DIGESTIVE SYSTEM

DIGESTIVE SYSTEM

- The digestive system consists of a series of tubular organs (oral cavity, esophagus, stomach, small and large intestines, rectum, and anus) and associated glands(salivary glands, liver, and pancreas).
- The main function of which is to break down the ingested food into smaller units that can be absorbed into the circulation and used for the maintenance of the organism.
- Large molecules such as proteins, fats, complex carbohydrates, and nucleic acids are broken down into small molecules that are easily absorbed through the lining of the digestive tract, mostly in the small intestine.

DIGESTIVE SYSTEM

- Water, vitamins, and minerals are also absorbed from ingested food.
- In addition, the inner layer of the digestive tract is a protective barrier between the content of the tract's lumen and the internal milieu of the body.
- The first step in the complex process known as digestion occurs in the mouth, where food is moistened by saliva and ground by the teeth into smaller pieces; saliva also initiates the digestion of carbohydrates.

DIGESTIVE SYSTEM

- Digestion continues in the stomach and small intestine, where the food—transformed into its basic components (eg, amino acids, monosaccharides, free fatty acids, monoglycerides)—is absorbed.
- Water absorption occurs in the large intestine, causing the undigested contents to become semisolid.

General Structure of Tubular Organs

- A general structural pattern exists for all tubular organs of the **digestive**, **respiratory**, **urinary**, and **reproductive** systems.
- Familiarity with this general pattern is helpful in understanding the spesific characteristics of each organ.
- The entire gastrointestinal tract presents certain common structural characteristics.
- It is a hollow tube composed of a lumen whose diameter varies, surrounded by a wall made up of four principal layers:
- Tunica mucosa,
- Tunica submucosa,
- Tunica muscularis
- Tunica serosa.

General Structure of Tubular Organs

- **Tunica mucosa** comprises an **epithelial lining;** a **lamina propria** of loose connective tissue rich in blood and lymph vessels and smooth muscle cells, sometimes also containing glands and lymphoid tissue.
- The **submucosa** is composed of dense connective tissue with many blood and lymph vessels and a **submucosal** (also called **Meissner's**) **nerve plexus.**
- It may also contain glands and lymphoid tissue.
- **Tunica muscularis** usually consisting of a thin inner circular layer and an outer longitudinal layer of smooth muscle cells separating the mucosa from the submucosa.

General Structure of Tubular Organs

- The **muscularis** contains smooth muscle cells that are spirally oriented and divided into two sublayers according to the main direction the muscle cells follow.
- In the internal sublayer (close to the lumen), the orientation is generally circular; in the external sublayer, it is mostly longitudinal.
- The muscularis also contains the **myenteric (or Auerbach's) nerve plexus,** which lies between the two muscle sublayers, and blood and lymph vessels in the connective tissue between the muscle sublayers.
- The **serosa** is a thin layer of loose connective tissue, rich in blood and lymph vessels and adipose tissue, and a simple squamous covering epithelium (**mesothelium**).

General Structure of Tubular Organs

- In the abdominal cavity, the serosa is continuous with the mesenteries (thin membranes covered by mesothelium on both sides), which support the intestines, and with the peritoneum, a serous membrane that lines the cavity wall.
- In places where the digestive organ is bound to other organs or structures, however, the serosa is replaced by a thick adventitia, consisting of connective tissue containing vessels and nerves, without the mesothelium.

General Structure of Tubular Organs

- The main functions of the epithelial lining of the digestive tract are to provide a selectively permeable barrier between the contents of the tract and the tissues of the body, to facilitate the transport and digestion of food, to promote the absorption of the products of this digestion, and to produce hormones that affect the activity of the digestive system.
- Cells in this layer produce mucus for lubrication and protection.
- The abundant lymphoid nodules in the lamina propria and the submucosal layer protect the organism (in association with the epithelium) from bacterial invasion.
- The necessity for this immunological support is obvious, because the entire digestive tract—with the exception of the oral cavity, esophagus, and anal canal—is lined with a simple thin, vulnerable epithelium.

General Structure of Tubular Organs

- The lamina propria, located just below the epithelium, is a zone rich in macrophages and lymphoid cells, some of which actively produce antibodies.
- These antibodies are mainly immunoglobulin A (IgA) and are bound to a secretory protein produced by the epithelial cells of the intestinal lining and secreted into the intestinal lumen.
- This complex protects against viral and bacterial invasion.
- The IgA present in the respiratory, digestive, and urinary tracts is resistant to proteolytic enzymes and can therefore coexist with the proteases present in the lumen.

General Structure of Tubular Organs

- The muscularis mucosae promotes the movement of the mucosa independent of other movements of the digestive tract, increasing its contact with the food.
- The contractions of the muscularis, generated and coordinated by nerve plexuses, propel and mix the food in the digestive tract.
- These plexuses are composed mainly of nerve cell aggregates (multipolar visceral neurons) that form small parasympathetic ganglia.

General Structure of Tubular Organs

- A rich network of pre- and postganglionic fibers of the autonomic nervous system and some visceral sensory fibers in these ganglia permit communication between them.
- The number of these ganglia along the digestive tract is variable; they are more numerous in regions of greatest motility.

The Oral Cavity

- The oral cavity is lined with stratified squamous epithelium, keratinized or nonkeratinized, depending on the region.

- The keratin layer protects the oral mucosa from damage during masticatory function and is present mostly in the gingiva (gum) and hard palate.
- The lamina propria in these regions has several papillae and rests directly on bony tissue.
- Nonkeratinized squamous epithelium covers the soft palate, lips, cheeks, and the floor of the mouth.

The Oral Cavity

- The lamina propria has papillae, similar to those in the dermis of the skin, and is continuous with a submucosa containing diffuse small salivary glands.
- In the lips, a transition from the oral nonkeratinized epithelium to the keratinized epithelium of the skin can be observed.
- The soft palate has a core of skeletal muscle, numerous mucous glands, and lymphoid nodules in its submucosa.

Lips and Cheeks

- The lips and cheeks are folds of tissue with skin on the external surface and mucous membrane adjacent to the oral cavity.
- The mucous membrane is stratified squamous epithelium which is keratinized in the ruminant and horse.
- Underlying connective tissue contains serous or mixed glands and skeletal muscle.

Hard and Soft Palate

- The hard palate has a keratinized stratified squamous epithelium on the surface with underlying connective tissue that blends with the periosteum of palate bones.
- The dental pad, which functions in place of upper incisors in ruminants, has very thick keratin.
- Further caudally in the oral cavity, the soft palate is present as a fold of mucous membrane with respiratory epithelium on the nasal side and stratified squamous epithelium on the oral side.
- Aggregated lymphatic tissue is present as the palatine tonsil.

Tongue

- The tongue is a muscular organ covered by a mucosa. It is important in the prehension, mastication, and deglutition of food.
- The epithelium covering the tongue is stratified squamous.
- It is keratinized and thick on the dorsum, and nonkeratinized and thin on the ventral surface.
- The dorsum bears numerous macroscopic **lingual papillae.**
- These papillae differ somewhat in shape, are named according to their morphologic characteristics, and serve either a mechanical or a gustatory function.

Tongue

- The filiform, conical, and lenticular papillae are purely mechanical; they facilitate the movement of ingesta within the oral cavity.
- The fungiform, vallate, and foliate papillae are gustatory; that is, they contain the taste buds, which are responsible for perception of the sense of taste.
- The filiform papillae are the most numerous type.
- They are slender, threadlike structures that project above the surface of the tongue and are covered by a keratinized stratified squamous epithelium with a thick stratum corneum.
- They are supported by a highly vascularized connective tissue core.

