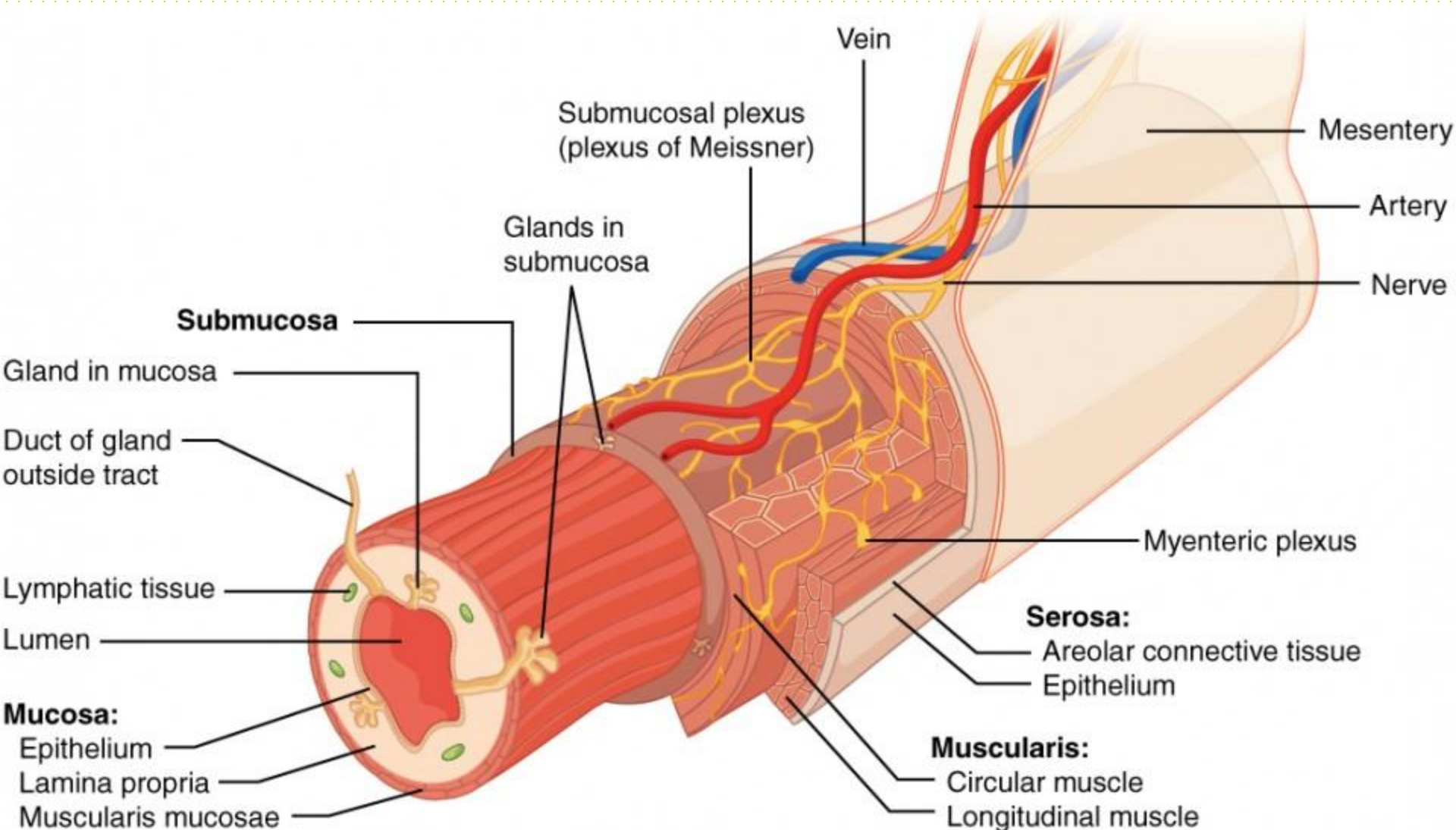


Cementum

Sharpey's fibers

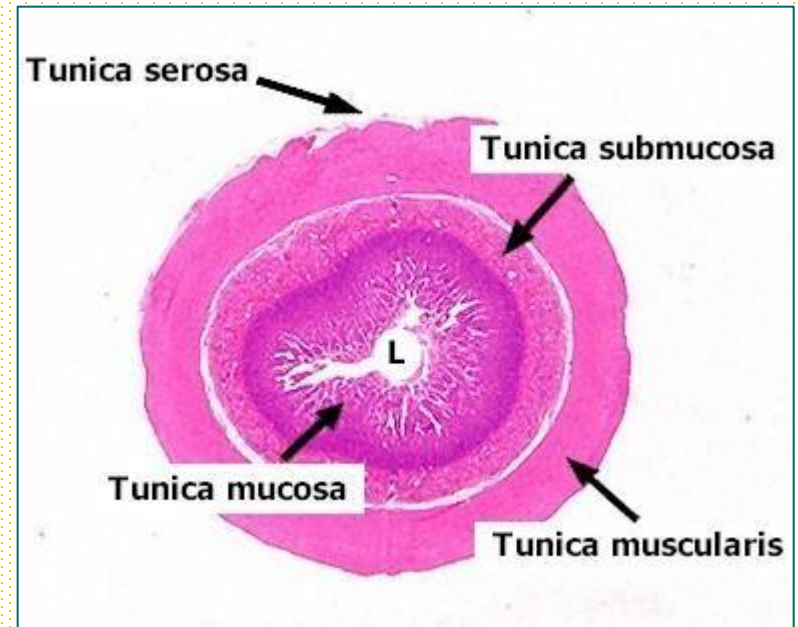
Digestive tract

Major layers and organization of the digestive tract.



Digestive tract

- **Tunica mucosa**
 - lamina epithelialis
 - lamina propria
 - lamina muscularis mucosae
- **Tunica submucosa**
- **Tunica muscularis**
 - stratum circulare
 - stratum longitudinale
- **Tunica serosa/adventitia**



- **Mucosa** consists of an **epithelial lining**; an underlying **lamina propria** of loose connective tissue rich in blood vessels, lymphatics, lymphocytes, smooth muscle cells, and often containing small glands; and a thin layer of smooth muscle called the **muscularis mucosae** separating mucosa from submucosa. The mucosa is also frequently called a mucous membrane.
- **Submucosa** contains denser connective tissue with larger blood and lymph vessels and the **submucosal (Meissner) plexus** of autonomic nerves. It may also contain glands and significant lymphoid tissue.
- **Muscularis** (or muscularis externa) is composed of smooth muscle cells organized as **two or more sublayers**. Orientation is circular in the internal and in the external sublayer it is longitudinal. **Myenteric (Auerbach) nerve** plexus of many autonomic neurons aggregated into small ganglia and interconnected by pre- and postganglionic nerve fibers.
- **Serosa/adventitia**, a thin sheet of loose connective tissue, rich in blood vessels, lymphatics, and adipose tissue. Serosa is covered with a simple squamous covering epithelium or mesothelium and is the outermost layer.

Innervation

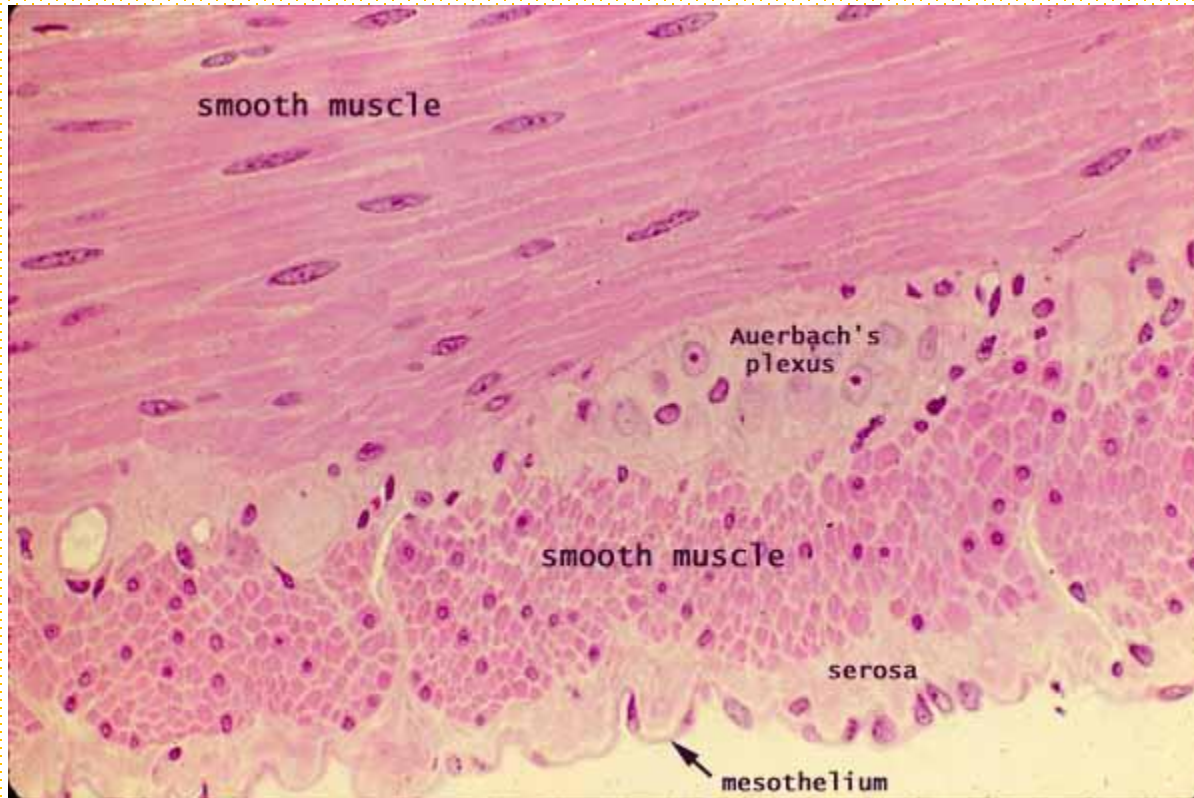
- The digestive tube is innervated by the internal (own) enteric neurons and external sympathetic and parasympathetic neurons.
- Enteric neurons form the enteric nervous system (ENS).
- The ENS is a part of the autonomic nervous system that functions in conjunction with the sympathetic and parasympathetic, but can also act independently of them .
- The ENS includes about 100 million neurons located in the wall of the digestive tube.
- **Meissner's submucosal** and **Auerbach myenteric** plexus.
- In both bundles, neurons form groups that are connected to each other by myelinated nerve fibers.

Submucosal plexus



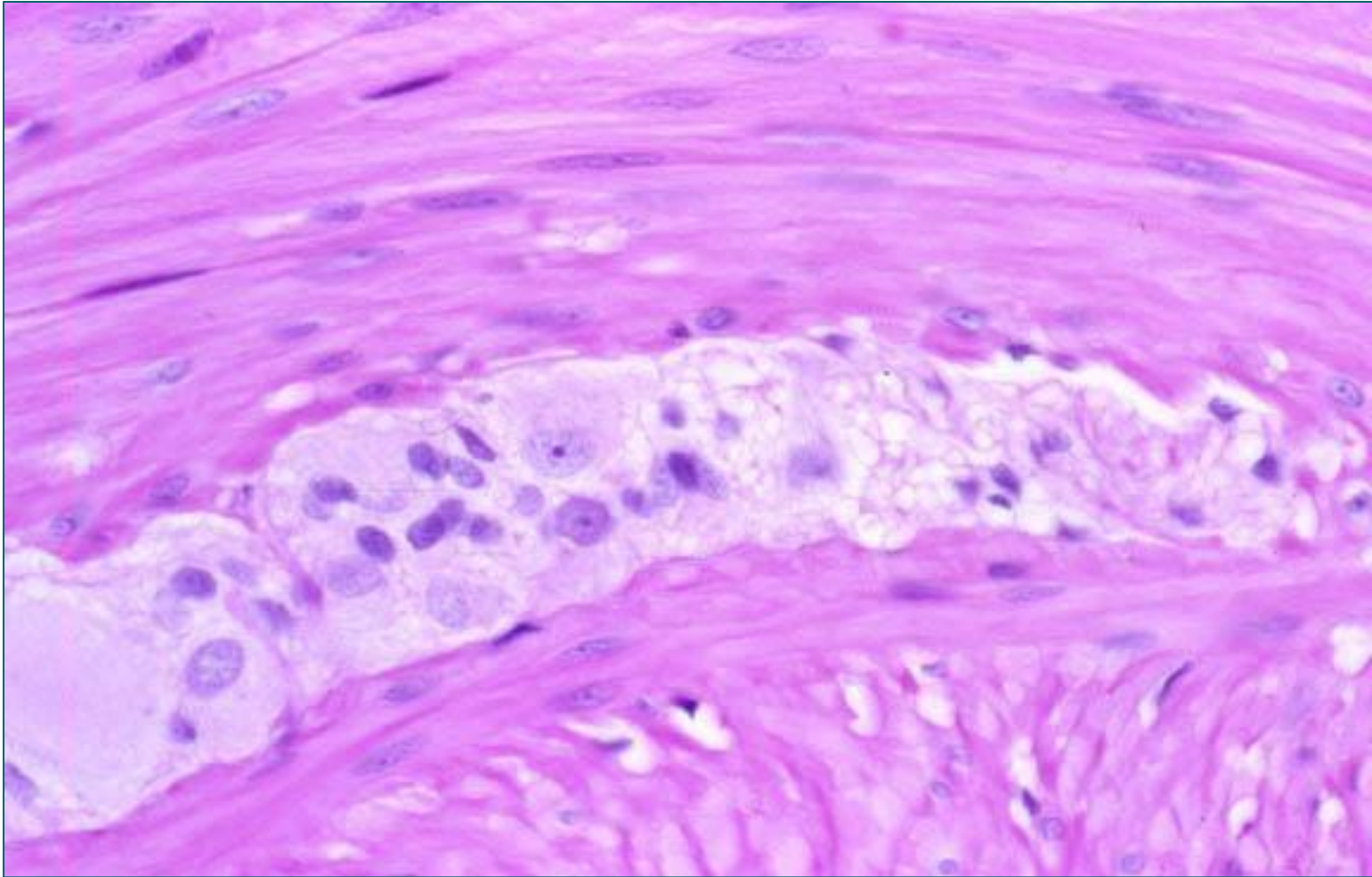
- It controls **endocrine** and **exocrine secretion**, **mucosal mobility**, **microcirculation**

Auerbah plexus



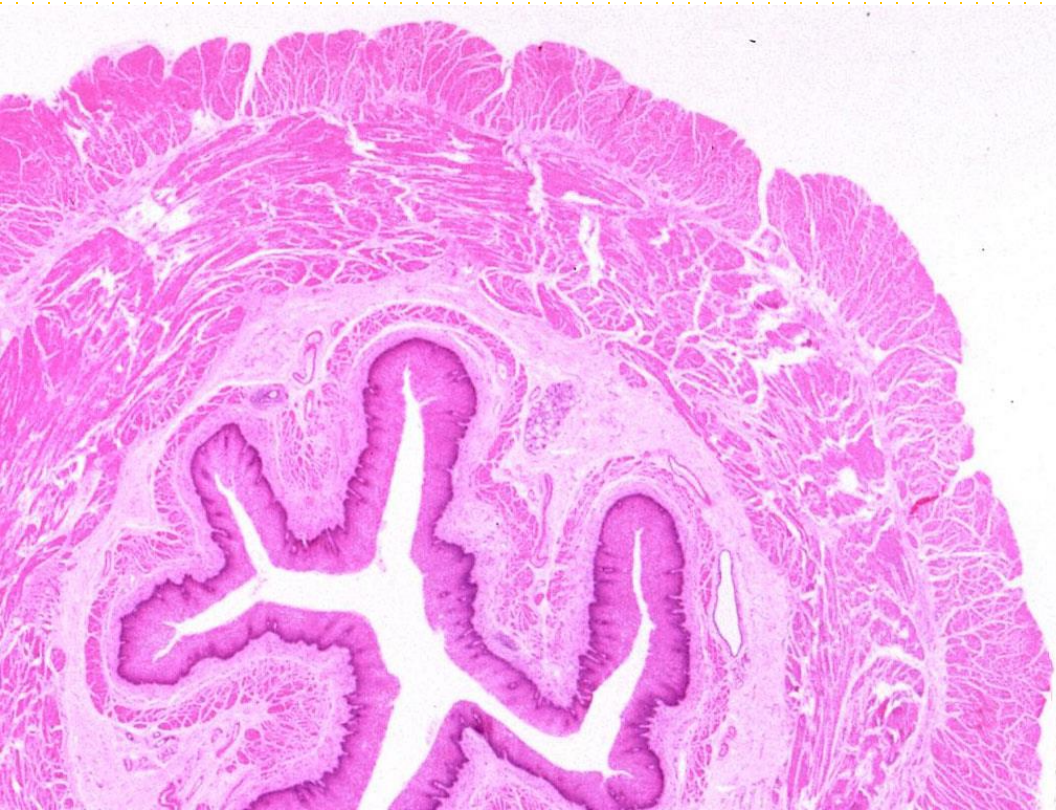
- Controls **peristaltic movement**.