Tongue

- Equine filiform papillae consist of very fine keratinized threads projecting above the surface.
- The connective tissue core ends at the base of the thread.
- In ruminants, a keratinized cone projects above the surface, and the connective tissue core has several secondary papillae.
- Cats have large papillae with two prominences of unequal size.
- The caudal prominence is especially large and gives rise to a caudally directed keratinized spine, supported by a more rounded rostral papilla with a thinner stratum corneum.

Tongue

- The filiform papillae of dogs may have two or more apices; the caudal apex is largest and has a stratum corneum thicker than that of the other(s).
- Conical papillae occur on the root of the tongue in dogs, cats, and pigs, and on the torus linguae of ruminants
- They are larger than the filiform papillae and usually are not highly keratinized.

Tongue

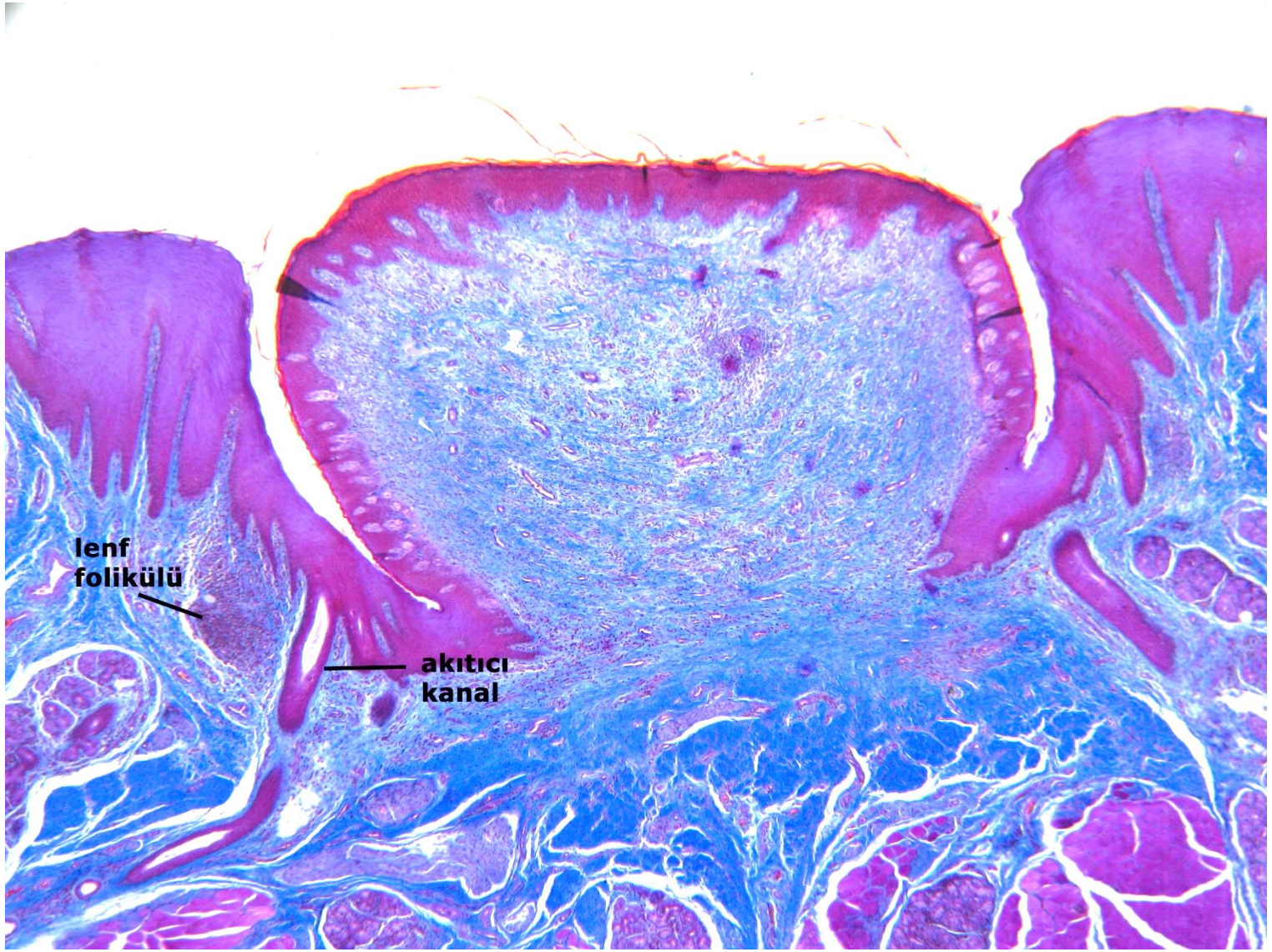
- Lenticular papillae are flattened, lens-shaped projections that are found on the torus linguae of ruminants.
- They are covered by keratinized stratified squamous epithelium and have a core of dense irregular connective tissue.
- The fungiform papillae are scattered among the filiform papillae and have a dome-shaped upper surface in horses and pigs.
- The shape is suggestive of mushroom, and thus the name fungiform.

Tongue

- The papillae are covered by a nonkeratinized stratified squamous epithelium containing one or more taste buds on the upper surface.
- The taste buds are sparse in these papillae in the tongues of horses and cattle, more numerous in those of sheep and pigs, and abundant in those of carnivores and goats.
- The vallate papillae are located on the dorsum of the tongue, just rostral to the root.
- They are large, flattened structures completely surrounded by an epithelium-lined sulcus.
- They extend only slightly, if at all, above the lingual surface and are covered by a stratified squamous epithelium.