Auerbah plexus



Esophagus

- **Esophagus** is a muscular tube, about 25-cm long in adults, which transports swallowed material from the pharynx to the stomach.
- The **four layers** of the GI tract first become well-established and clearly seen in the esophagus.
- Esophagus is subdivided into **upper** (**entirely skeletal muscle** in the muscularis externa), **middle** (**mixed smooth and skeletal muscle**) and **lower** (**entirely smooth muscle**) portions



Esophagus

Mucosa

- Epithelium (squamous-stratified epithelium without keratinization)
- Lamina propria
 - cardiac glands of the esophagus (mucus)
- Muscularis mucosae

Submucosa

- Esophageal glands (open on the surface of the epithelium, mucous secretion)
- venous plexus near the cardia

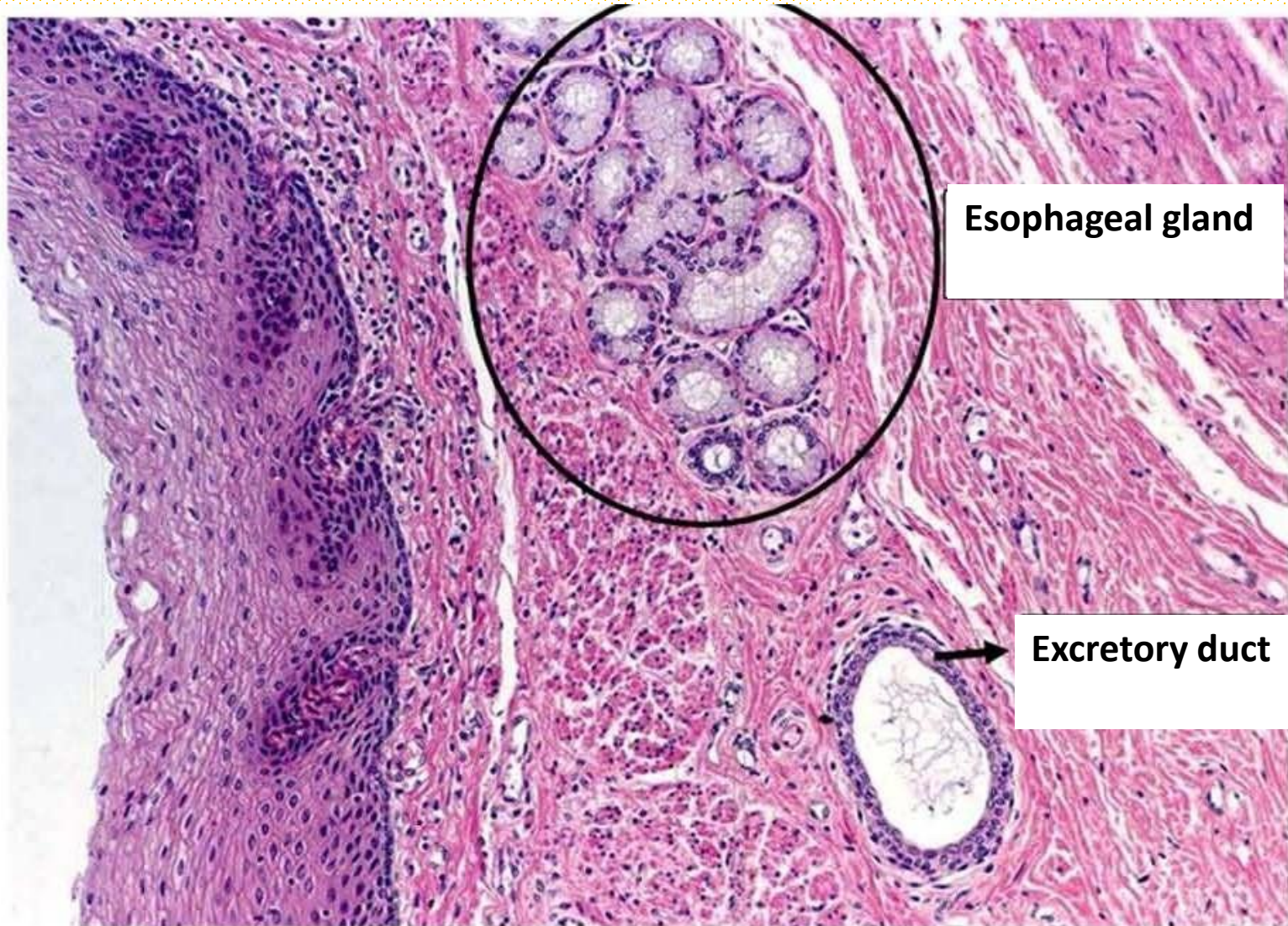
Muscularis externa

- circular sublayer
- longitudinal sublayer

Adventitia



Esophagus



Stomach

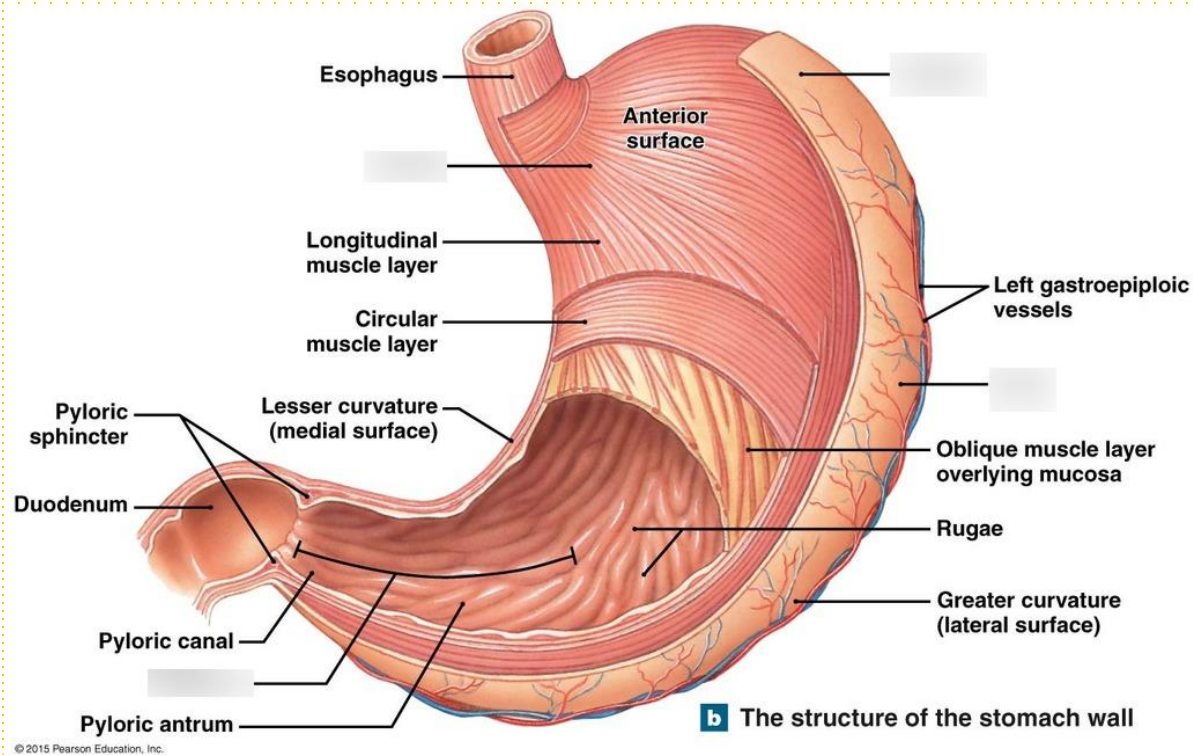
- Four parts:

- **Cardia**

- **Fundus**

- **Body**

- **Pylorus**



- The body and the fundus have an identical structure.
- The mucosa and submucosa of the stomach form long folds - **rugae**.
- **Gastric pits** are visible on inner surface, at the bottom of which the **gastric glands** open.

Mucosa

- Simple columnar epithelium
- Lamina propria
 - Gastric glands (opens at the gastric pits)
- Muscularis mucosae

Submucosa

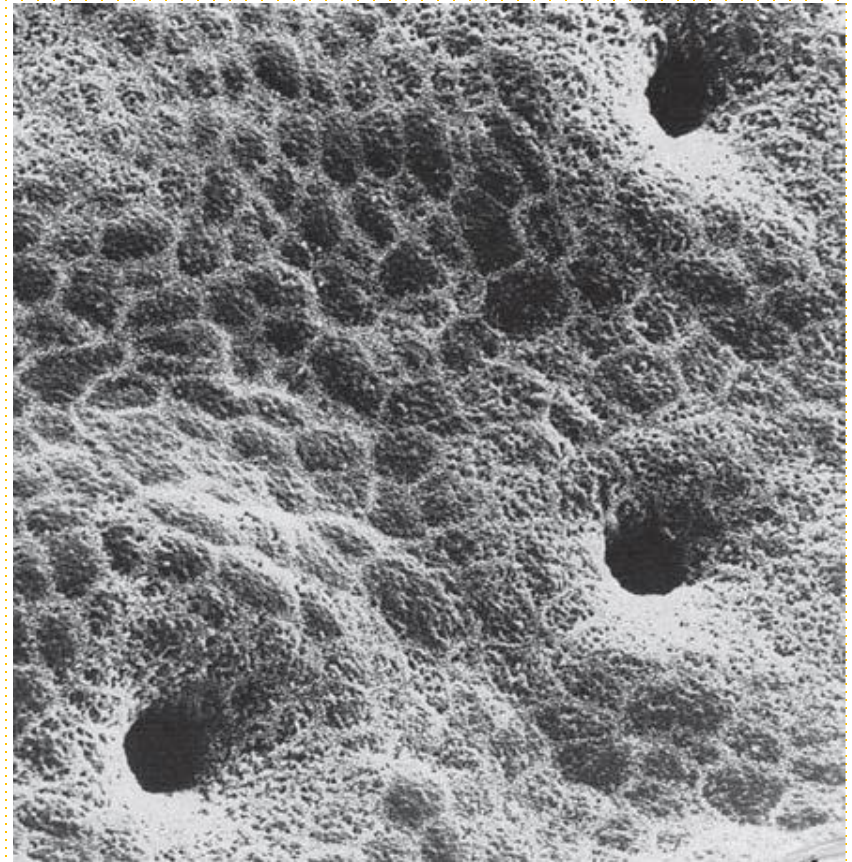
- Connective tissue, blood vessels, nerves

Muscularis externa

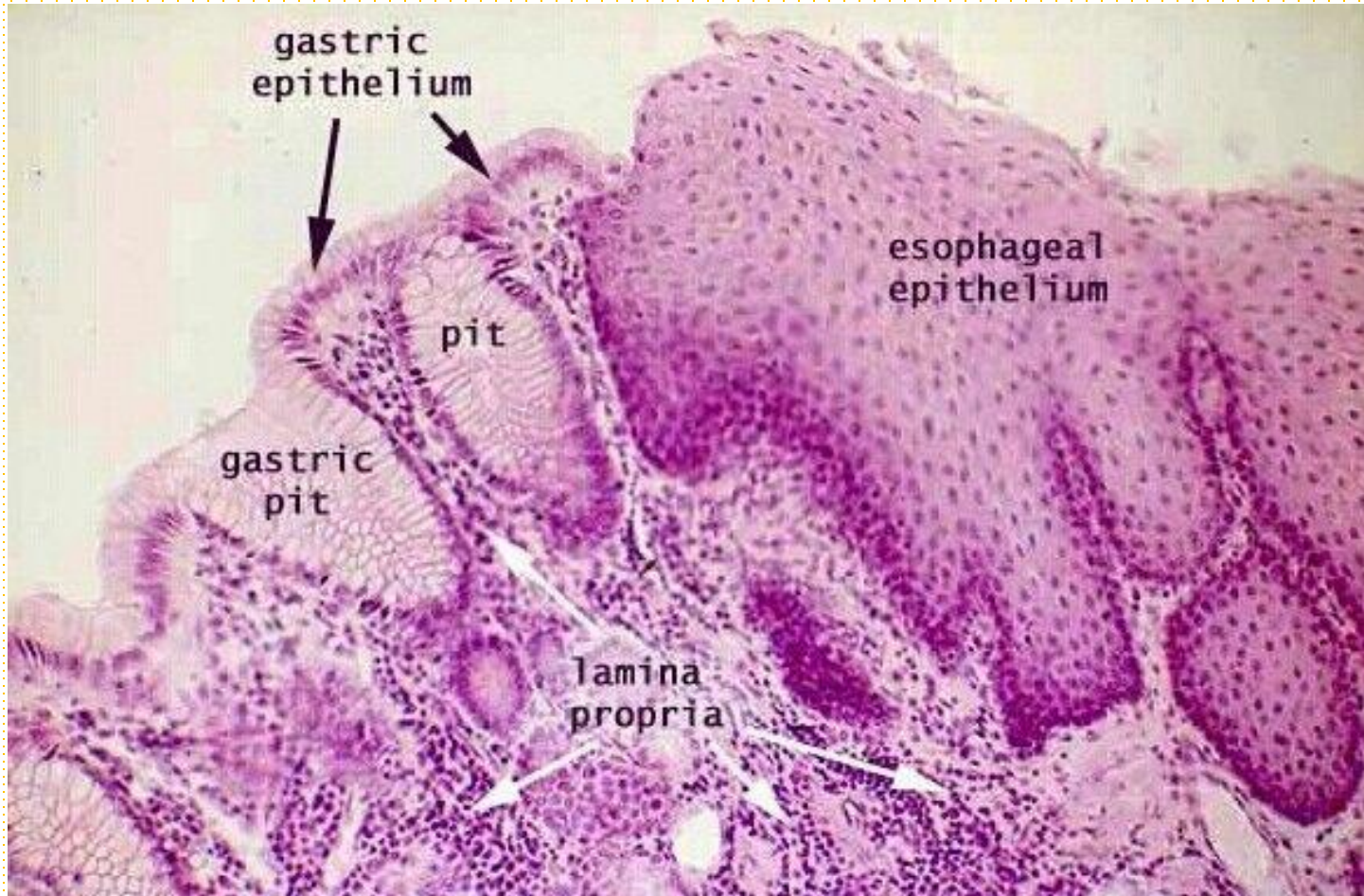
- oblique sublayer
- circular sublayer
- longitudinal sublayer

Serosa

- Loose CT covered by mesothelium



Cardia



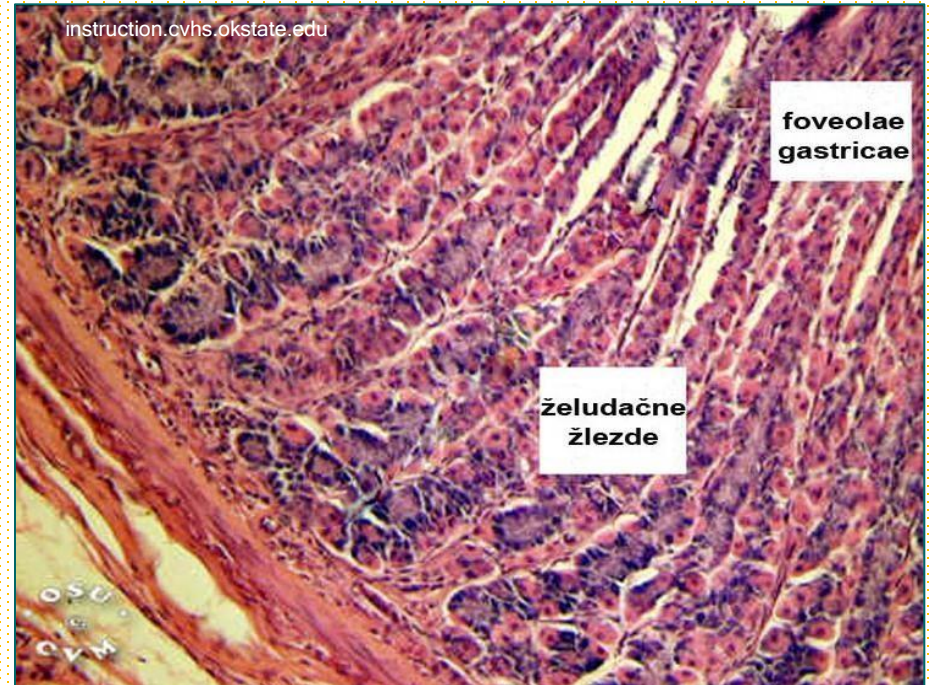
- Change of the non-keratinized squamous epithelium of the esophagus into a simple columnar epithelium of the stomach.
- In lamina propria **cardiac glands**
- **Strong cardiac sphincter**

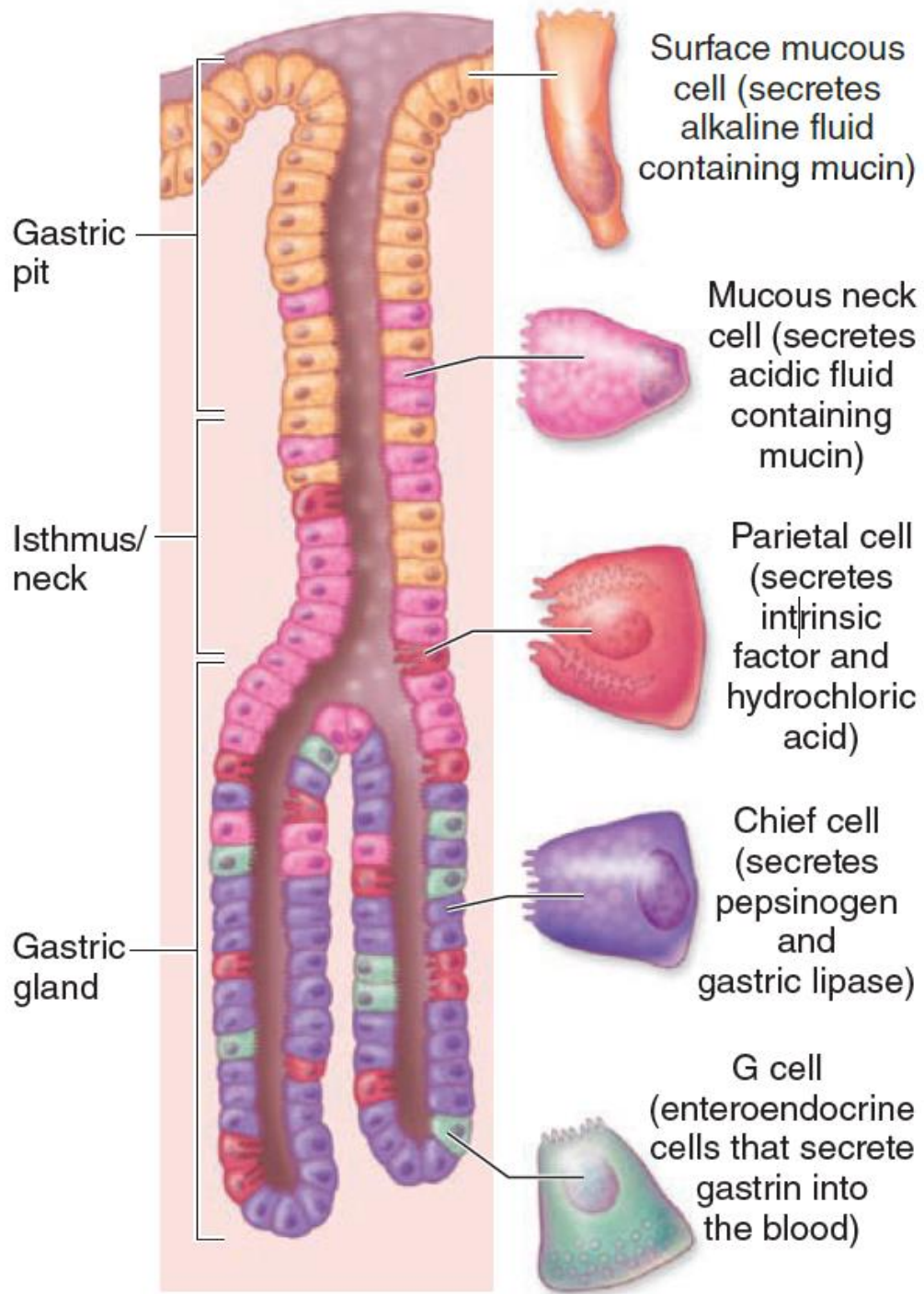
Gastric glands cell population

- The surface of the stomach and gastric pit is lined by simple columnar superficial **mucus cells**.
- At the bottom of each pit, 3-7 simple tubular, specific gastric glands open.
- The epithelium of specific gastric glands continues on the epithelium of the gastric pits.

It consists of five cell types:

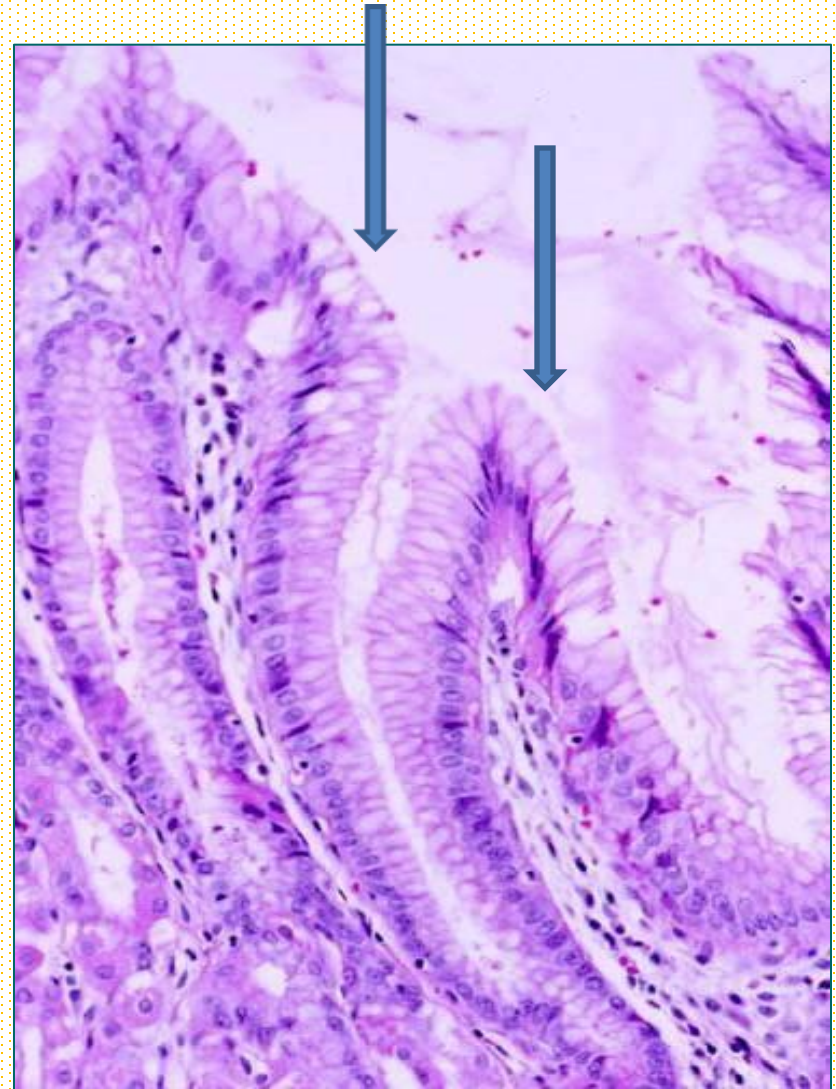
- **Mucus neck cells**
- **Chief cells**
- **Parietal cells**
- **Endocrine (enteroendocrine) cells**
- **Stem cells**





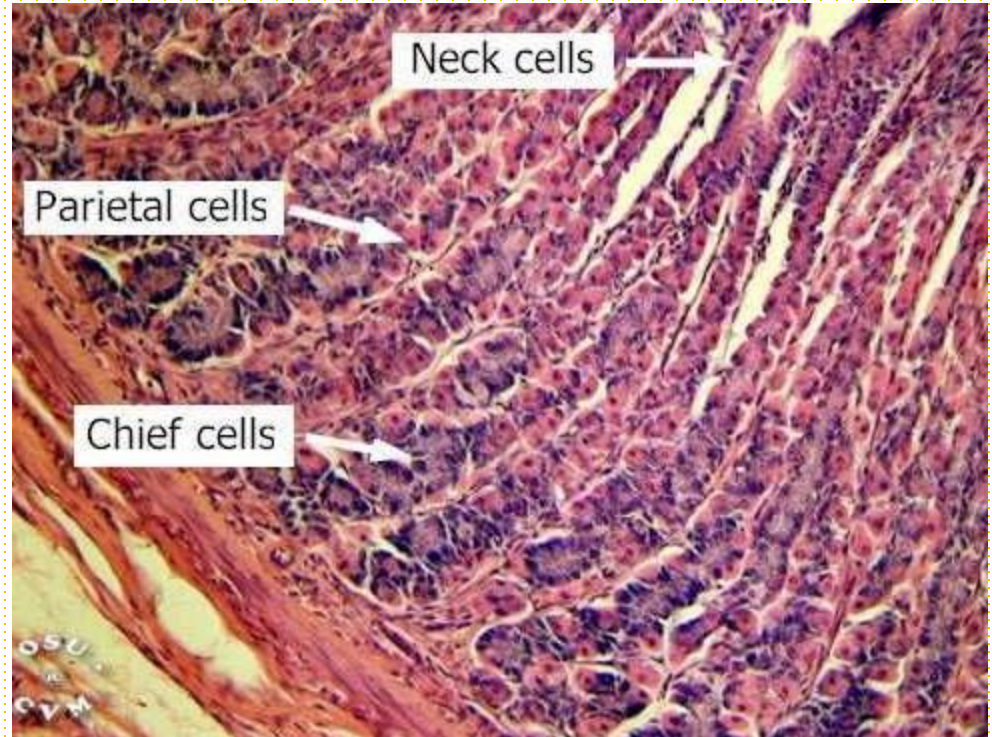
Surface mucous cells

- On the apical surface, rare **microvilli and glycocalyx**.
- Apically - **mucous granules** - are released by exocytosis at the apical pole.
- They contain glycosaminoglycans which bind bicarbonate ions.
- In the stomach, mucin is converted into mucus - forms thick gelatinous layer resistant to gastric HCl.
- Protective role, but suitable medium for *H. pylori*.



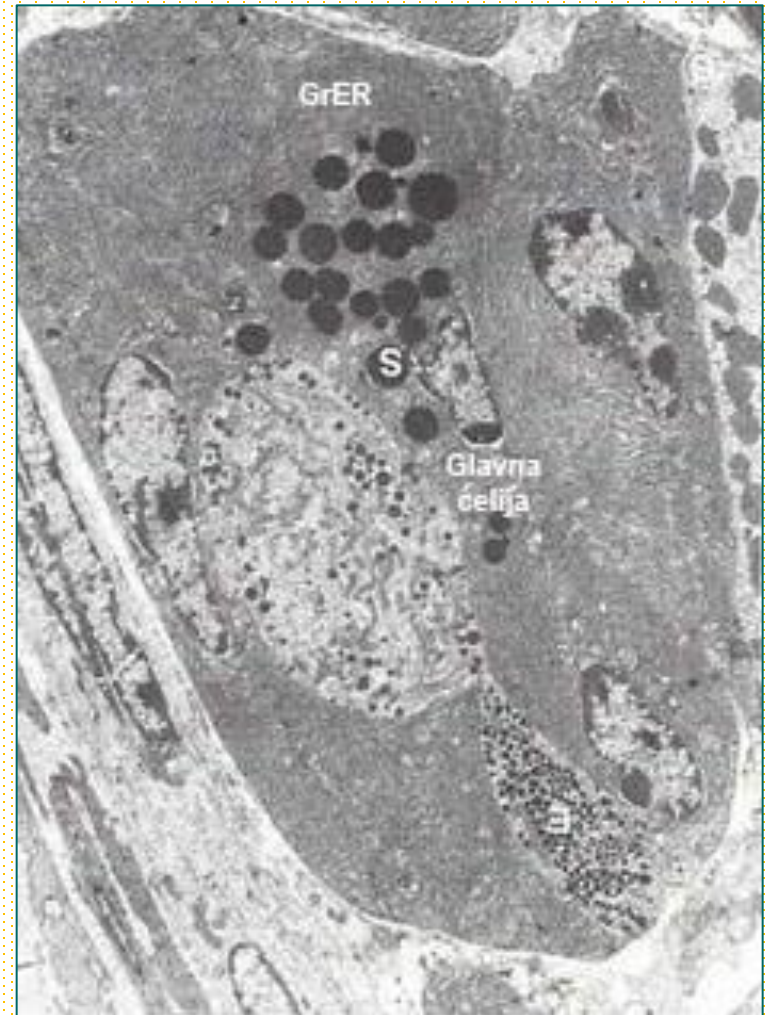
Mucus neck cells and stem cells

- **Mucus neck cells**, less columnar than the surface mucous cells
 - often distorted by neighboring cells, but they have round nuclei and apical secretory granules.
 - Their mucus secretion is less alkaline than that of the surface epithelial mucous cells.
 - Life span 4-7 days
-
- **Stem cells** are found in a narrow segment between each gastric pit and the gastric glands.
 - They divide asymmetrically, producing progenitor cells for all the other epithelial cells.



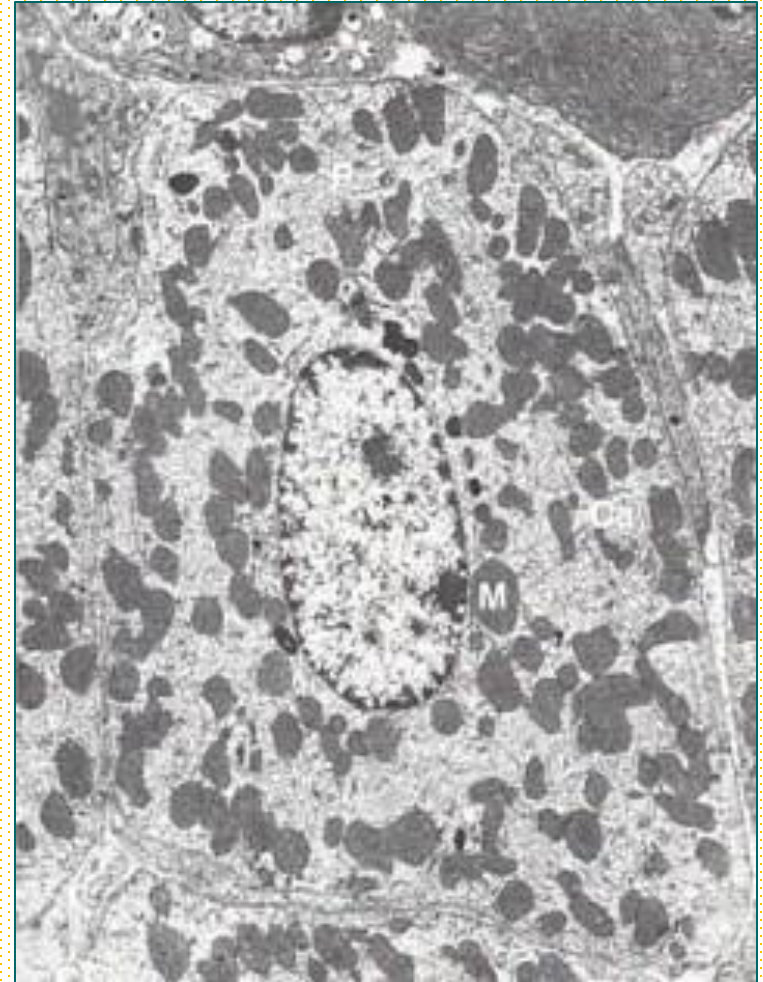
Chief cells

- **Chief** (zymogenic) cells predominate in the lower regions of the gastric glands
- Have all the characteristics of active protein-secreting cells.
- Ultrastructurally chief cells show abundant RER and numerous apical secretory granules
- The granules contain inactive enzyme **pepsinogen**, precursors which are converted in the acid environment of the stomach into active **pepsin**.
- Produce small amount of gastric lipase.
- In the basal domain, receptors for the **secretin** hormone.
- Life span 1-3 years

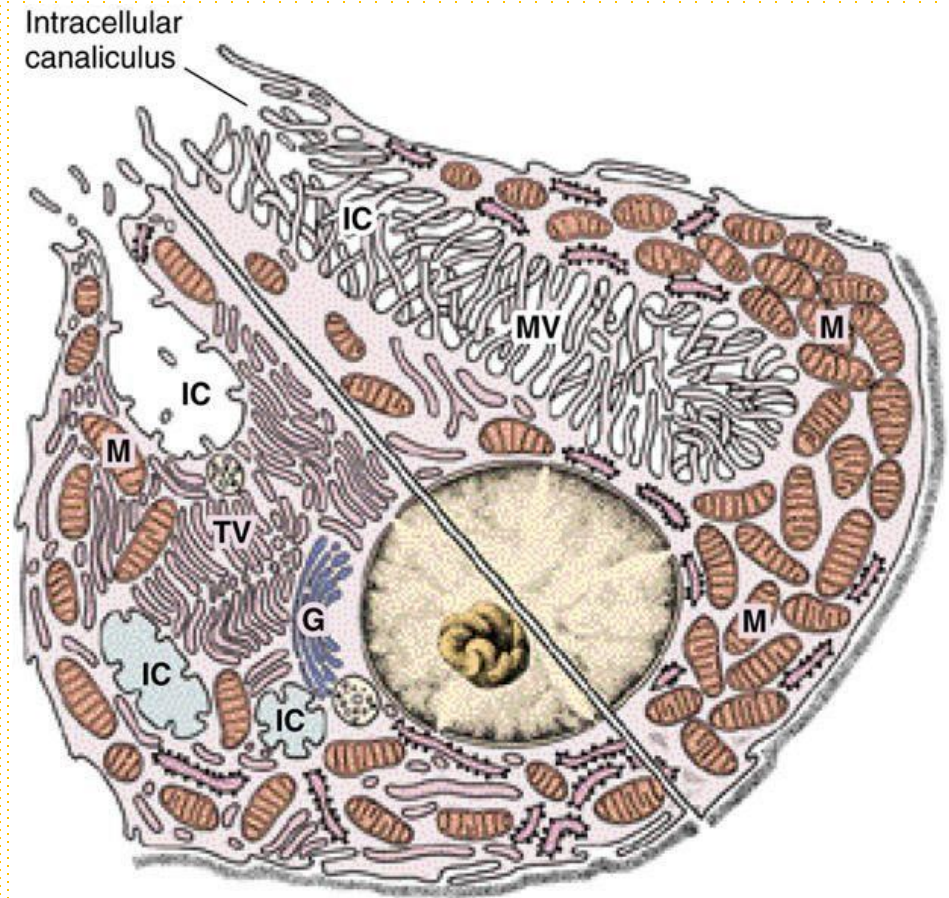


Parietal cells

- **Parietal (oxyntic) cells** are large (oval or pyramidal) cells that produce hydrochloric acid (HCl).
- Have one to two centrally placed nuclei, many mitochondria and the system of **branched intracellular canaliculus** (apical plasmalemmal invagination)
- In the basal region of the cell - receptors for **gastrin**, **histamine** and **acetylcholine** (promotes secretion of HCl)



- Ions of hydrogen and chlorine are pumped from the apical cytoplasm .
- Chlorine and hydrogen ions bind in the gastric lumen.
- From the intracellular channels, HCl reaches the lumen of the gastric gland.
- In addition to HCl, parietal cells also synthesize **intrinsic factor** - a glycoprotein necessary for the absorption of vitamin B12.
- The intrinsic factor-vitamin B12 complex is created in the stomach and absorbed in the ileum.
- Deficiency - **pernicious anemia**.



parietal cell canalicular network

m

can

can

m

2

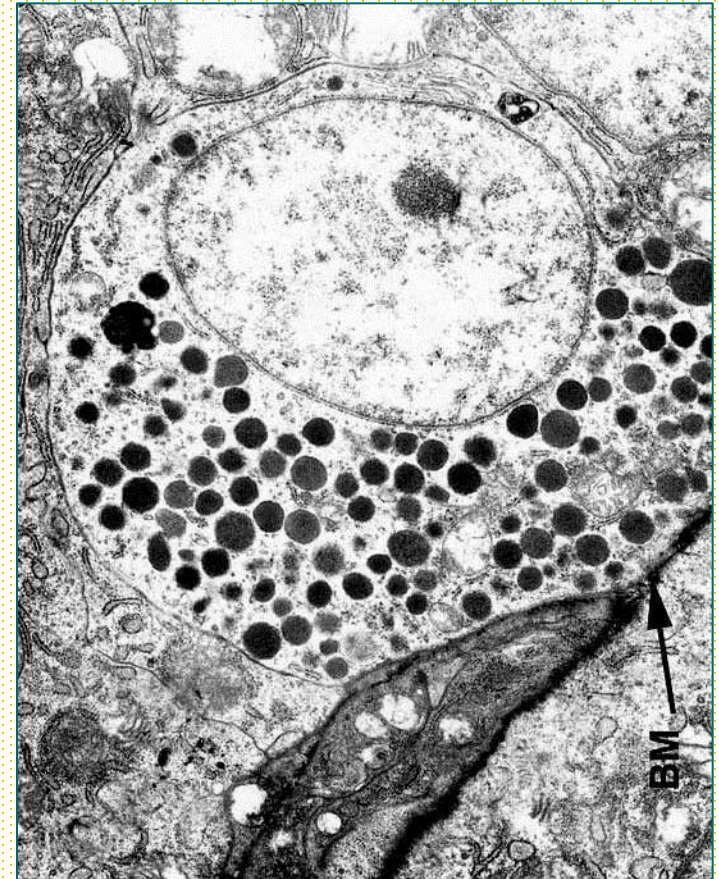


Endocrine cells

- **Enteroendocrine cells** are scattered epithelial cells in the gastric mucosa with endocrine or paracrine functions.
- Enteroendocrine cells secreting different hormones are also found in the intestinal mucosa and are of major importance for function of the digestive tract
- All such cells are more generally considered part of **the diffuse neuroendocrine system (DNES)**

Two classes:

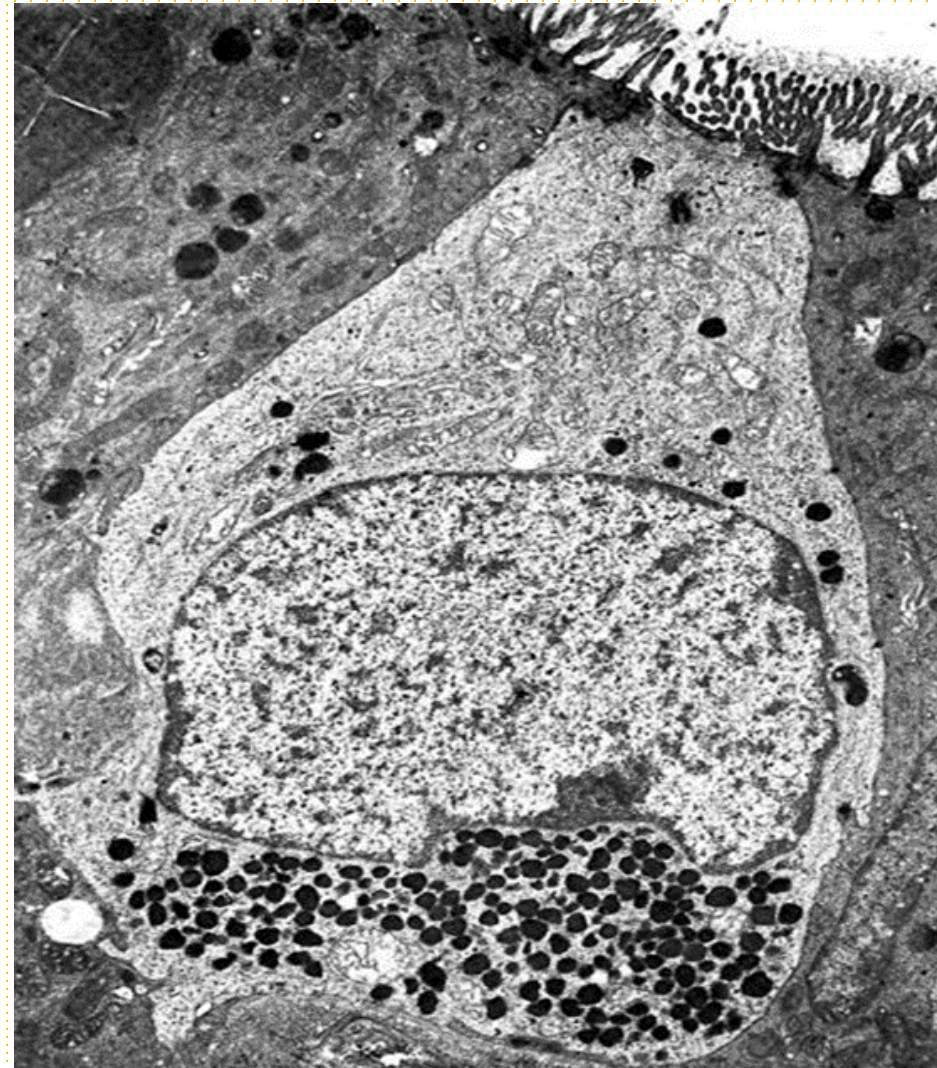
- “closed” type, in which the cellular apex is covered by neighboring epithelial cells
- “open” type, in which the constricted apical end of the cell contacts the lumen and bears chemoreceptors that sample the lumen’s contents.