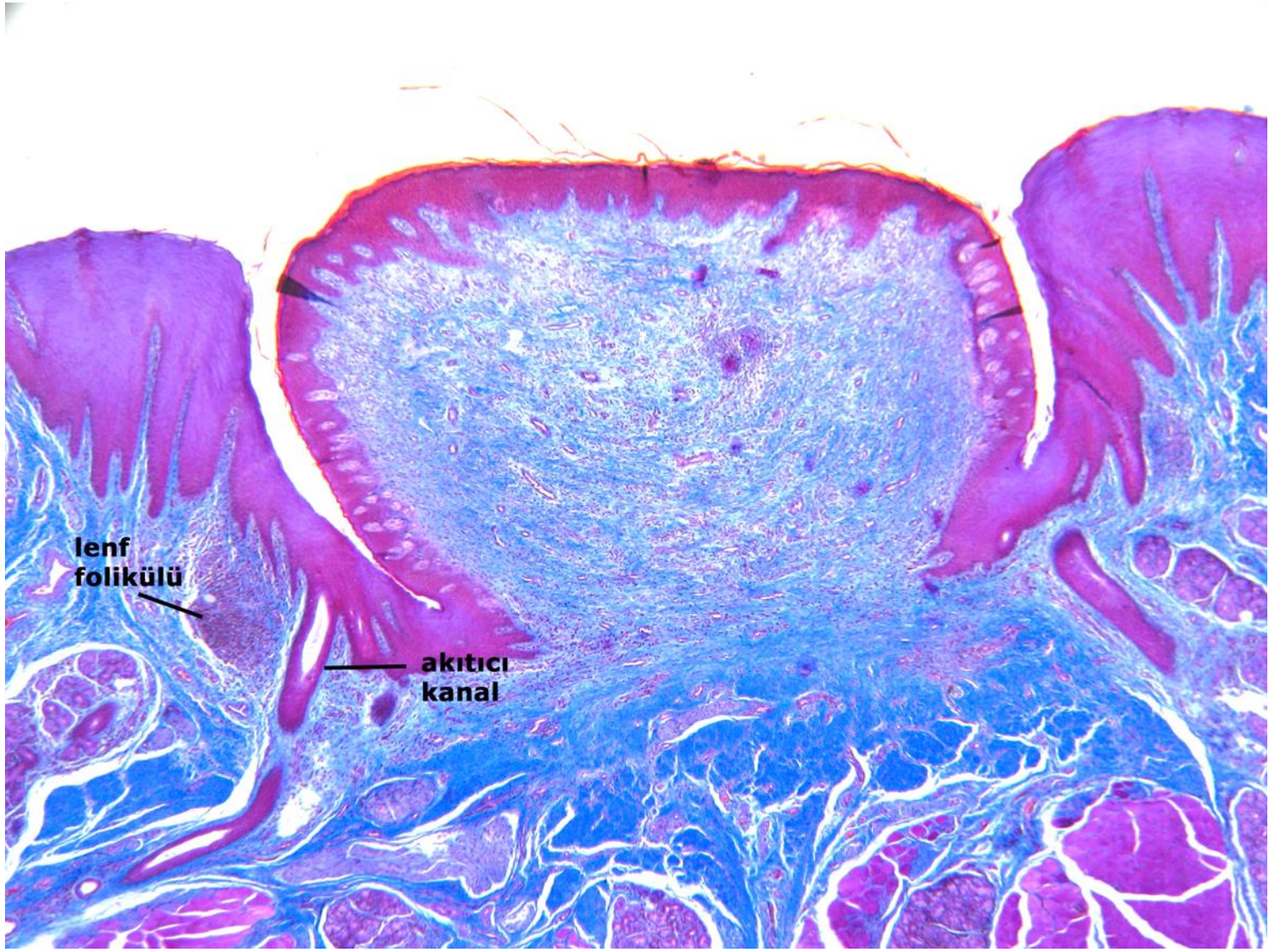
Tongue

- The epithelium on the papillary side of the sulcus contains many tastes buds.
- Groups of serous gustatory glands are located deep to the sulcus and have ducts that open into the sulcus at various levels.
- Mucous glans may also be found beneath the papillae, but their secretory products are emptied directly onto the lingual surface.



Tongue

- The connective tissue core is rich in blood vessels and nerves.
- The number of vallate papillae varies with the species;horses and pigs typically have one pair, carnivores have four to six pairs, and ruminants have eight to 24 pairs.



Tongue

- The foliate papillae are parallel folds of the lingual mucosa located on the margin of the tongue just rostral to the palatoglossal arch.
- Taste buds are located in the epithelium on the sides of the folds.
- The folds are separated by gustatory sulci.
- Deep to the sulci lie serous gustatory glands, the ducts of which empty into the sulci.
- Foliate papillae are absent in ruminants; they are rudimentary and lack taste buds in cats.
- The taste buds are ellipsoid clusters of specialised epithelial cells embedded in the stratified squamous epithelium of the fungiform, vallate, and foliate papillae of the tongue.

Tongue

- They also ocur widely dispersed in the soft palate, epiglottis, or other areas of the oral cavity and pharynx.
- The taste bud consists of a cluster of spindle-shaped epithelial cells that extend from the basement membrane to a small opening, the taste pore, at the epithelial surface.
- In most mammalian species, three cell types have been identified.
- They are referred to as type I cells, type II cells, and type III cells.

Tongue

- Type I and Type III cells have apical microvilli that project into the taste pore; type III cells have a club-shaped apex that also projects into the taste pore.
- The type II cell is characterized by clusters of cytoplasmic vesicles, resembling synaptic vesicles, adjacent to intraepithelial nonmyelinated afferent nerve fibers.
- Therefore, the type III cell is considered to be the **chemoreceptor (taste)** cell, whereas the type I and type II cells are believed to serve a **sustentacular (supportive)** role.

Tongue

- The average life span of the cells is approximately 10 days.
- New cells are recruited from mitotically dividing cells in the perigemmal region (Latin gemma, meaning ‘bud’).
- The proper (intrinsic) lingual muscles consist of longitudinally, transversely, and perpendicularly arrenged bundles of skeletal muscle.
- Because of the diverse arrangement of these muscle fibers, the tongue has extensive mobility to facilitate movement of food into and within the oral cavity.
- The ventral surface of the tongue is covered by nonkeratinized stratified squamous epithelium.
- The mucosa contains an abundance of capillaries, arteriovenous anastomoses, and branches of the lingual artery and vein.

Tongue

- They participate in thermoregulation.
- Scattered among the muscle fibers and in the propria-submucosa of the tongue are clusters of seromucous minör salivary glands, which are collectivelly referred to as the **lingual glands.**

Teeth

- Teeth are highly mineralized structures in the oral cavity that serve domestic mammals during the procuring, cutting, and crushing of food and as weapons of offense and deffense.
- The tooth consists of a highly mineralized outer part surrounding the **pulp cavity**, which contains the **dental pulp**, a core of connective tissue, blood vessel, lymph vessels, and nerves.

BRACHYODONT AND HYPSODONT TEETH

- Two types of teeth ocur in the domestic mammals: **brachyodont** and **hypsodont**.
- These teeth differ in their rates of growth and in the arrangement of the layers of mineralized.
- **Brachyodont teeth** are short and cease to grow after eruption is completed.
- They have a **crown** (the portion above the gingiva), a **neck** (the constricted region just below the gingival line), and one or more **roots** embedded in a bony socket called the **alveolus**.

BRACHYODONT AND HYPSODONT TEETH

- **Brachyodont teeth** include all those of carnivores (and human beings), the incisor teeth of ruminants, and the teeth of pigs, except for the canine teeth.
- **Hypsodont teeth** are much longer than brachyodont teeth and continue their growth throughout a portion, if not all, of the adult life of the animal.
- They do not have a crown and neck but, instead, have an elongated **body**; some species, the roots and neck form only after a delayed period.
- The tusks of the boar continue to grow throughout life and never develop roots.
- **Hypsodont teeth** include all those of horses, the cheek teeth of ruminants, and the canine of pigs.

Structure

- The mineralized tissues of the teeth are **enamel**, **dentin**, and **cementum**.
- Each of these has a separate origin and differs morphologically and in degree of mineralization.
- **Enamel (mina-s.adamantina)** covers the external surface of the crown of brachydont teeth and lies beneath a layer of cementum in hypsodont teeth.
- It is the hardest substance in the body, composed of 99% mineral (hydroxyapatite) and 1% organic matrix by weight.

Structure

- Histologically, enamel is composed of long, slender rods, **enamel prisms,** held together by **interrod enamel**.
- Parallel bundles of rods pursue a wavy or oblique course from the inner to the outersurface of the enamel layer.
- Curved lines (**incremental lines**) appear where these bundles change directions.
- Enamel is produced by **enameloblasts**(**ameloblasts)** that differentiate from the inner enamel epithelium of the enamel organ.
- Ameloblasts dissapear from the fully developed brachydont tooth, but a small population of columnar cells remains at the base of the hypsodont tooth to continue enamel production.