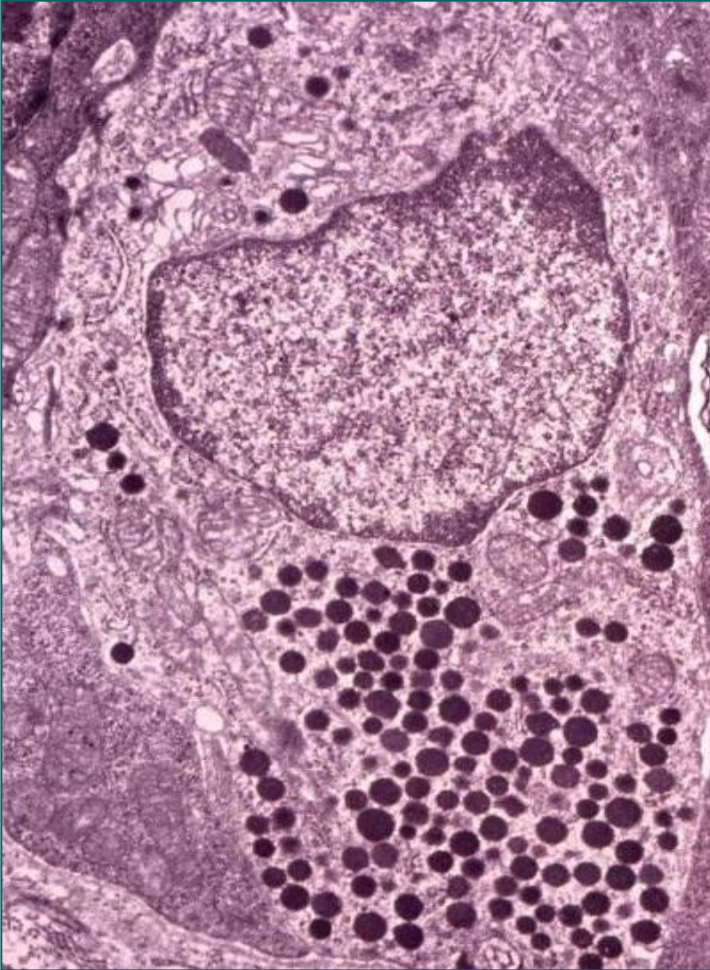
Dr Ihab El-Zhogby of the Faculty of Veterinary Medicine at Zagazig University in Egypt

DNES

- In the antrum, 50% are G-cells ([gastrin](#)), 30% EC-cells ([serotonin](#)), 15% D-cells ([somatostatin](#)),
- in the fundus and body, the most numerous are ECL-cells ([histamine](#)).

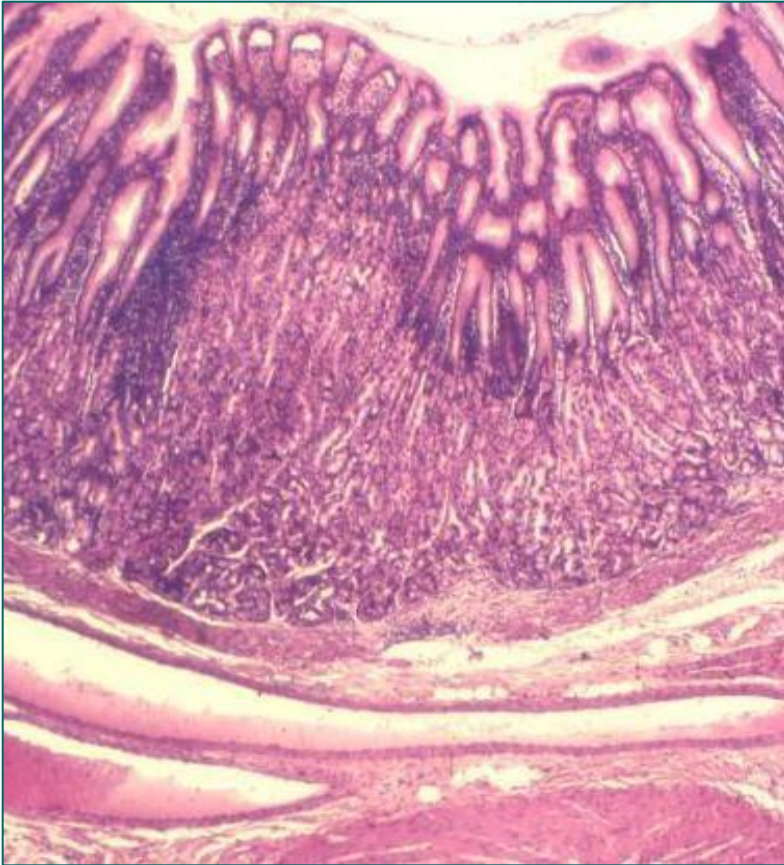


DNES



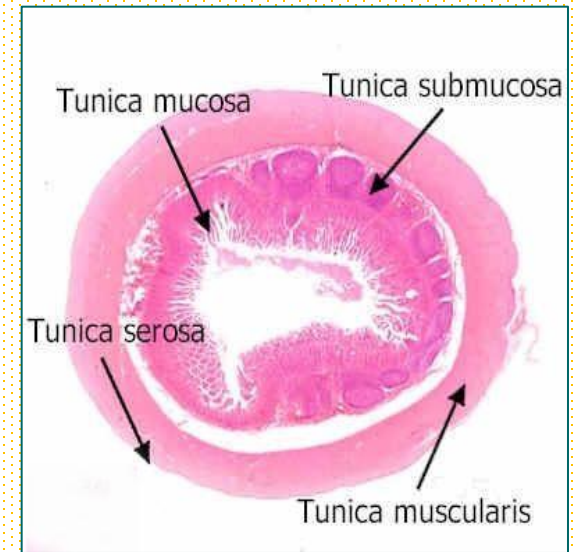
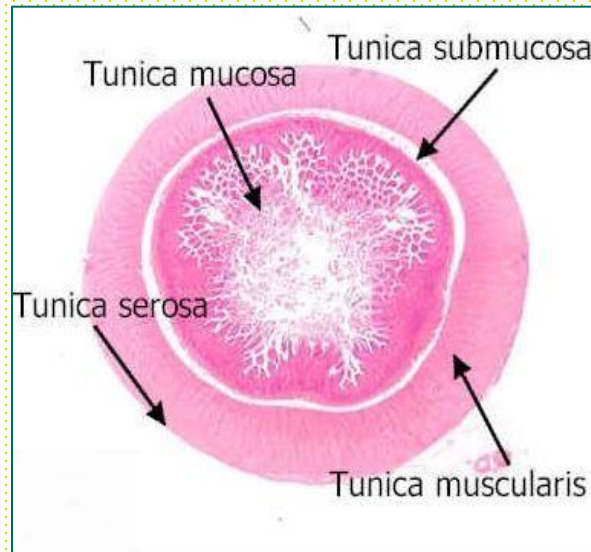
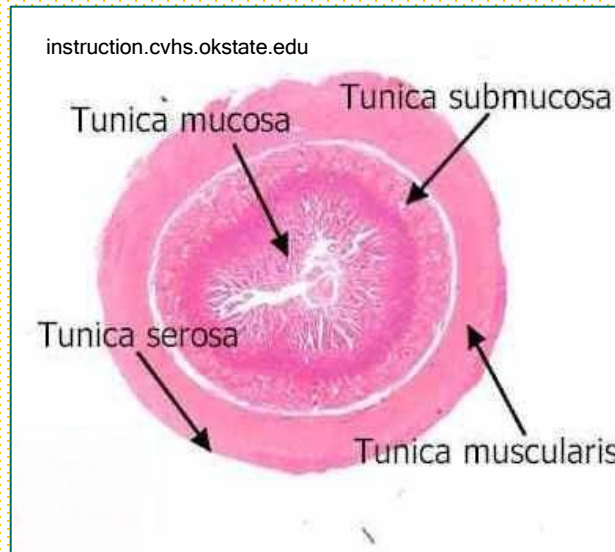
- Through their peptides and biogenic amines, they regulate **secretion**, **absorption**, **digestion**, **motility**, **cell proliferation** and **diameter of blood vessels**.
- DNES neurons possess neuroendocrine or even neurotransmitter function.
- Apart from the digestive system, DNES cells are also present in the epithelium of the respiratory system, urogenital system and skin.

Pylorus



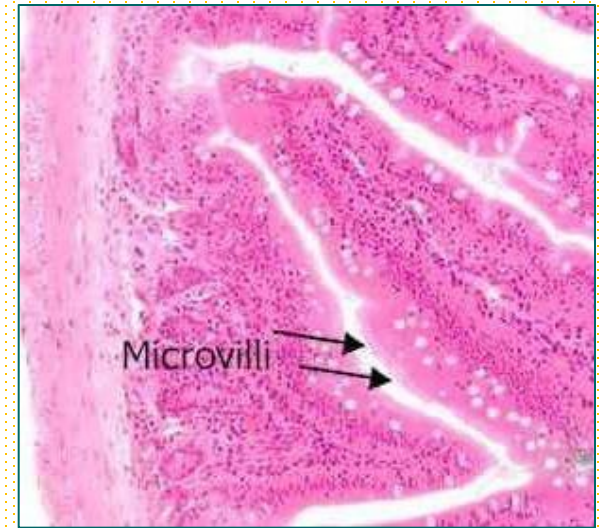
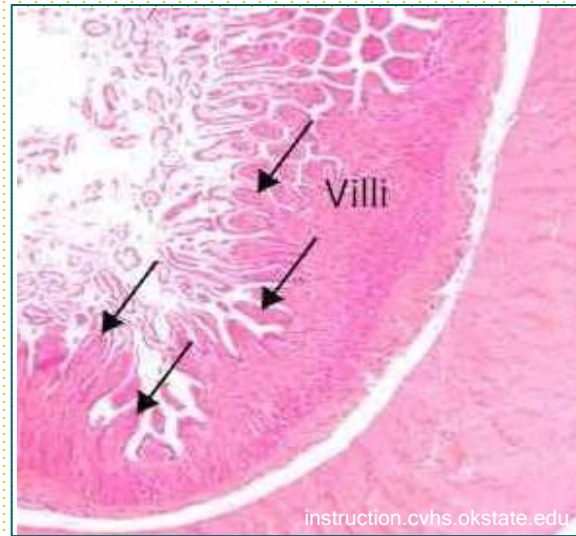
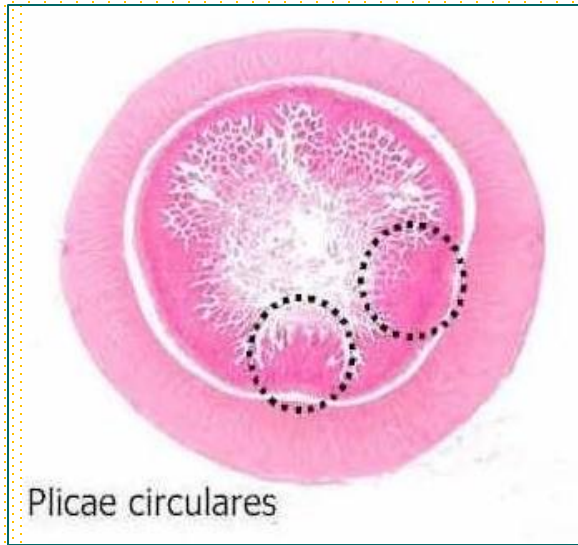
- Short **pyloric glands** in the lamina propria (highly branched).
- Muscularis externa - **strong pyloric sphincter** (middle sublayer)

Small intestine



The small intestine extends from the pylorus to the ileocecal valve.

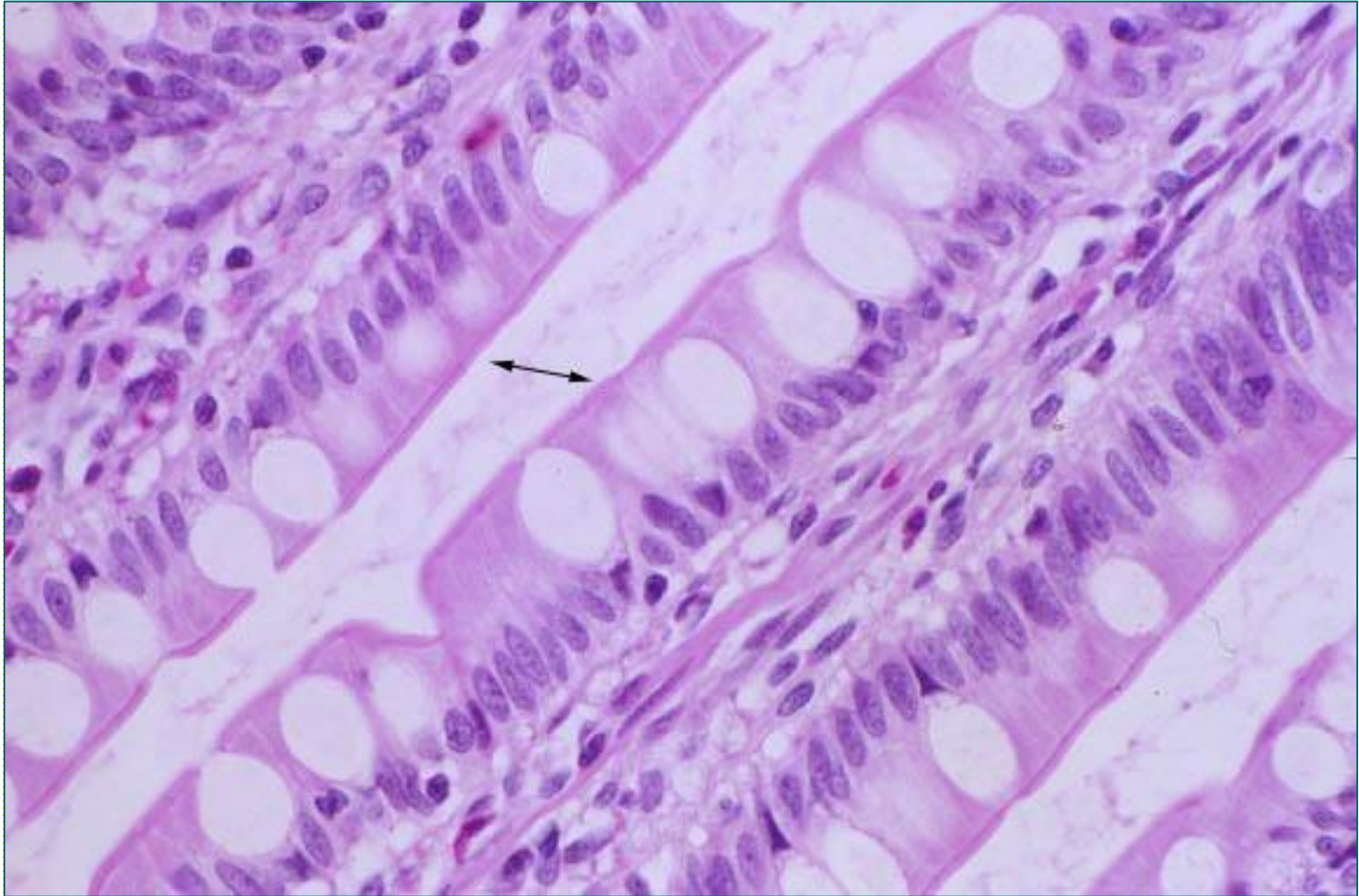
- It is about 6m long, 4 cm wide and has three segments:
 - duodenum (25 cm)
 - jejunum (2,5 m)
 - ileum (3,5 m)



- **Circular folds** - folds of the mucosa and part of the submucosa (1-1.5cm). They appear 5 cm from the pylorus, they are most abundant in the distal parts of the duodenum and the beginning parts of the jejunum.
- **Intestinal villi** – mucosal outgrowths that protrude into the intestinal lumen (0.5-1.5mm). In the duodenum - leaf-shaped, in the jejunum and ileum finger-shaped.
- **Microvilli** - cytoplasmic processes of enterocytes (1 μ m). Each enterocyte has several thousand microvilli - a brushed (striated) border.

Specializations increase the surface area of the small intestine from 1m² to 900m².....or 200m².....or 600m².....or 4500m²

Brushed border - microvilli

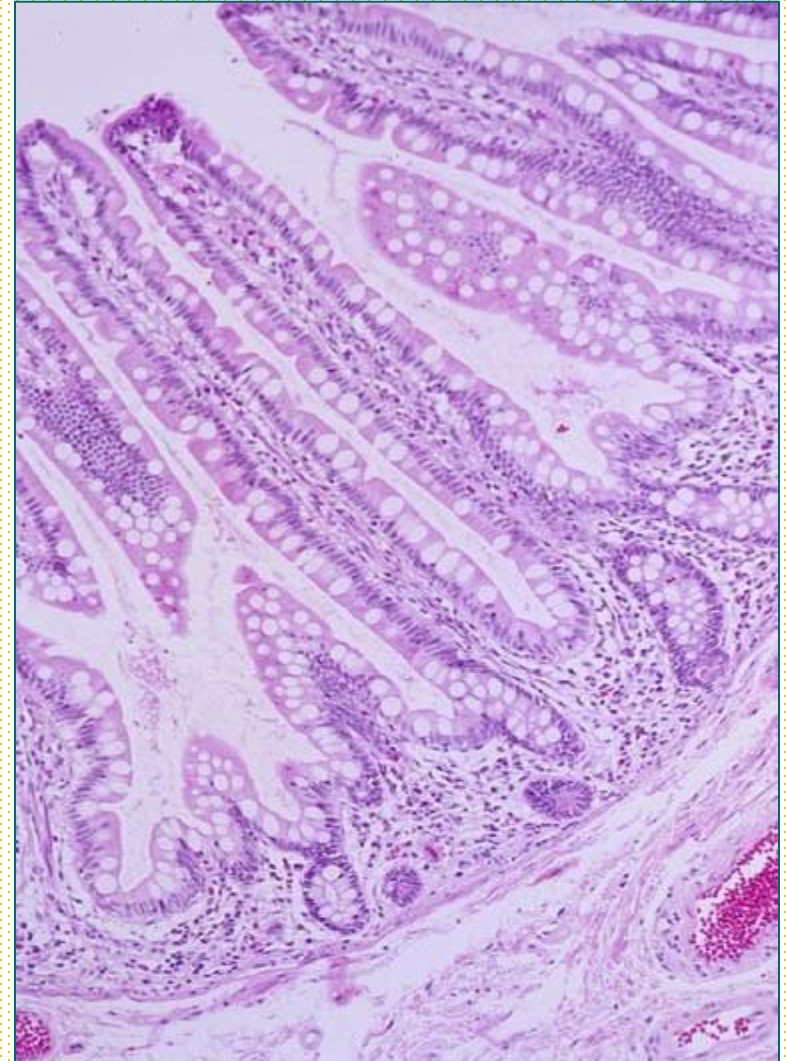


Mucosa

The mucosa is made up of **epithelium, lamina propria and muscularis mucosae**.

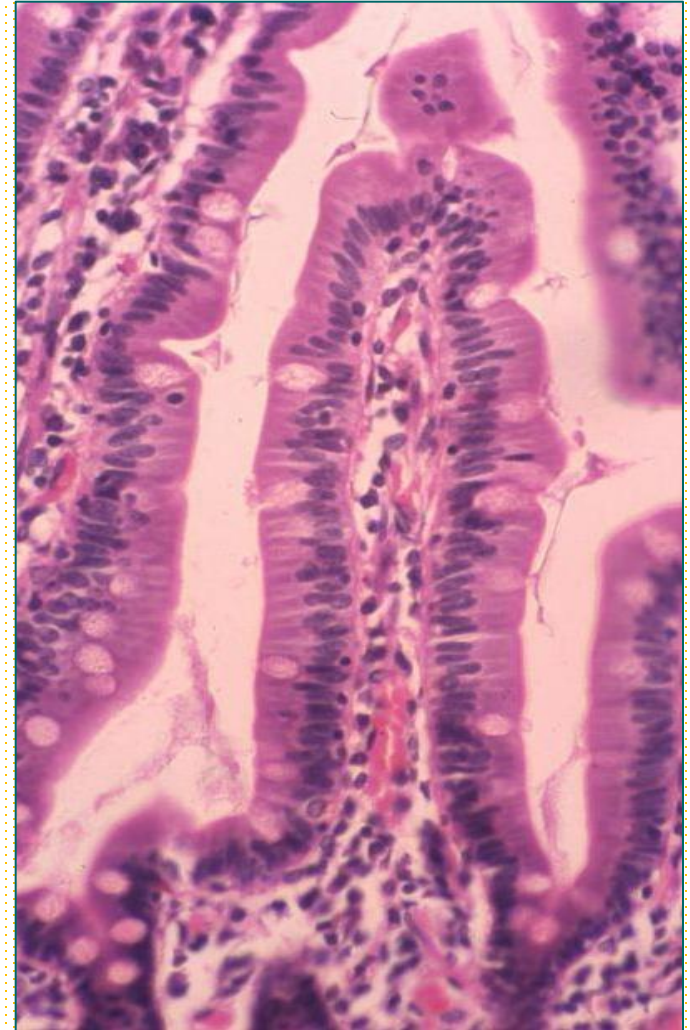
Intestinal villi and intestinal glands (crypts of Lieberkuhn)

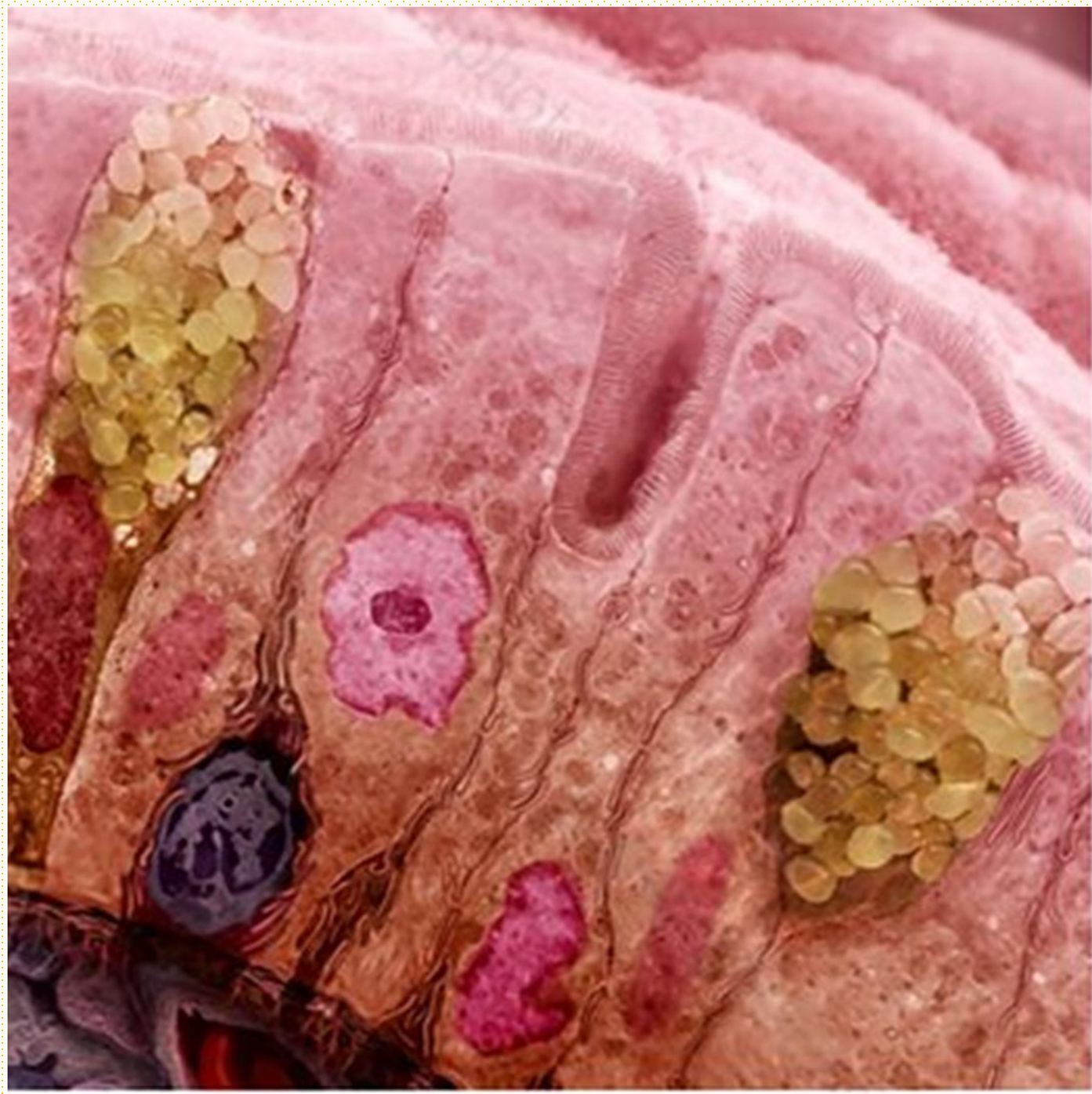
- Simple columnar epithelium with **enterocytes** (surface epithelium) and
- **Lieberkuhn crypts** responsible for secretion, regulation of normal bacterial flora and restoration of the entire intestinal epithelium.
- **Smooth muscles** in muscularis mucosae

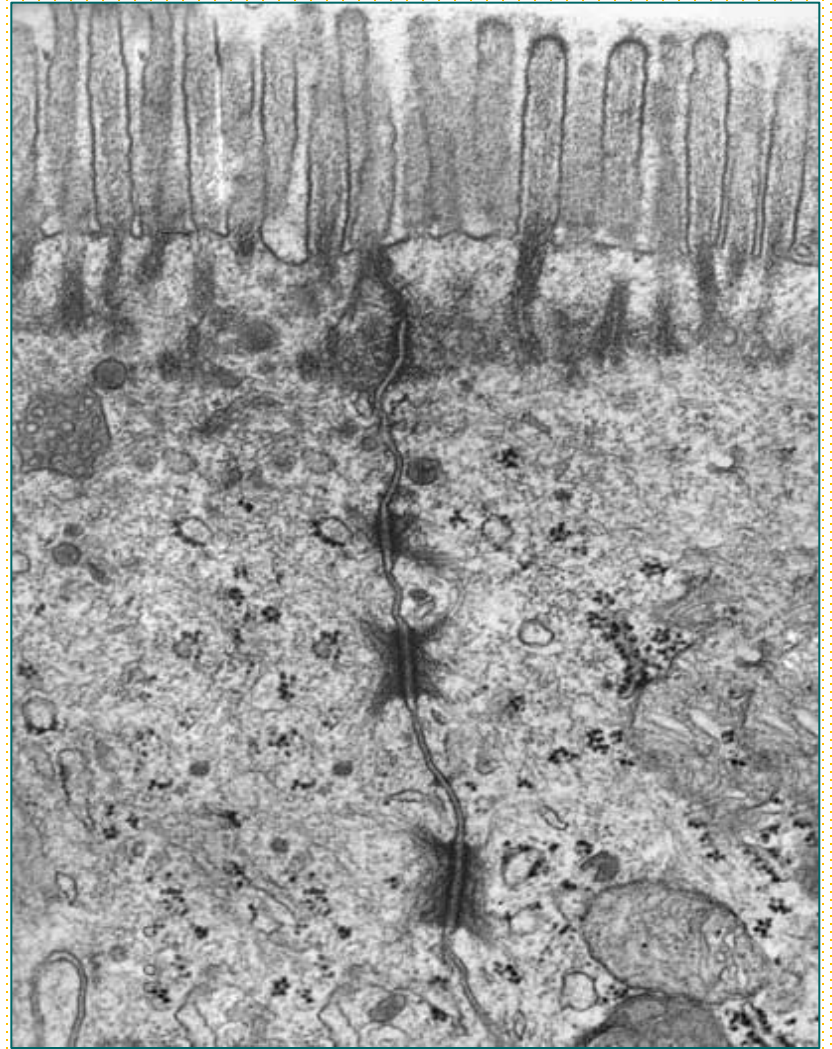


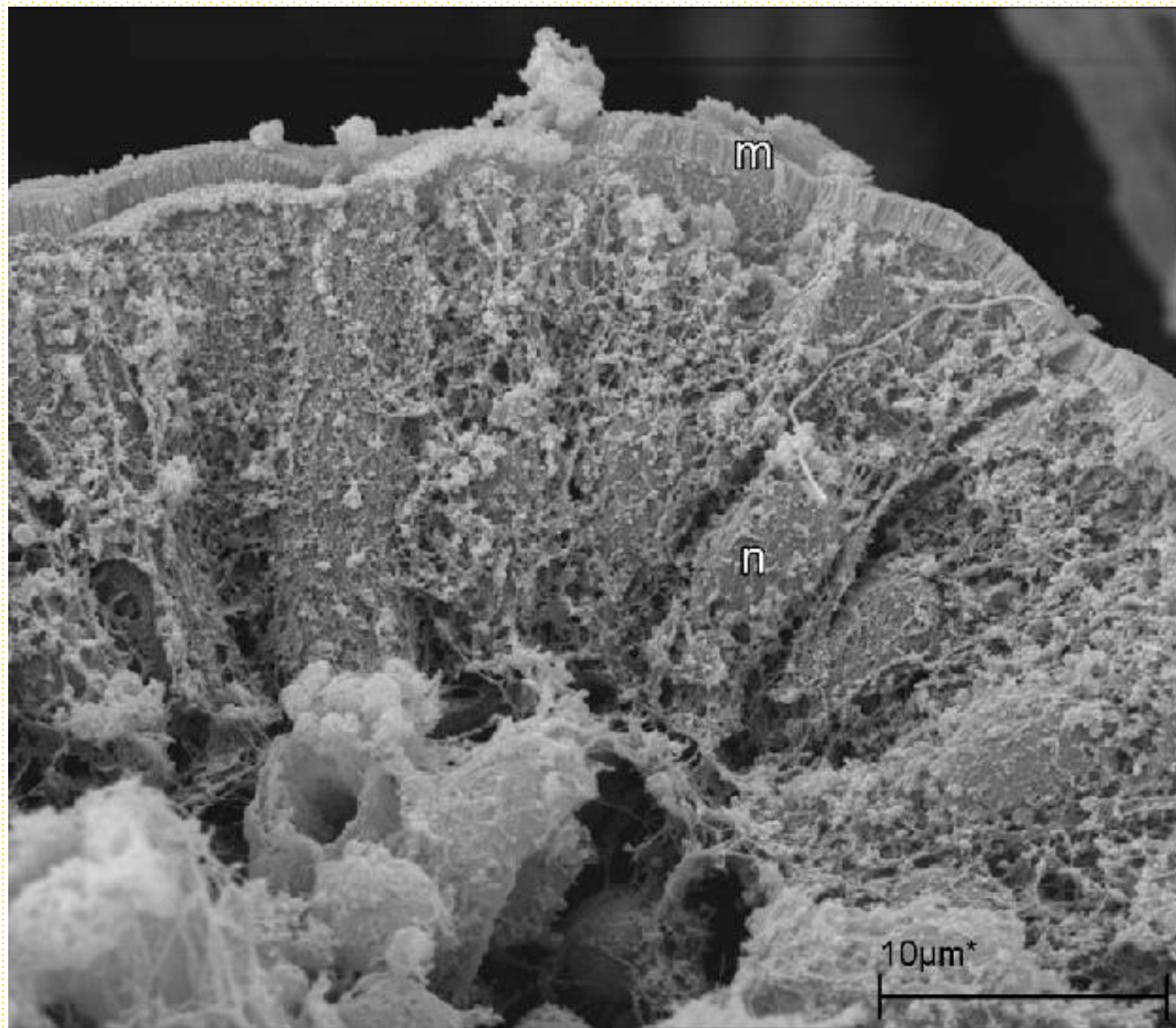
Enterocytes

- **Enterocytes** are absorptive cells.
- The most numerous cells in the epithelium of the small intestine.
- Specialized for the transport of substances from the lumen to the vascular system of the lamina propria.
- Cylindrical cells joined by occlusive and adherent junctions.
- On the apical surface - **microvilli** –brush border.
- The **glycocalyx** protects them from autodigestion.
- The glycocalyx contains digestive enzymes incorporated into the apical plasmalemma - terminal digestion of peptides and carbohydrates.
- At the basal pole – receptor for IgA.
- The lifespan of enterocytes is **1.5 to 3 days**.





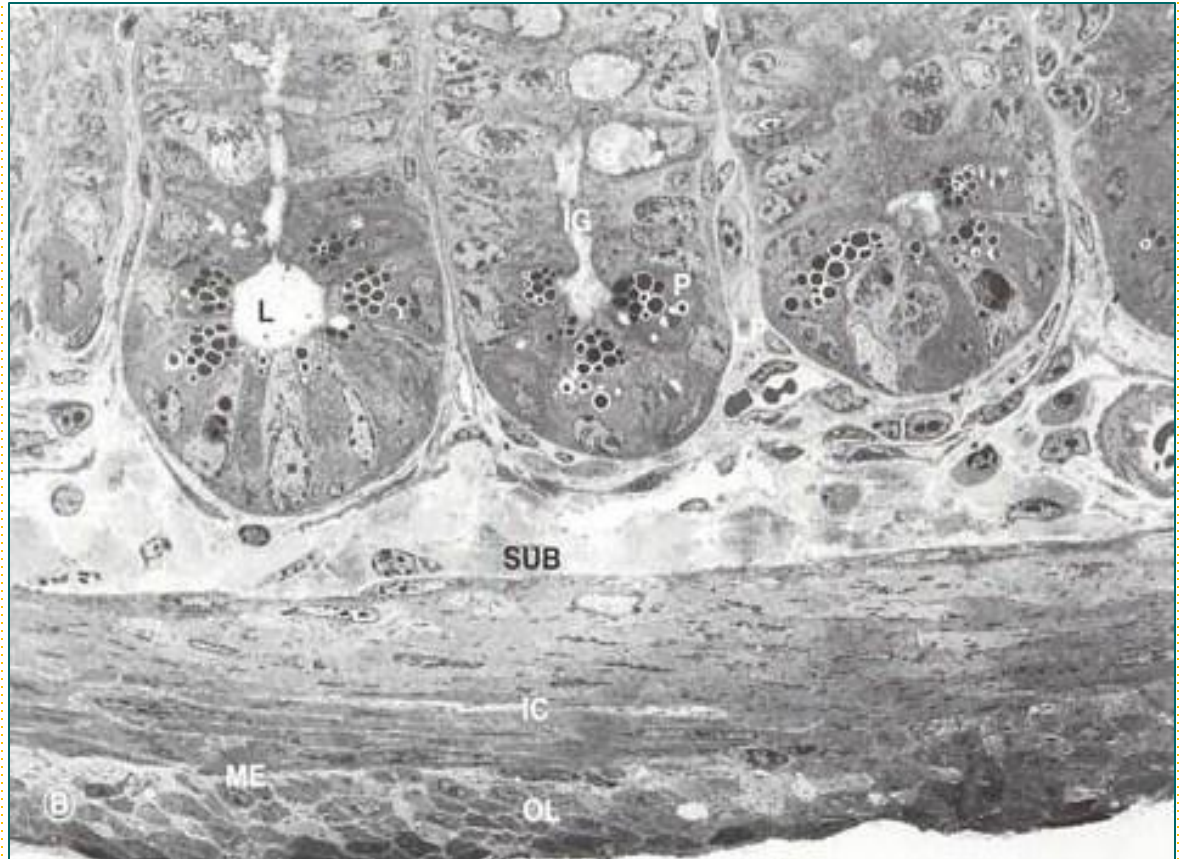




Lieberkuhn crypt

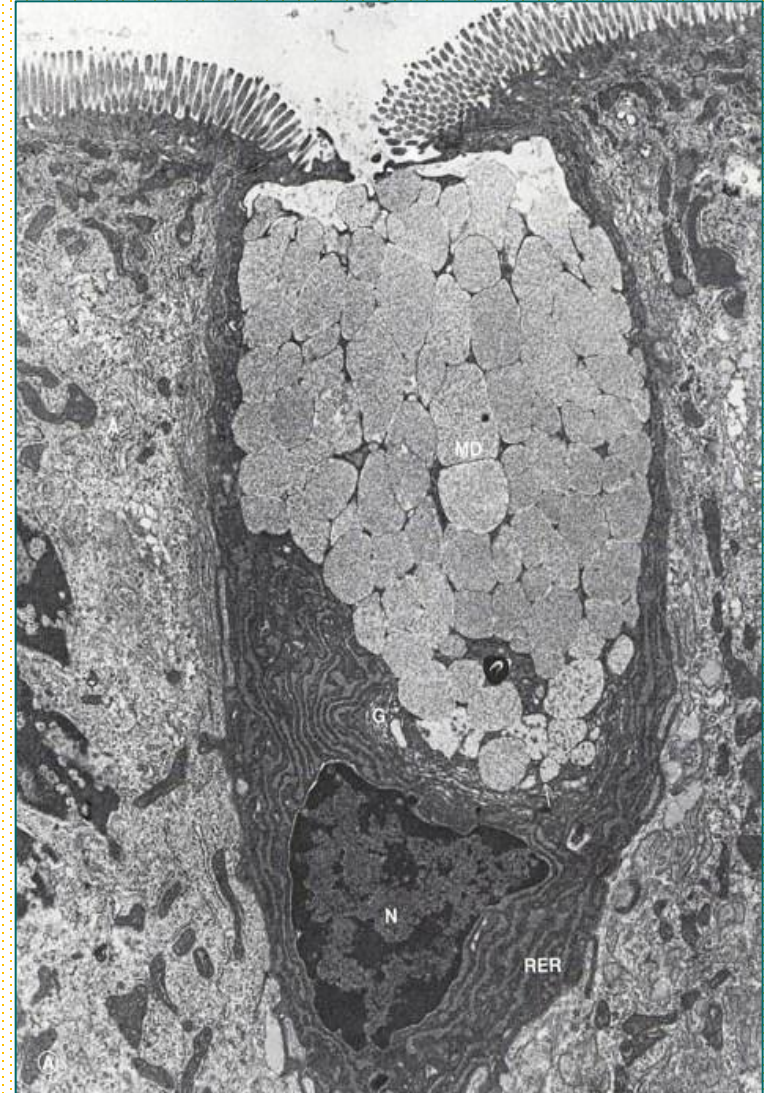
The epithelium of Lieberkuhn crypts (intestinal glands) is made up of:

- enterocytes
- goblet cells
- enteroendocrine cells
- Paneth cells
- M cells
- stem cells

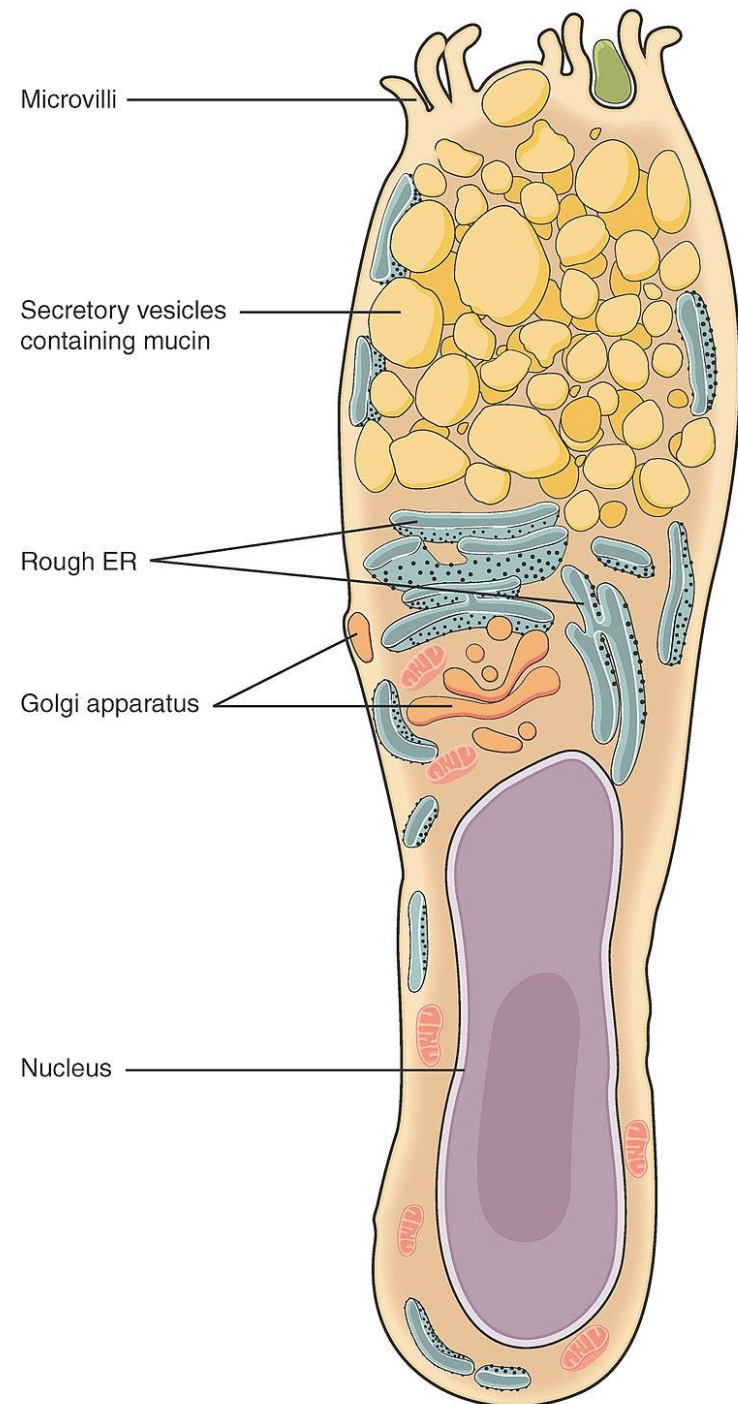


Goblet cells

- **Goblet cells** are interspersed among the absorptive enterocytes. They secrete glycoprotein mucins, which are then hydrated to form mucus, whose main function is to protect and lubricate the lining of the intestine
- Their number increases in the proximal-distal direction.
- Highly polarized with the nucleus and other organelles concentrated at the base of the cell and secretory granules containing mucin, at the apical surface.