Structure

- **Cementum (Substantia ossea)** covers the outer surface of the tooth root. It made of collagen and mineral. Cementum resembles bone in all its structural features.
- **Acellular cementum** is composed of lamellae oriented parallel to the surface of the tooth.
- **Cellular cementum** has **cementocytes**, which occupy lacunae and canaliculi similar to those of bone.
- Bundles of collagen fibers, called cementoalveolar (Sharpey's) fibers, extend from the alveolar bone into the cementum of the tooth.
- Collectively, these fibers form the **periodontal ligament**, which anchors the tooth in the alveolus.

Structure

- Cementoblasts at the junction of the cementum and the periodontal ligament produce the fibrous matrix of the cementum, and then later mineralize the cementum by depositing hydroxyapatite crystals within the matrix.
- Once the cementoblast are surrounded by matrix, they are known as **cementocytes.**
- The roots of brachydont teeth are covered by a layer of cementum that may slightly overlap the enamel on the neck.
- Cementum covers the outside surface of equine and ruminant hypsodont teeth, both above and below the gingiva.

Structure

- **Dentin (substantia eburnea)** is a highly mineralized tissue that constitutes the major part of the tooth.
- It underlies the enamel of the crown and the cementum of the root in brachydont teeth, and also underlies the enamel of the body in hypsodont teeth.
- Dentin also forms the wall of the **pulp cavity**.
- It consists of a matrix of organic material, mainly randomly oriented collagen fibrils and glycoproteins, upon which is deposited minerals including primarily hydroxyapatite with some carbonate, magnesium, and flüoride.
- The composition is approximately 70% mineral and 30% organic matter.

Structure

- Dentin is produced by a columnar layer of cells, called **odontoblasts**, which are located adjecent to the interior surface of the dentin in the outer layer of the dental pulp.
- **Odontoblast processes** lie in roughly parallel anastomotic channels, the dentinal tubules (canaliculi dentales), that extend from the inner to the outer surface of the dentin.
- **Dental pulp** occupies the pulp cavity of the tooth.
- It is composed of connective-tissue cells and fibers, amorphous ground substance, numerous blood and lymph vessels, and nerves.
- It resembles embryonic connective tissue in texture, with delicate collagen fibers coursing through the amorphous ground substance.

Structure

- The most peripheral part of the pulp is the layer of odontoblasts, from which the odontoblast processes extend into the dentinal tubules.

Periodontal Ligament

- The periodontal ligament is composed of a special type of connective tissue whose fibers penetrate the cementum of the tooth and bind it to the bony walls of its socket while permitting limited movement of the tooth.
- Its fibers are organized to support the pressures exerted during mastication.
- This avoids transmission of pressure directly to the bone, a process that would cause the bone's localized resorption.
- Collagen of the periodontal ligament has characteristics that resemble those of immature tissue.
- The space between its fibers is filled with glycosaminoglycans.

Alveolar Bone

- The alveolar bone is in immediate contact with the periodontal ligament.
- It is an immature type of bone (primary bone) in which the collagen fibers are not arranged in the typical lamellar pattern of adult bone.
- Many of the collagen fibers of the periodontal ligament are arranged in bundles that penetrate this bone and the cementum, forming a connecting bridge between the two structures (**Sharpey's fibers**).
- The bone closest to the roots of the teeth forms the socket.
- Vessels run through the alveolar bone and penetrate the periodontal ligament along the root, forming the **perforating vessels.**
- Some vessels and nerves run to the apical foramen of the root to enter the pulp.

Gingiva

- The gingiva is a mucous membrane firmly bound to the periosteum of the maxillary and mandibular bones.
- It is composed of stratified epithelium asquamous and lamina propria containing numerous connective tissue papillae.

Pharynx

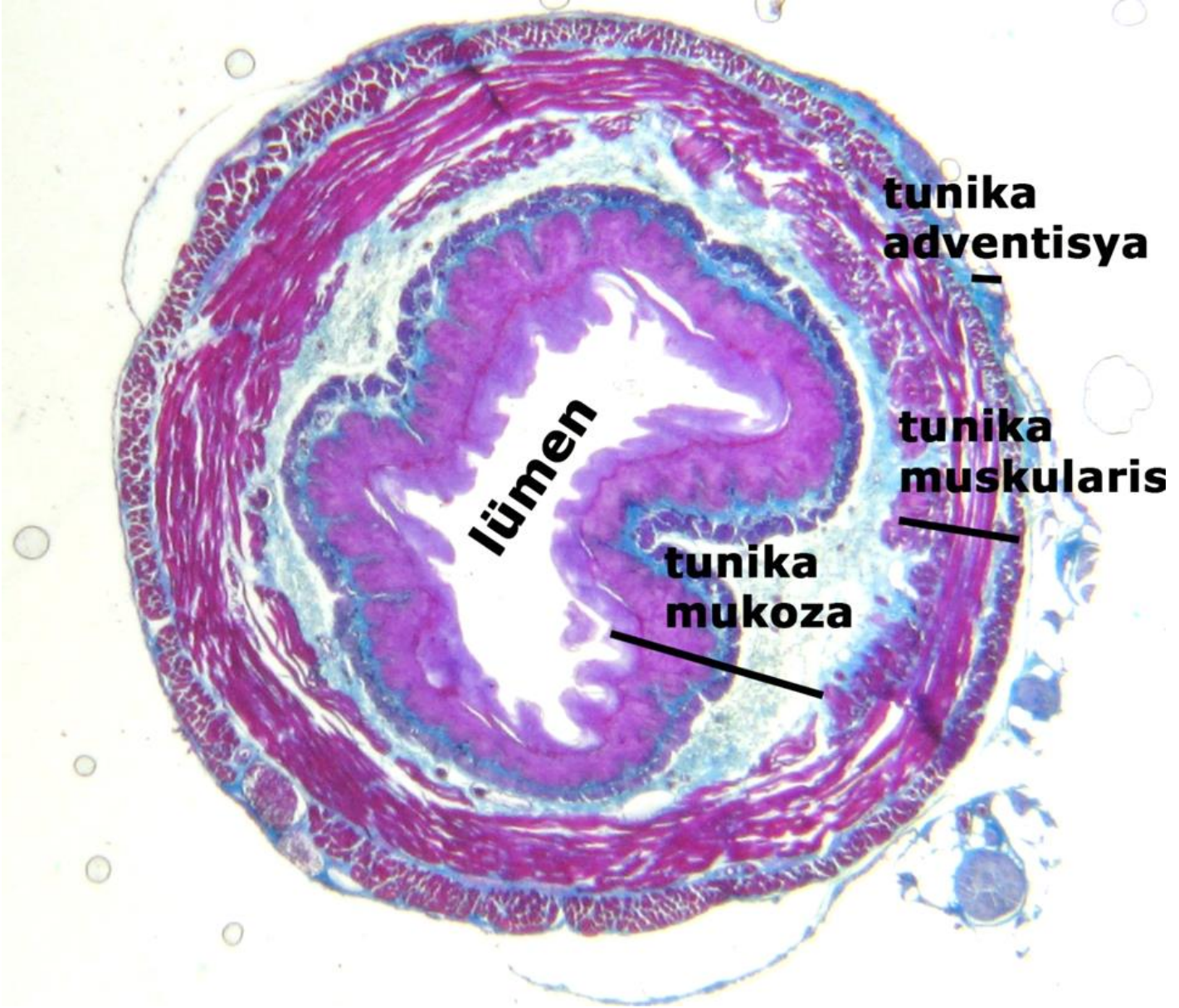
- The pharynx, a transitional space between the oral cavity and the respiratory and digestive systems, forms an area of communication between the nasal region and the larynx.
- The pharynx is lined by stratified nonkeratinized squamous epithelium in the region continuous with the esophagus and by ciliated pseudostratified columnar epithelium containing goblet cells in the regions close to the nasal cavity.