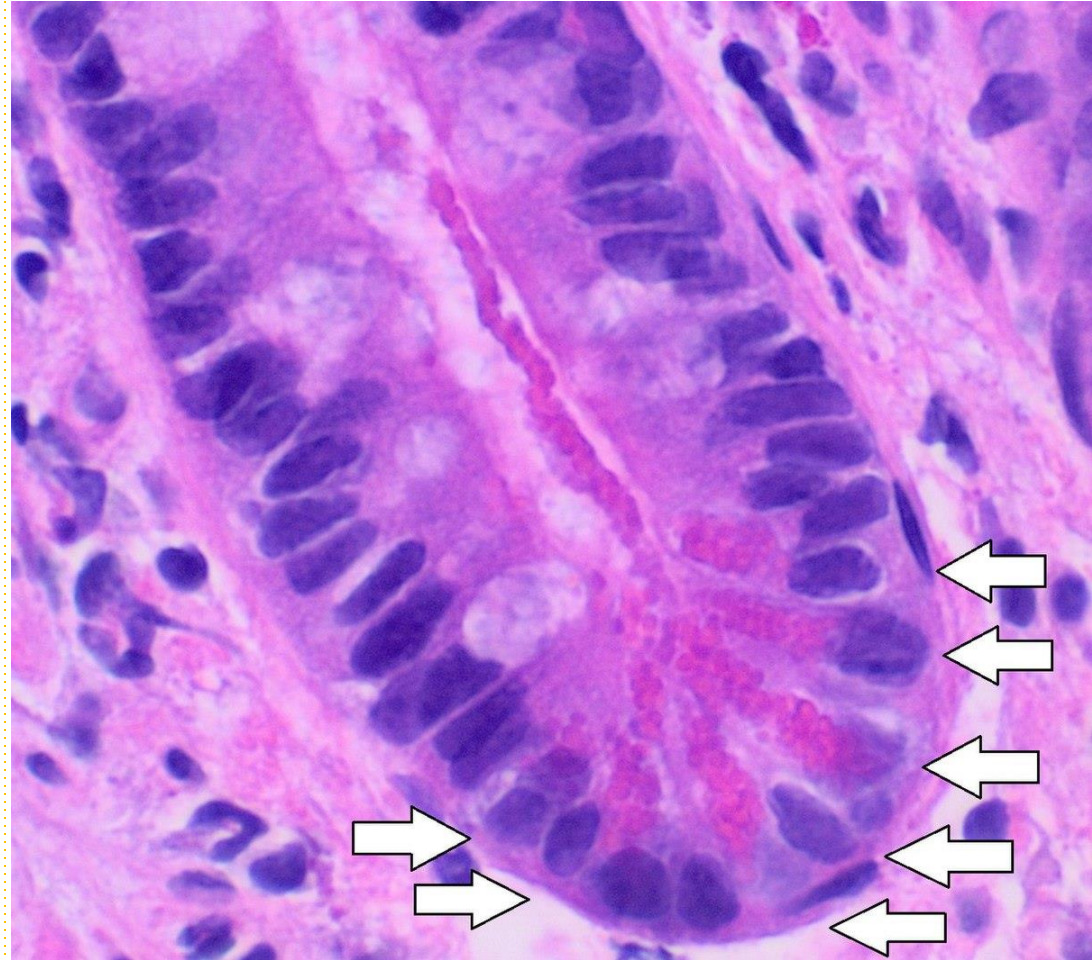


- The gel-like properties of mucins are given by its carbohydrates attracting relatively large quantities of water.
- On the inner surface of the human intestine, it forms a 200 μm thick layer that lubricates and protects the wall of the organ.



Paneth cells

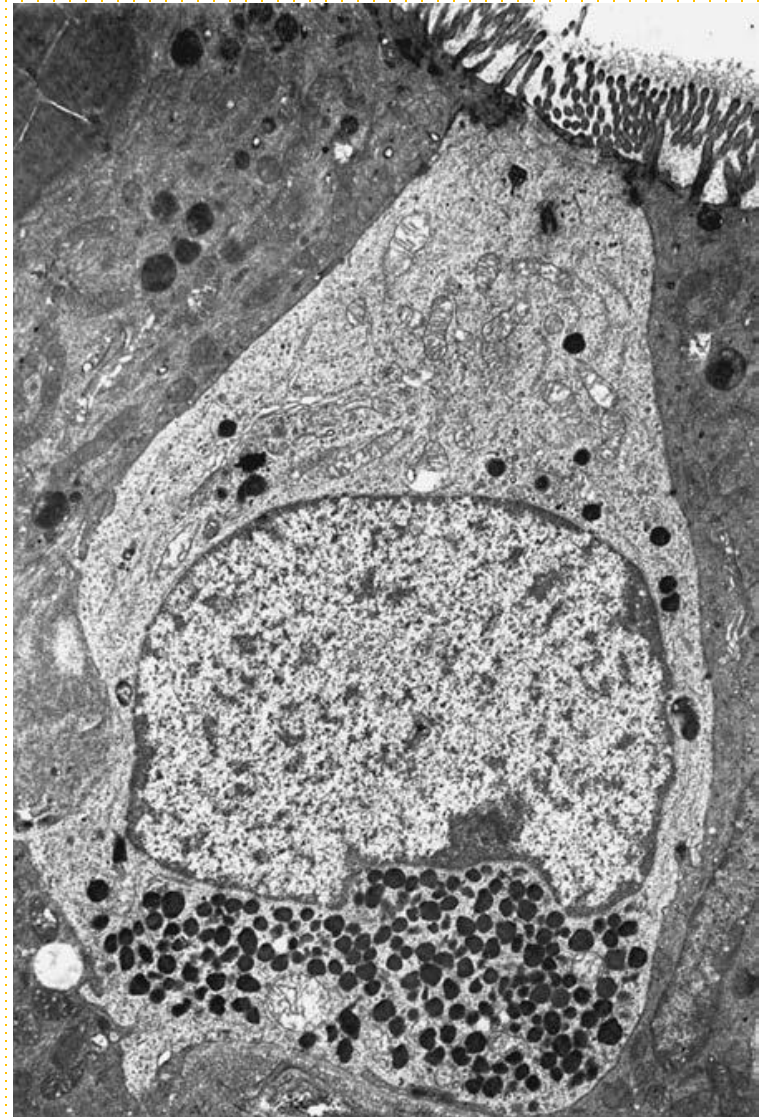
- Located at the **bottom of Lieberkuhn crypts**.
- They produce antimicrobial peptides and proteins and other components that are important in host defense and immunity.
- Cylindrical or pyramidal in shape, nucleus and rER localized basally.
- In the supranuclear space - numerous primary and secondary lysosomes and large secretory granules.
- Contains the enzymes **lysozyme** (destroys the bacterial wall) and **defensins**.
- They can phagocytose some bacteria and protozoa.
- Longest lifespan among intestinal cells - 20 days.





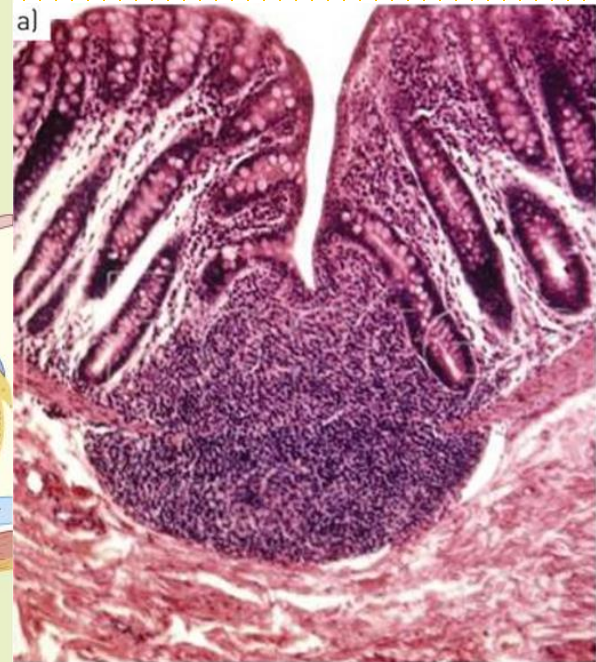
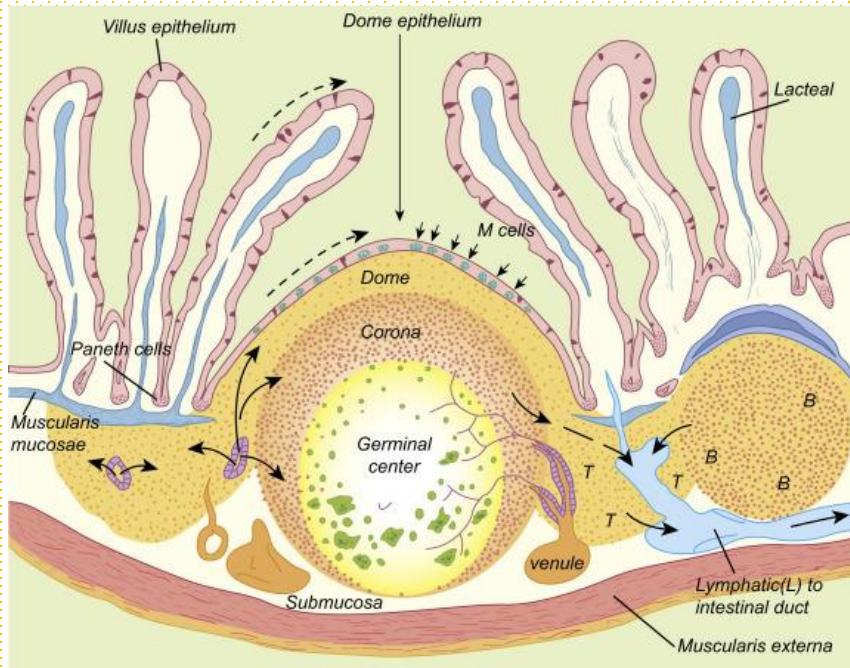
Ентероендокрине ћелије

- Enteroendocrine cells represent less than 1%.
- Cholecystokinin, secretin, gastric inhibitory polypeptide, motilin and neurotensin-secreting cells are found in the small intestine.
- Many of these are of the “open” type, with apical end of the cell contacts the intestinal lumen and has chemoreceptors sampling certain nutrients to regulate hormone release basally.

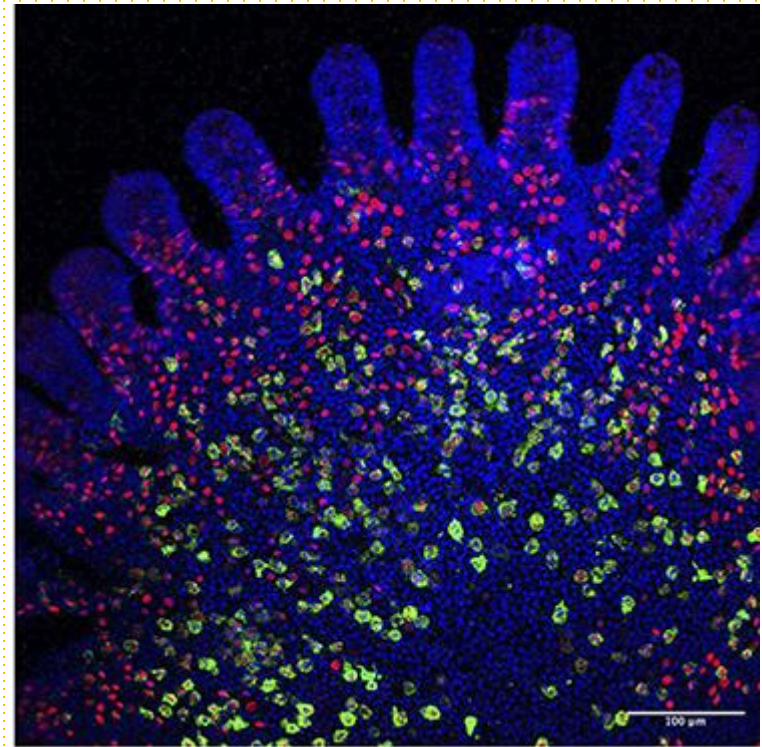


M cells

- Microfold cells (or M cells) are found in the gut-associated lymphoid tissue (GALT) of the Peyer's patches in the small intestine, and in the mucosa-associated lymphoid tissue (MALT) of other parts of the gastrointestinal tract.
- Antigen-transporting cells.
- They have microfolds on the apical plasmalemma - microfold cells.
- Between the basolateral compartments of M cells are intraepithelial T lymphocytes.



- M cells accept antigens from the lumen by endocytosis and transport them to the basolateral compartment (bring them into contact with T lymphocytes).
- More recent research has shown that M cells phagocytose bacteria and viruses.
- They can also transport antigens into the lamina propria (discontinuous BM below the M-cells)



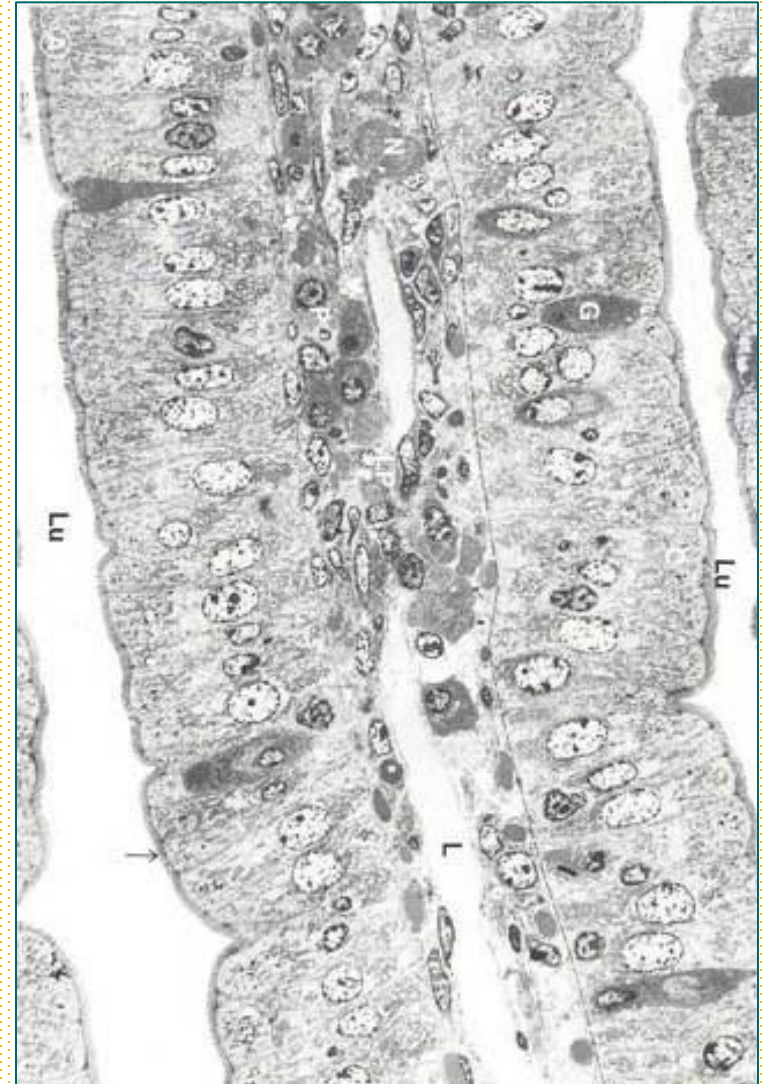
Stem cells

- Located in the lower half of Lieberkühn's crypts, just above Paneth's cells (zone of cell replication).
- They have short microvilli, scarce organelles.
- Have a 24 hours life cycle.
- Their division creates the other intestinal epithelial cells.

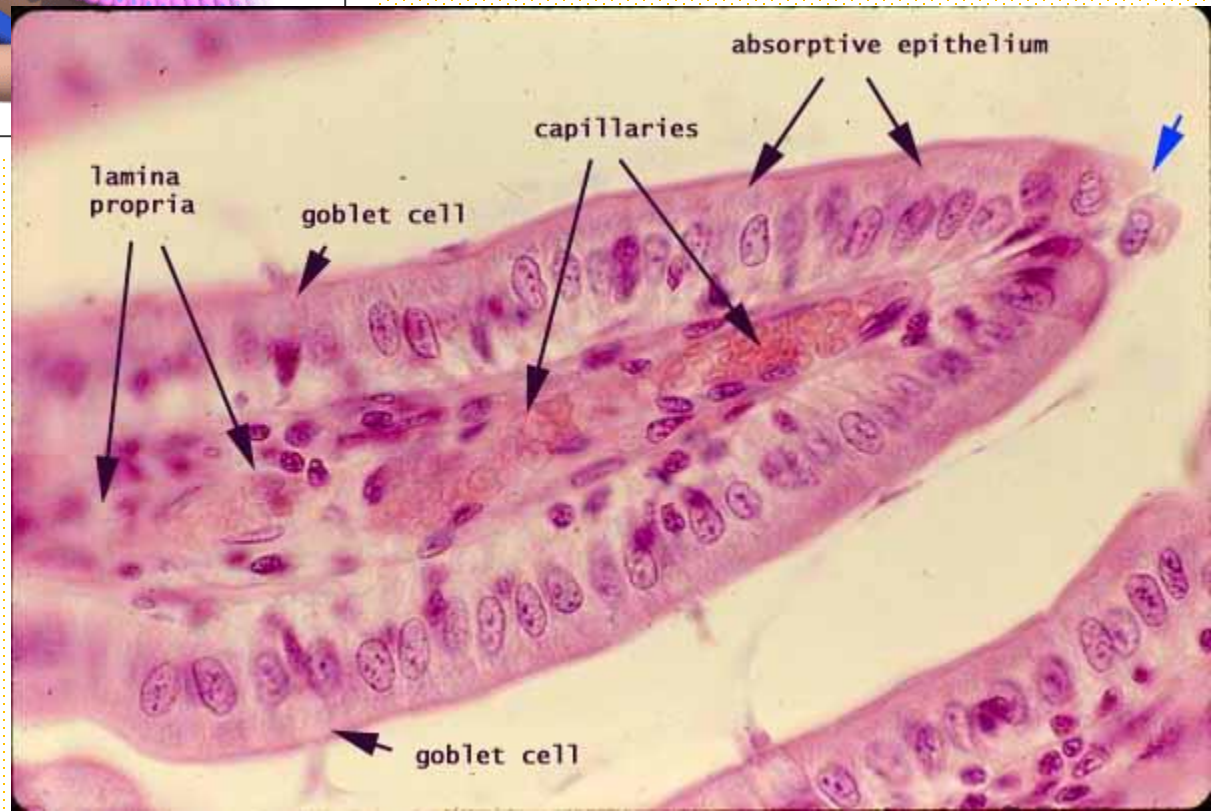
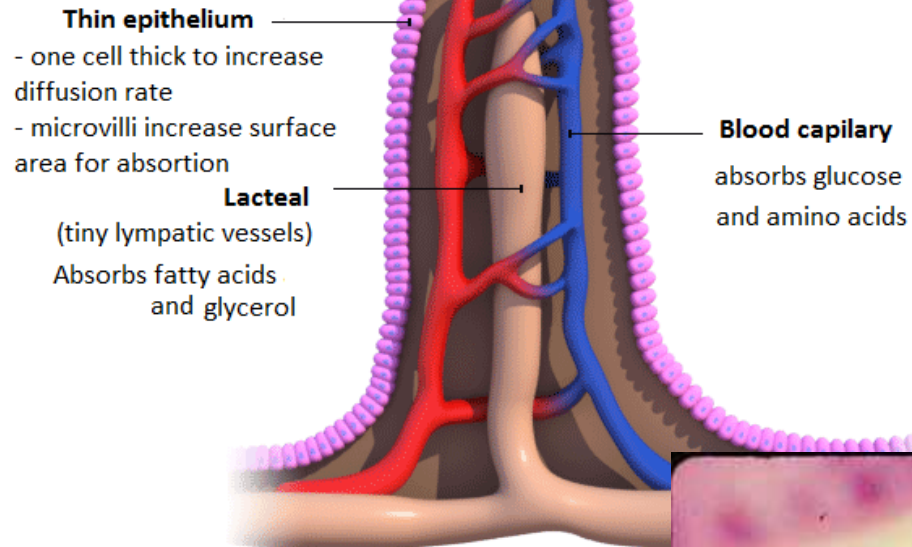


Intestinal villi (TEM)

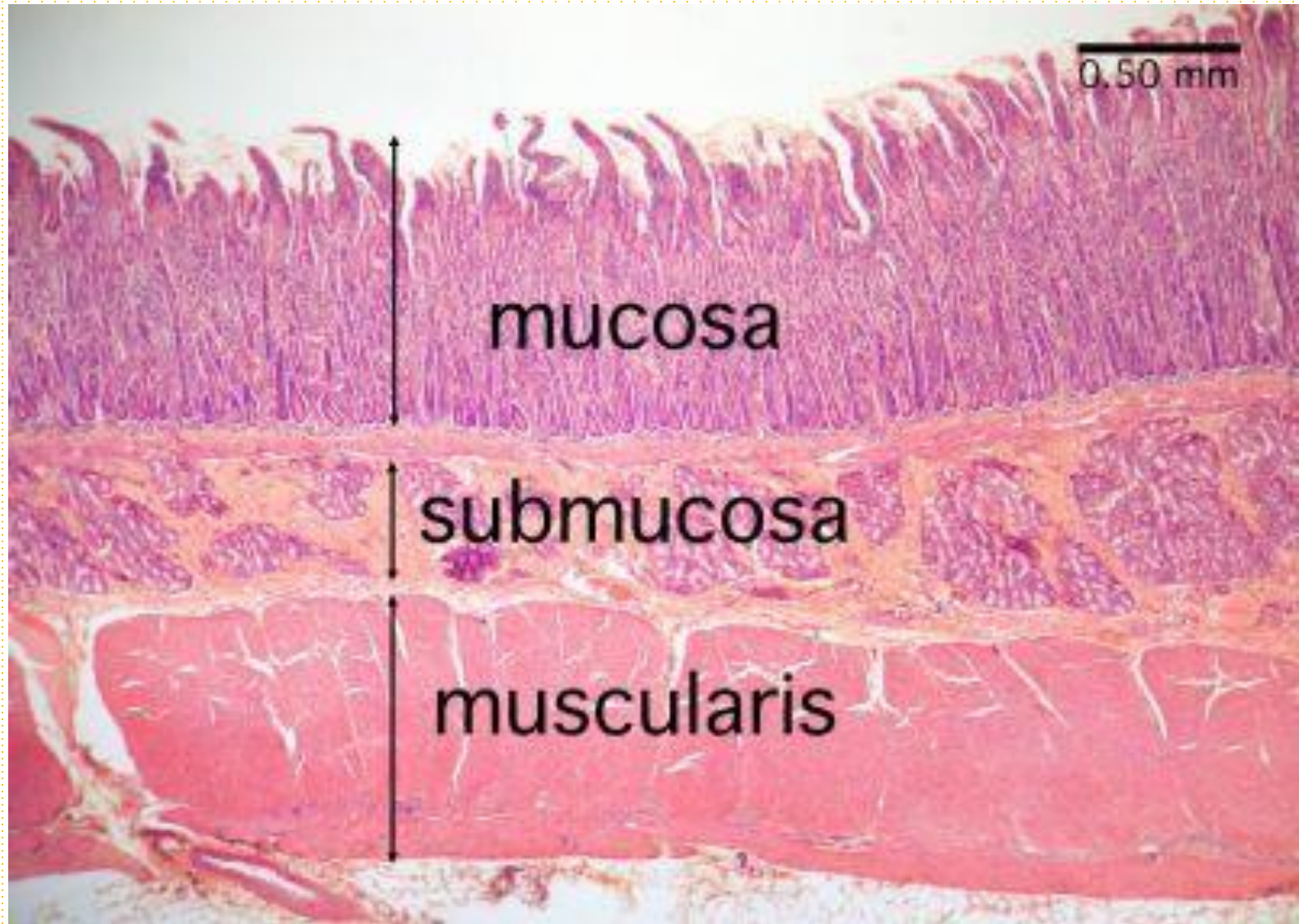
- Densely covering the entire mucosa of the small intestine are short (0.5-1.5 mm) mucosal outgrowths called villi that project into the lumen.
- In the **lamina propria** of the intestinal villi, there is loose connective tissue with capillaries (immediately below the basal lamina of the epithelium).
- **Lymphatic capillaries** (lacteal) pass through the middle intestinal villi.
- The smooth muscle cells of the lamina muscularis extend along the entire length of the villi.



Longitudinal section through a villus

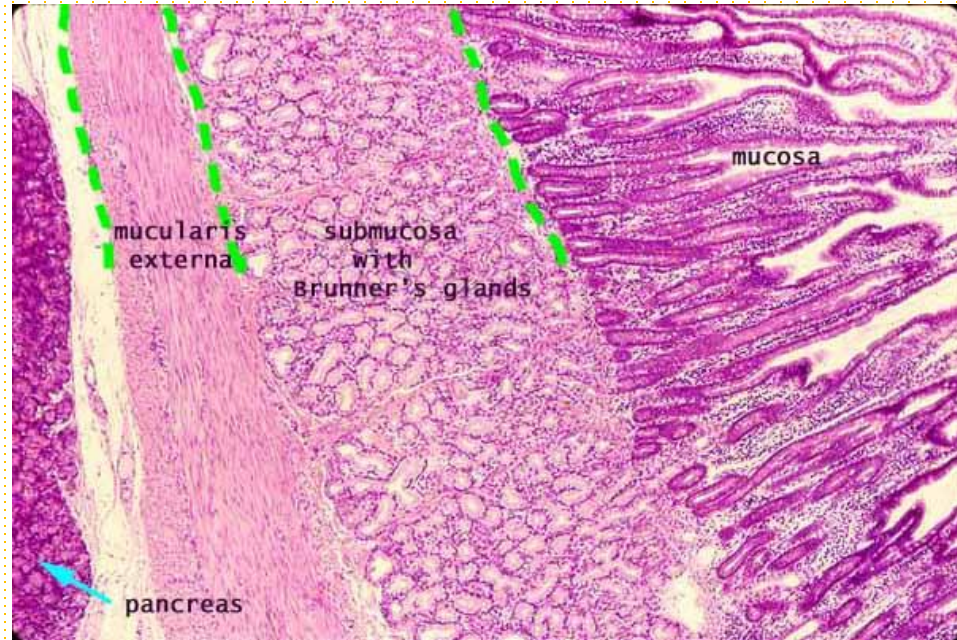


Duodenum

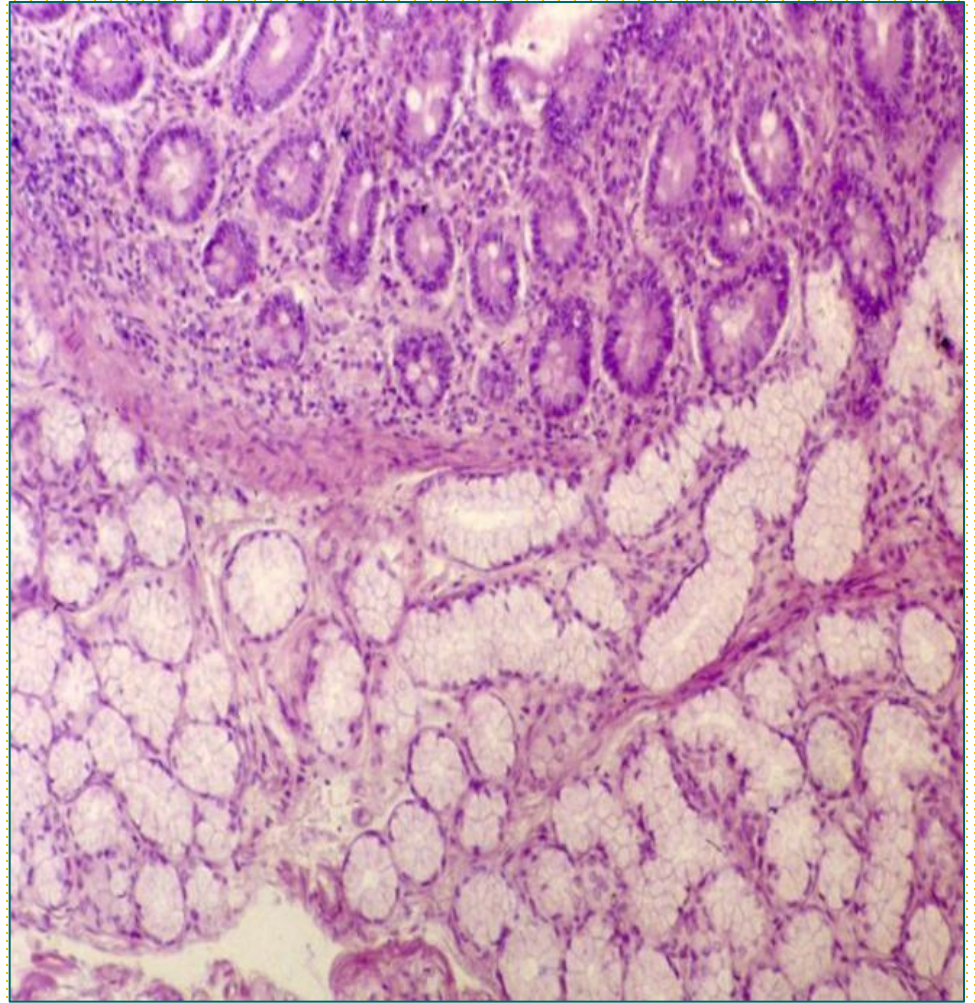
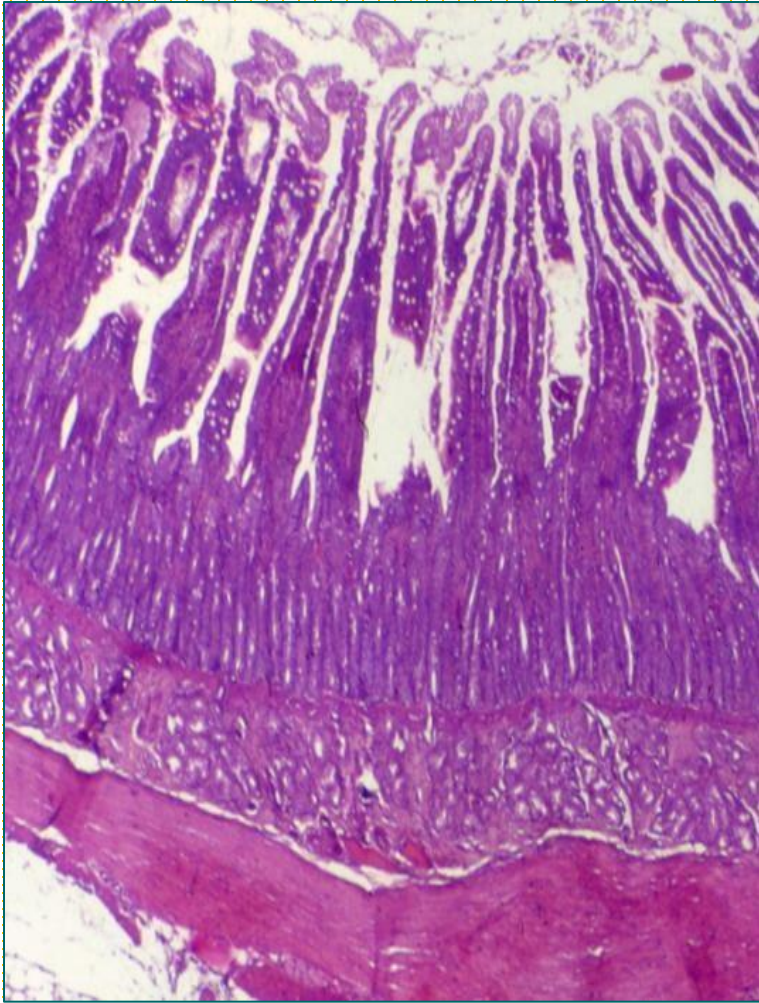


Duodenum

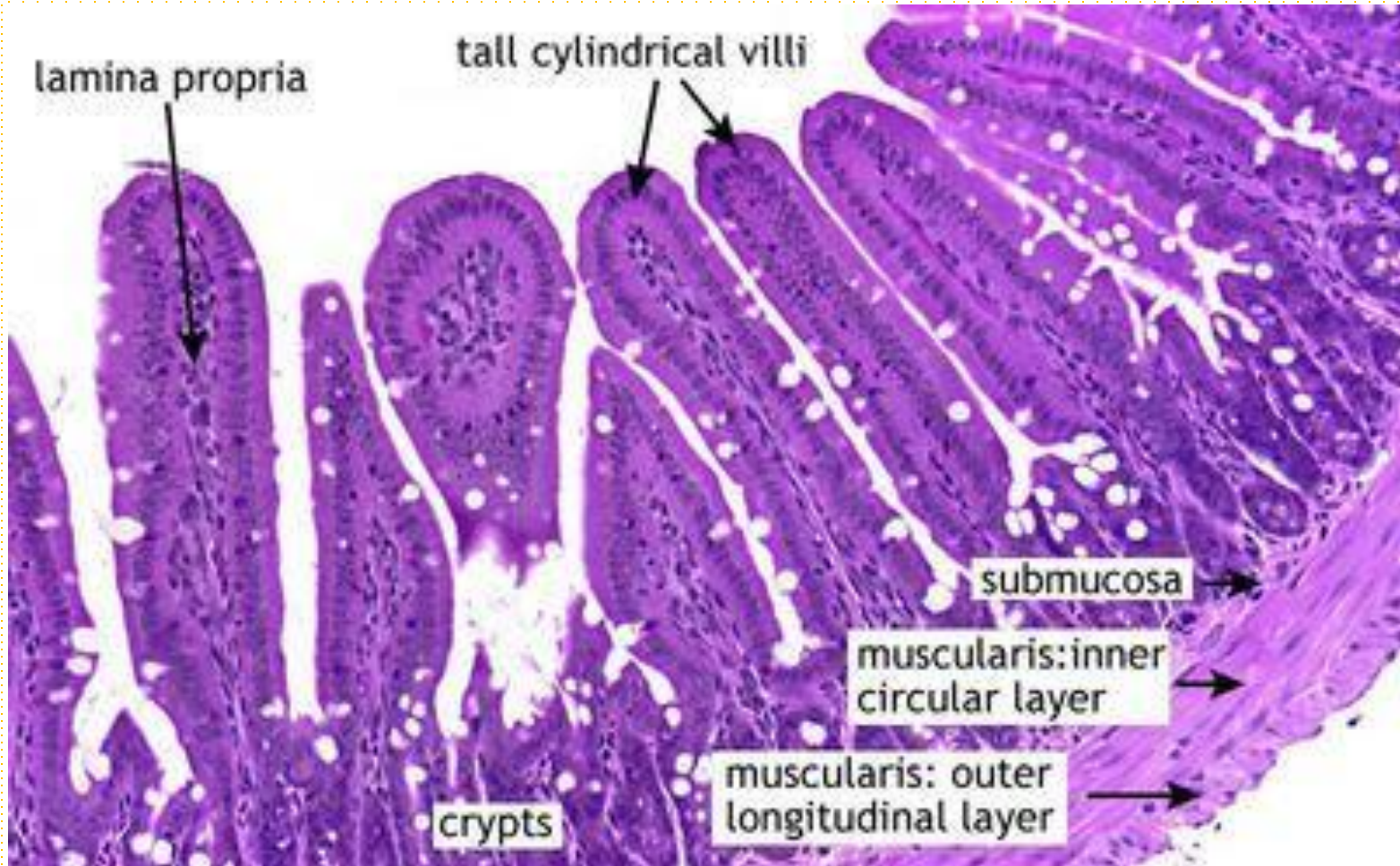
- The main characteristic of the duodenum is the presence of **Brunner's glands** (gll. duodenales) in the submucosa.
- Brunner's glands extend from the pylorus to the duodenojejunal joint.
- Excretory ducts - open in Lieberkühn's crypts or between the villi.
- Brunner's glands secrete an alkaline secretion that neutralizes the HCl of the stomach and corrects the pH of the intestinal content for the action of pancreatic enzymes.
- They secrete **urogastrin** - inhibits HCl secretion, stimulates cell renewal in the crypts.