Pharynx

- The pharynx contains the tonsils. The mucosa of the pharynx also has many small mucous salivary glands in its lamina propria, composed of dense connective tissue.
- The constrictor and longitudinal muscles of the pharynx are located outside this layer.

Esophagus

- The part of the gastrointestinal tract called the **esophagus** is a muscular tube whose function is to transport foodstuffs from the mouth to the stomach and to prevent the retrograde flow of gastric contents.
- Transport is achieved by peristaltic contractions and relaxation of the esophageal sphincters (upper and lower), usually controlled by reflexes and by the autonomic nervous system.



Esophagus

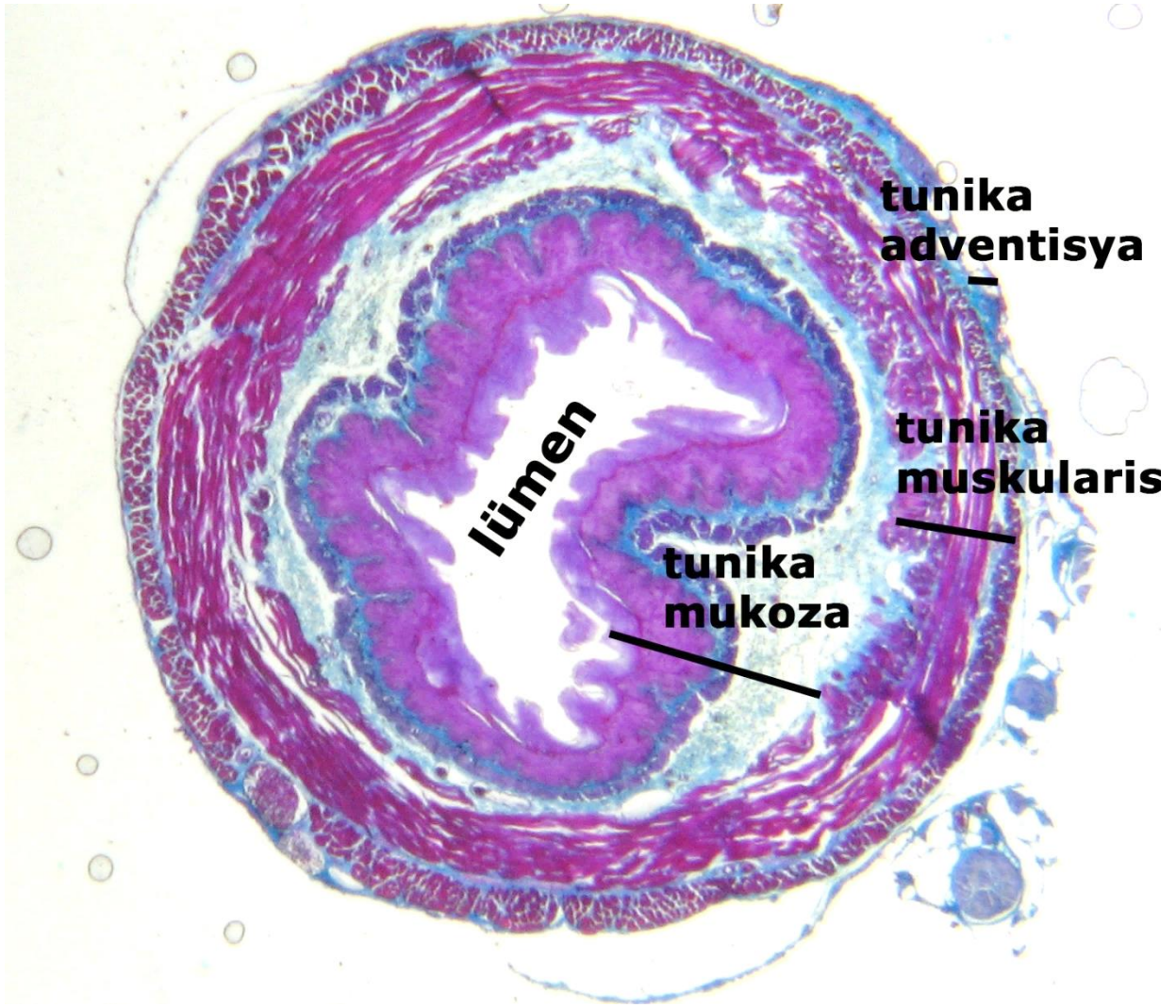
- The mucosa is composed of three layers:

-a stratified squamous epithelium

-a lamina propria, and

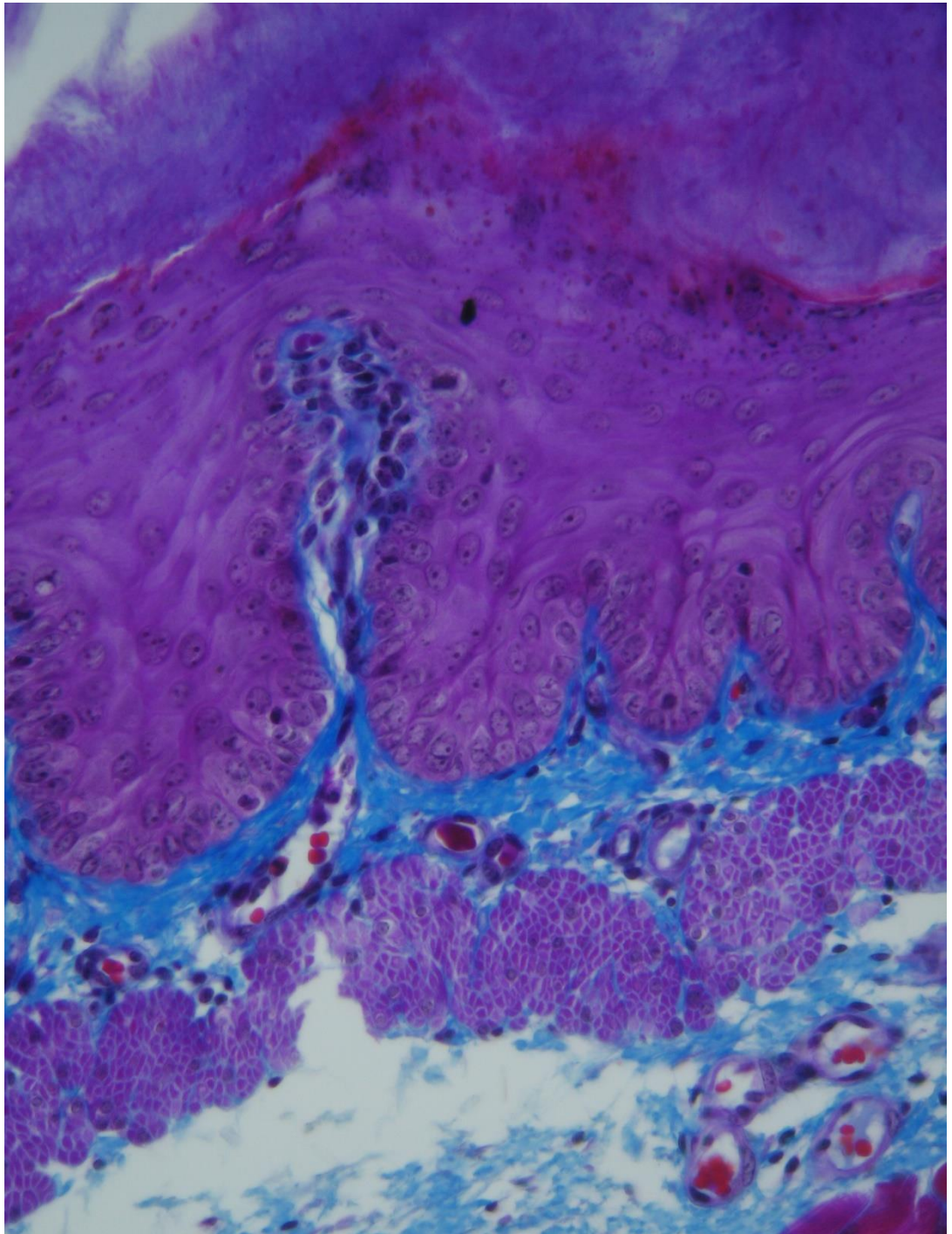
-a lamina muscularis.

- The degree of keratinization of the stratified squamous epithelium varies with the species.
- It is usually nonkeratinized in carnivores, slightly keratinized in pigs, more so in horses, and keratinized to a high degree in ruminants.



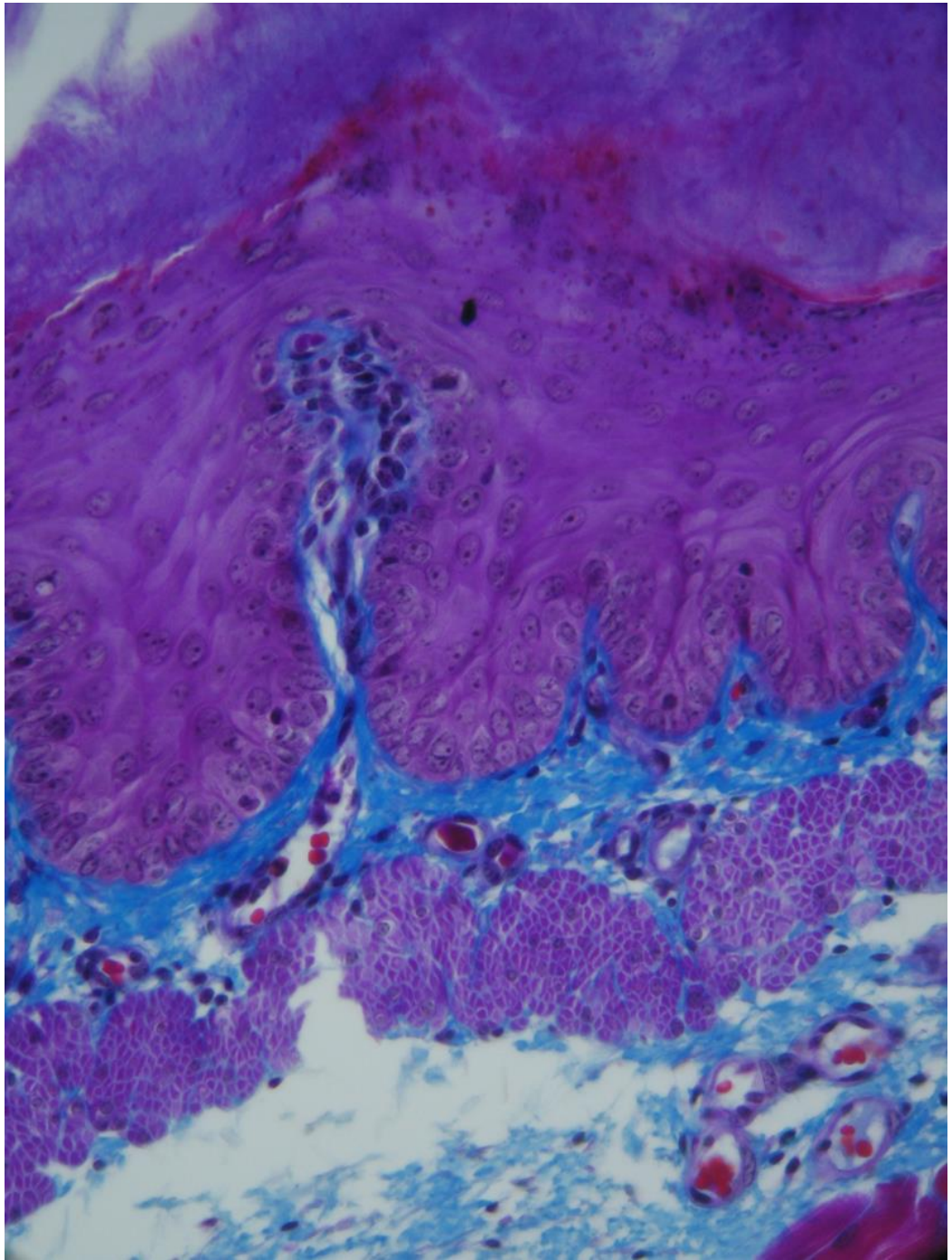
ESOPHAGUS

- The lamina propria consists largely of a dense feltwork of fine collagen fibers with an abundance of evenly distributed elastic fibers; the esophagus is atypical in that the connective tissue of the lamina propria is more dense than the connective tissue of the submucosa.