Duodenum



Jejunum



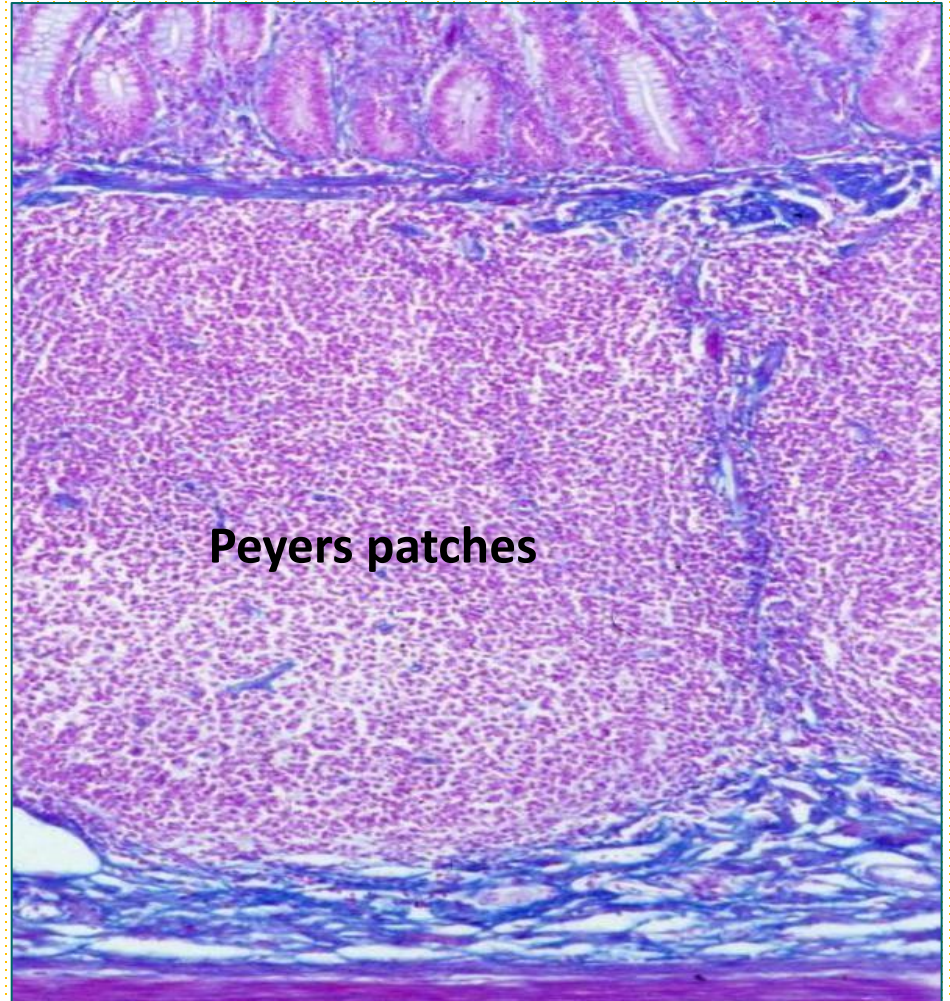
Without structural specificity

Ileum

- The lamina propria and submucosa of the ileum contain aggregates (10-400) of lymphatic follicles - Peyer's patches.
- The intestinal villi above Peyer's patches are reduced.
- M-cells are present in the epithelium.
- GALT



Ileum



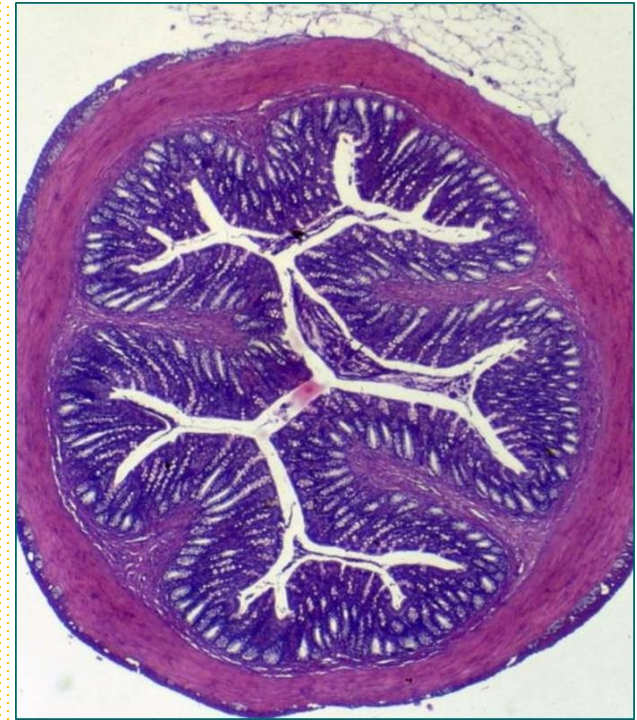
Large intestine

From the ileocecal valve to the anal canal (1.5m).

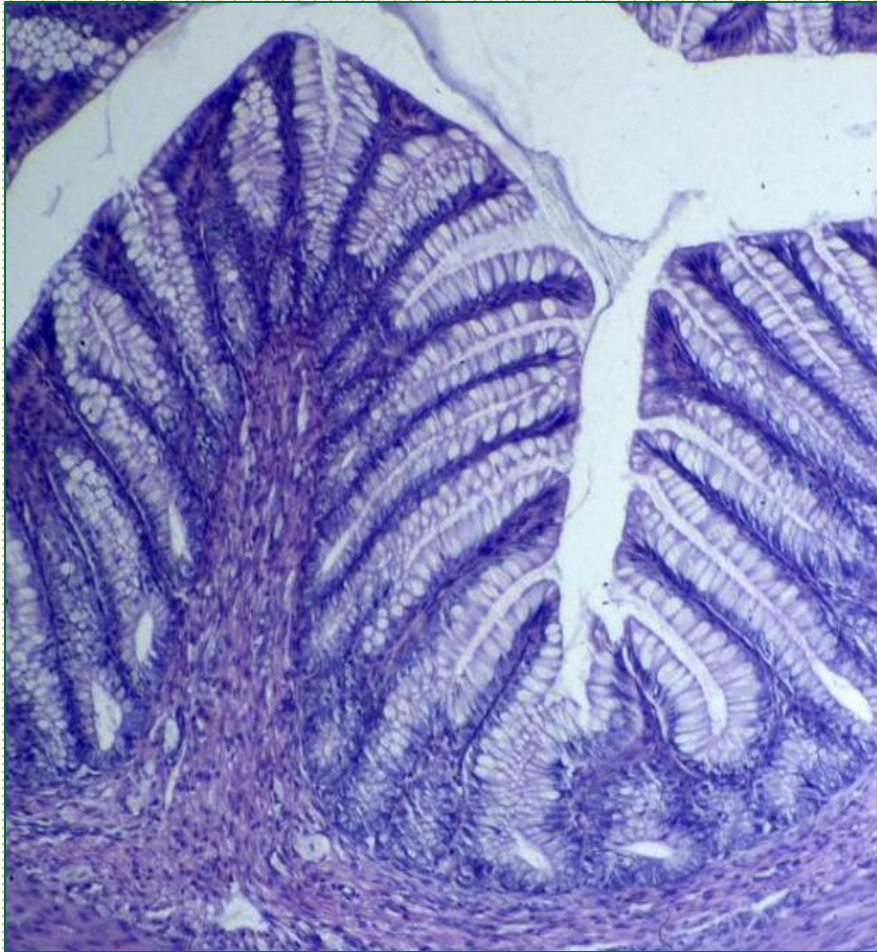
Includes:

- caecum
- appendix
- colon
- rectum

- More uniformly built than small intestine.
- The differences are in the mucosa and muscularis externa.
- There are **no intestinal villi** or circular folds, since only water and electrolyte absorption takes place in it.



Large intestine

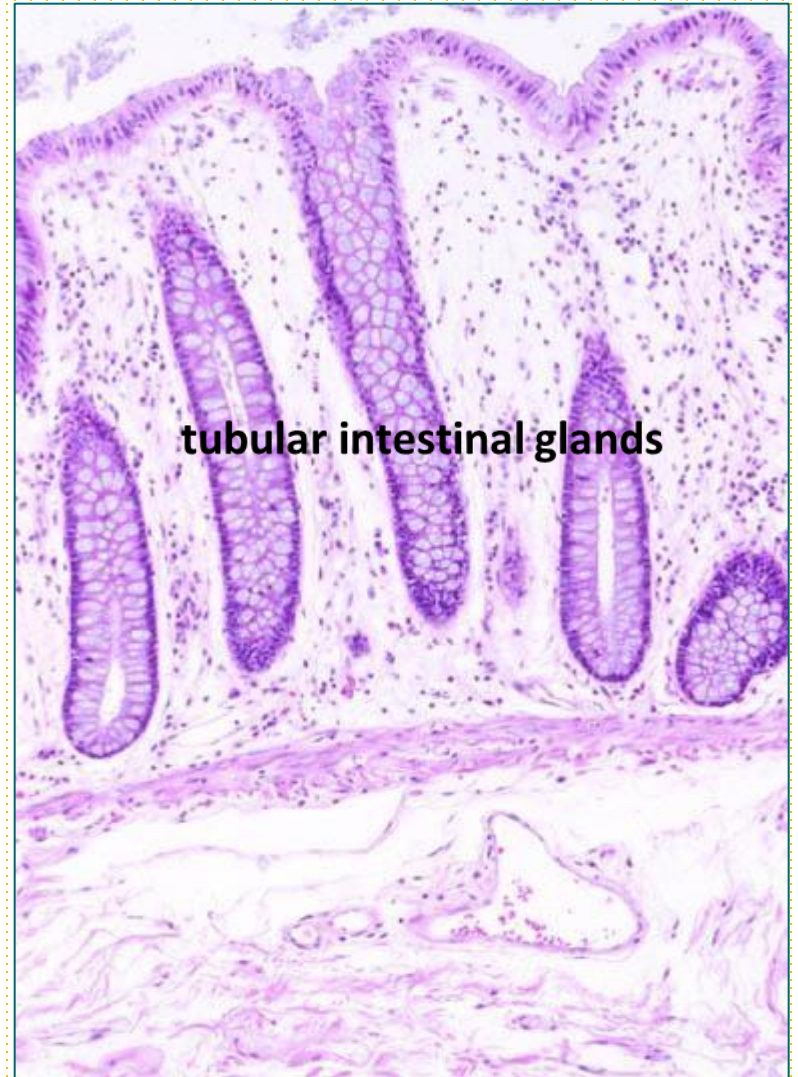
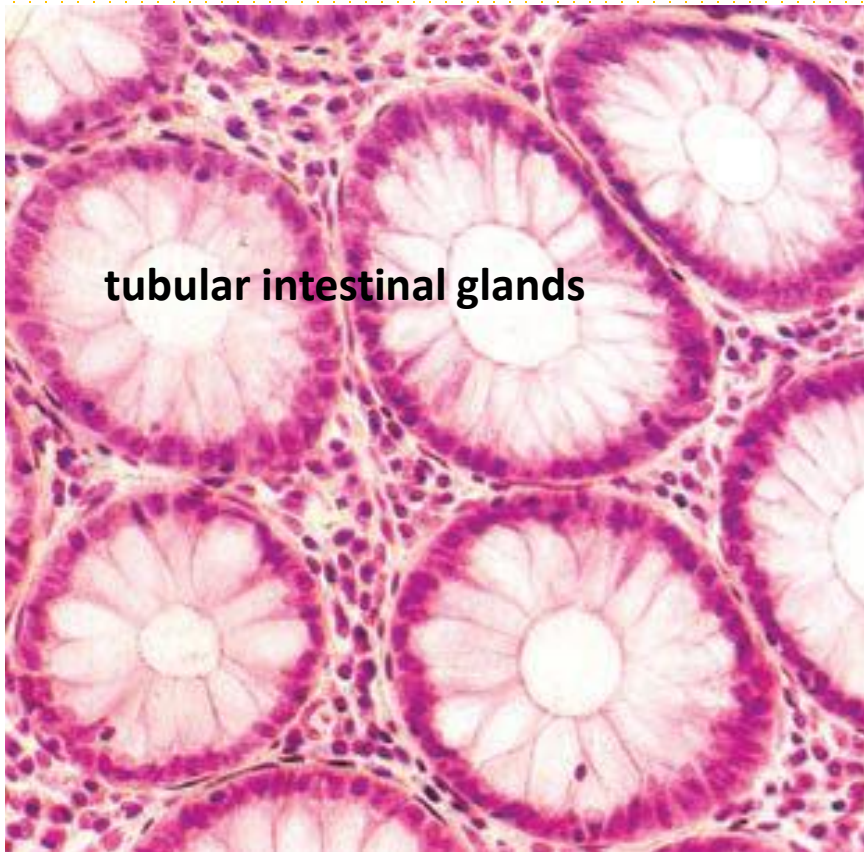


- The mucosa of the large bowel is are lined by goblet and absorptive cells, with a small number of enteroendocrine cells..
- Columnar absorptive cells or colonocytes have microvilli and dilated intercellular spaces indicating active fluid absorption. Goblet cells producing lubricating mucus become more numerous along the length of the colon. Epithelial stem cells are located in the bottom third of each gland.
- Throughout mucosa length and thickness **tubular intestinal glands** are present

Large intestine

- Lamina propria contains blood but not lymphatic vessels (there are no metastases until infiltration into the submucosa).
- Muscularis of the colon has longitudinal and circular layers, with fibers of **the outer layer gathered in three separate longitudinal bands called teniae coli.**
- Their contraction causes **haustra and plicae.**
- Outer layer is **serosa**, and in retroperitoneal parts adventitia

Colon

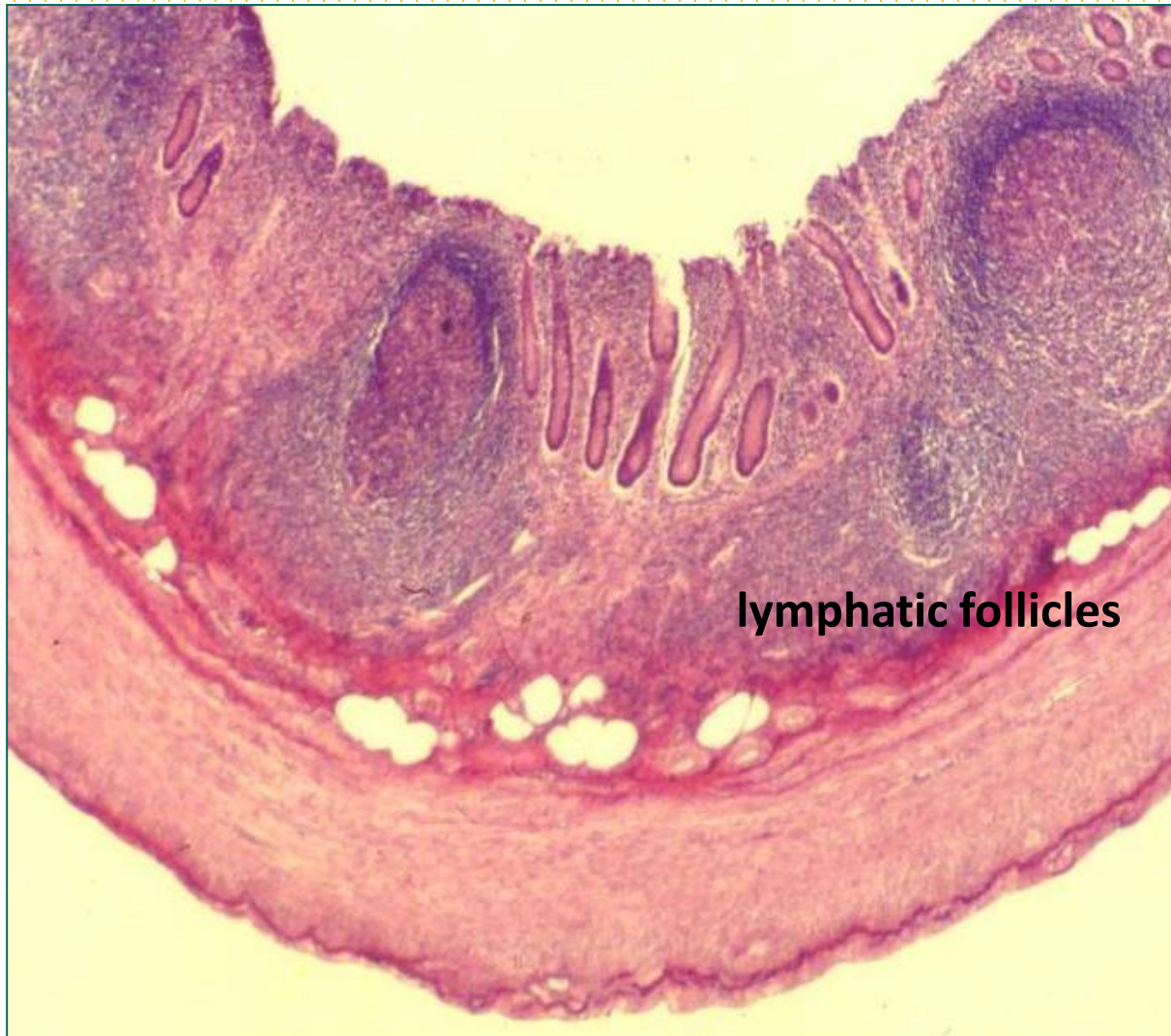


Appendix

- The main feature is the numerous **secondary lymphatic follicles** present throughout the circumference.
- They affect most of the **mucosa and submucosa**.
- Lymphatic follicles belong to the GALT.

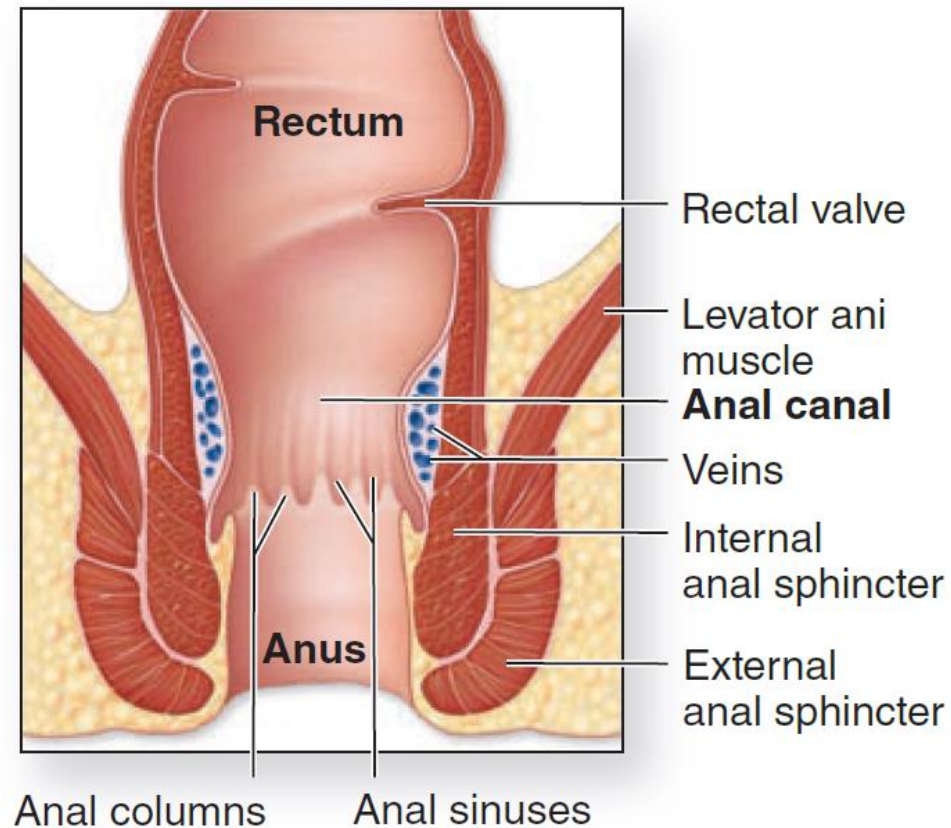


Appendix



Rectum and anal canal

- Distal end of the rectum, the anal canal, the mucosa, and submucosa are highly vascularized, with venous sinuses, and are folded as a series of longitudinal folds called **anal columns** (of Morgagni) with intervening **anal sinuses**.
- Fecal material is eliminated by muscular contraction, including action of an **internal anal sphincter** continuous with the circular layer of the muscularis and an **external sphincter** of striated (voluntary) muscle
- At the **rectoanal junction** the **simple columnar** mucosal lining of the rectum is replaced by **stratified squamous epithelium**



Peritoneum

- The peritoneum is the serous membrane that lines the abdominal cavity. It is composed of mesothelial cells that are supported by a thin layer of fibrous tissue
- It consists of the **parietal and visceral leaves**.
- The parietal sheet lines the walls of the abdominal and pelvic cavity, the visceral sheet lines the organs.
- The visceral leaf forms the tunica serosa of the intraperitoneal organs.
- Mesothelial cells possess microvilli and a glycocalyx. They secrete peritoneal fluid.
- The connective tissue layer is of variable thickness, in some places it forms subserosa.
- The parietal layer of the peritoneum has a similar structure to the visceral layer.