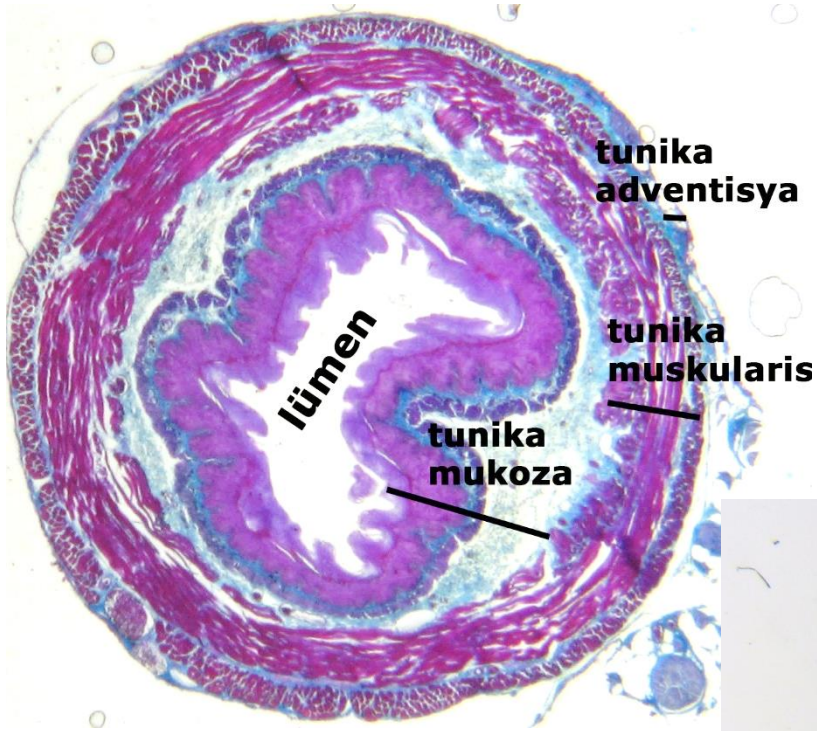
ESOPHAGUS

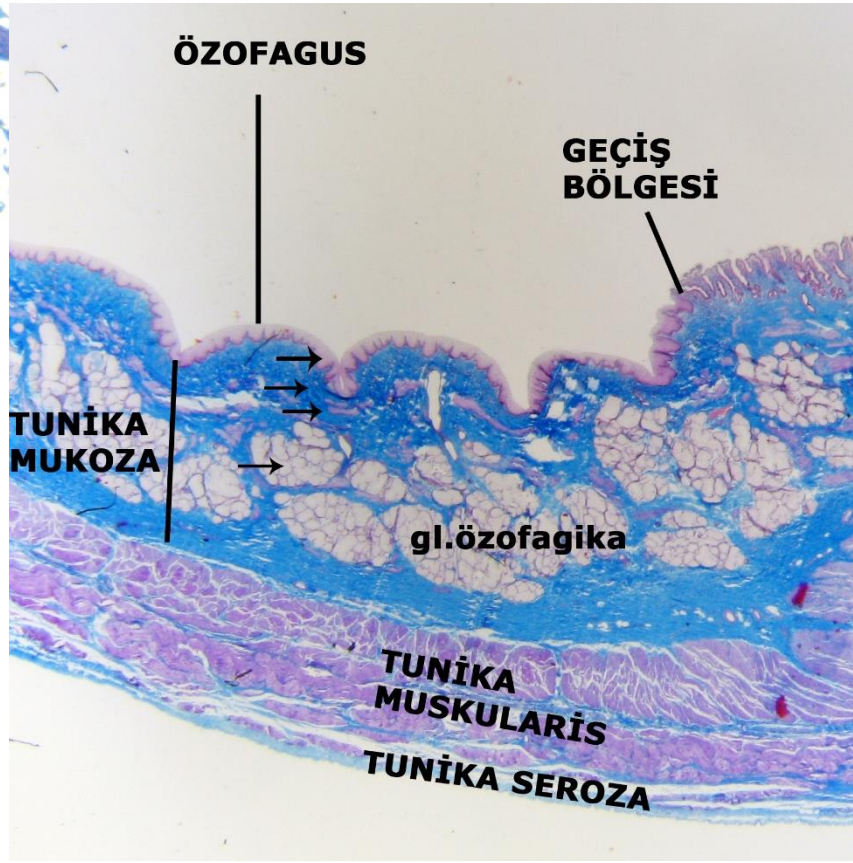
- The lamina muscularis contains only longitudinally oriented smooth muscle bundles.
- It is absent in the cranial end of the esophagus of pigs and dogs, but cats, horses, and ruminants have isolated smooth muscle bundles near the pharynx that increase in number and become confluent toward the stomach.
- In pigs, the lamina muscularis is especially well developed in the caudal end, where it is as thick as the outher layer of the tunica muscularis.



ESOPHAGUS

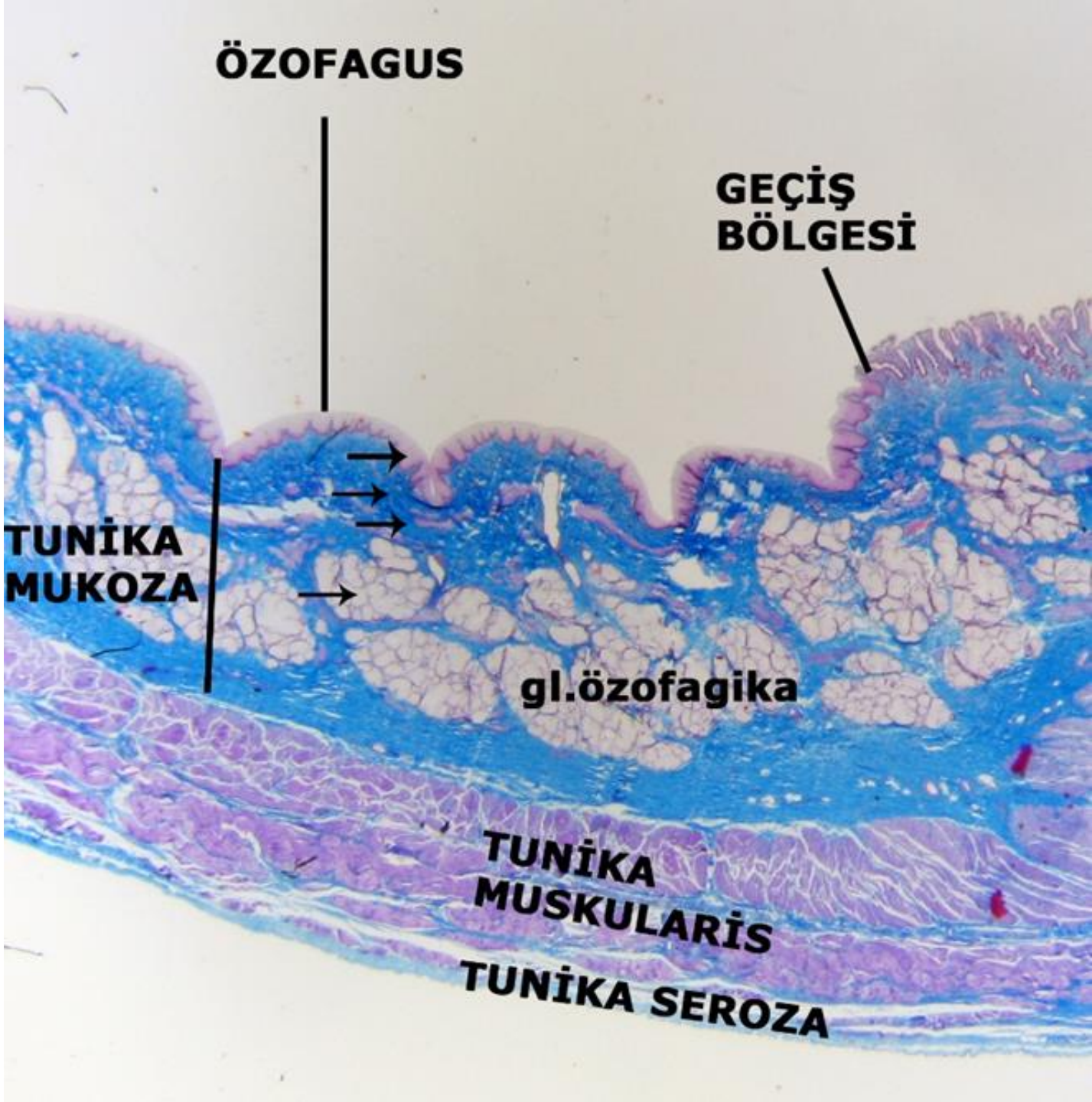
- The submucosa is loose connective tissue containing large, longitudinally oriented arteries, veins, large lymph vessels, and nerves.
- Seromucous glands containing mucous acini with serous demilunes are present in this layer in pigs and dogs.





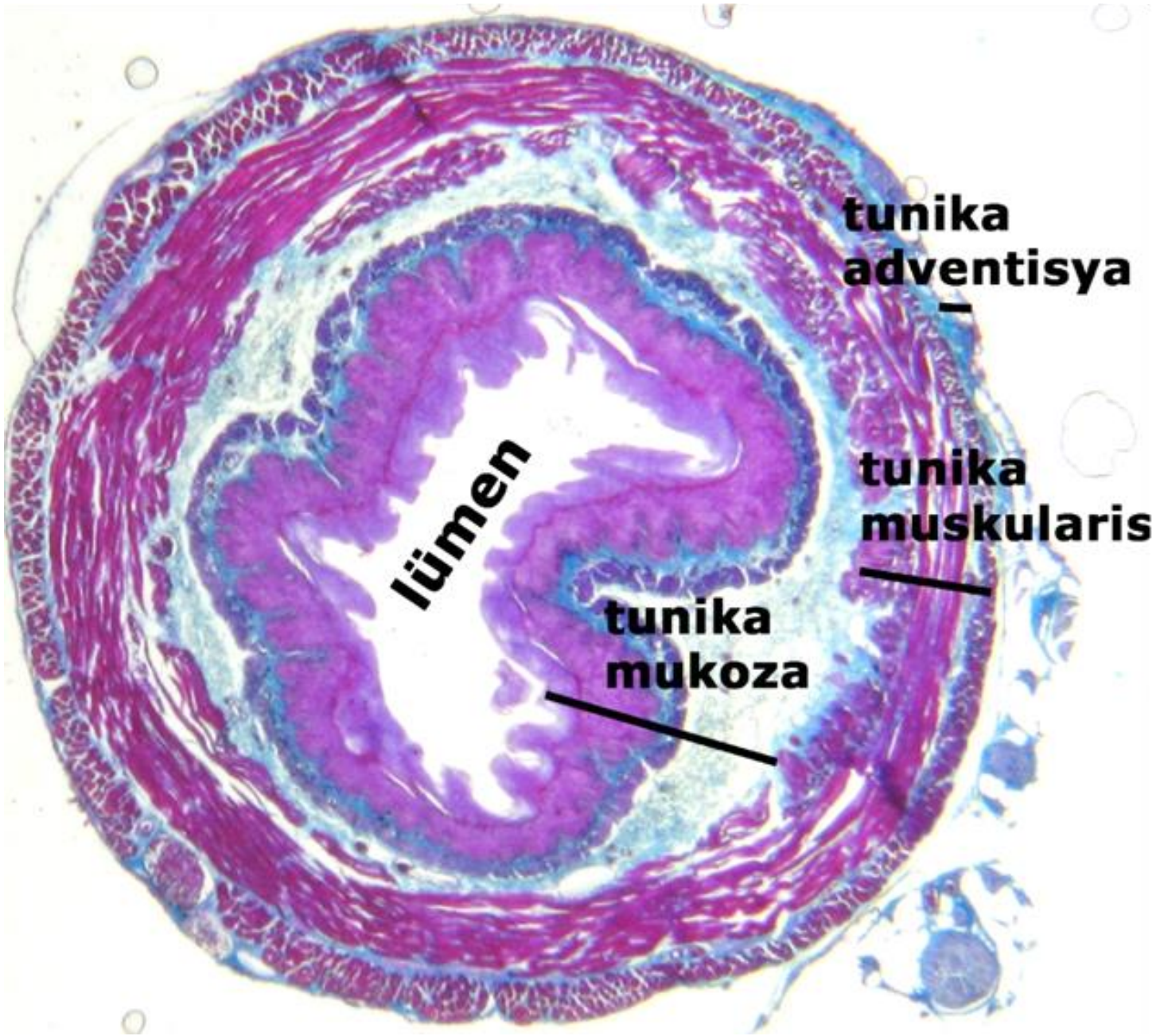
ESOPHAGUS

- In pigs, the glands are abundant in the cranial half but do not extend into the caudal half, whereas in dogs, they are present throughout, extending into the cardiac gland region of the stomach.
- Glands are present only at pharyngoesophageal junction in horses, cats, and ruminants.



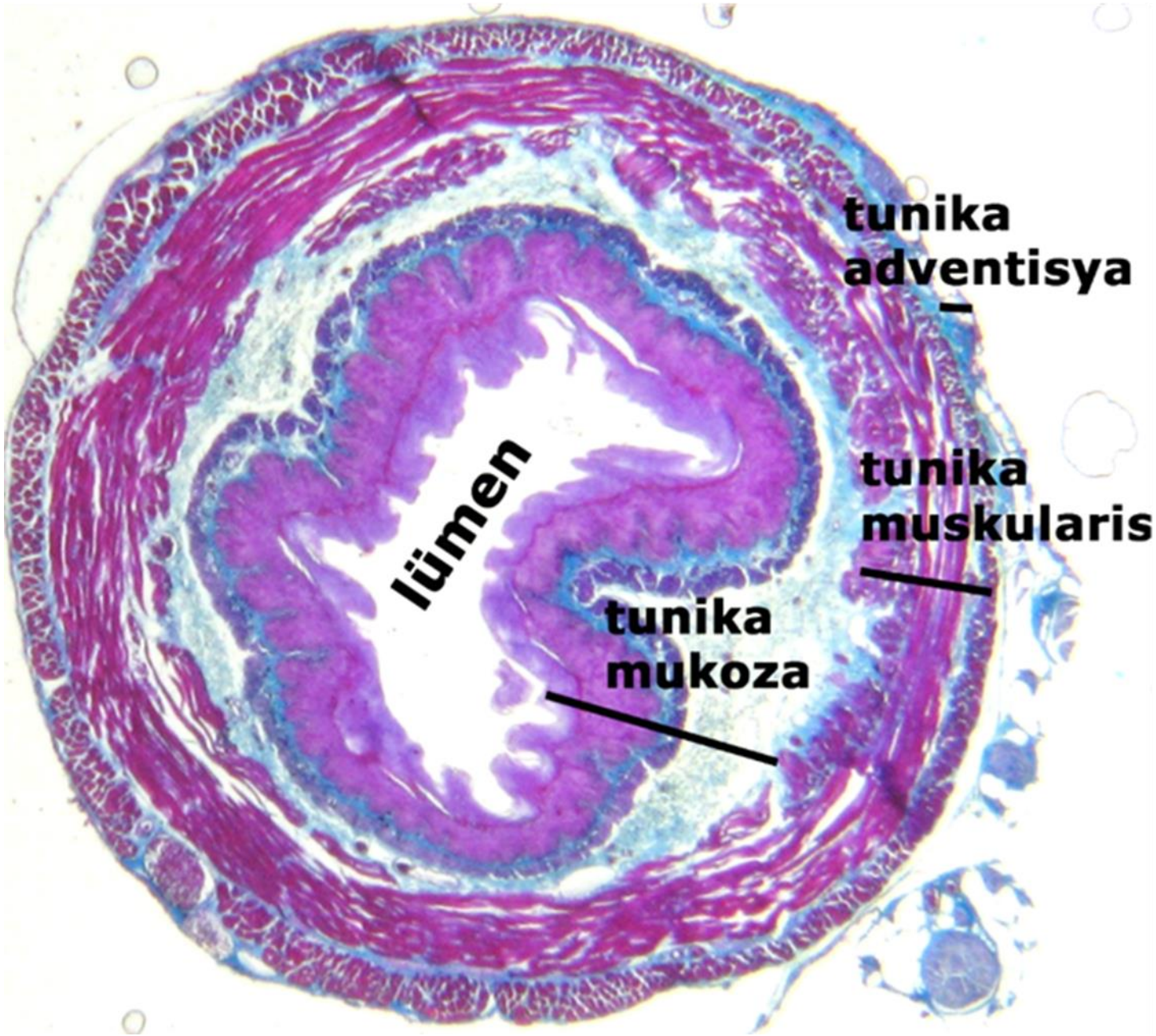
ESOPHAGUS

- The tunica muscularis of the esophagus consists of two layers of muscle.
- In ruminants and dogs, the tunica muscularis consists entirely of skeletal muscle.
- In horses, skeletal muscle comprises the cranial two thirds of the tunica muscularis but gradually changes to smooth muscle in the caudal third.



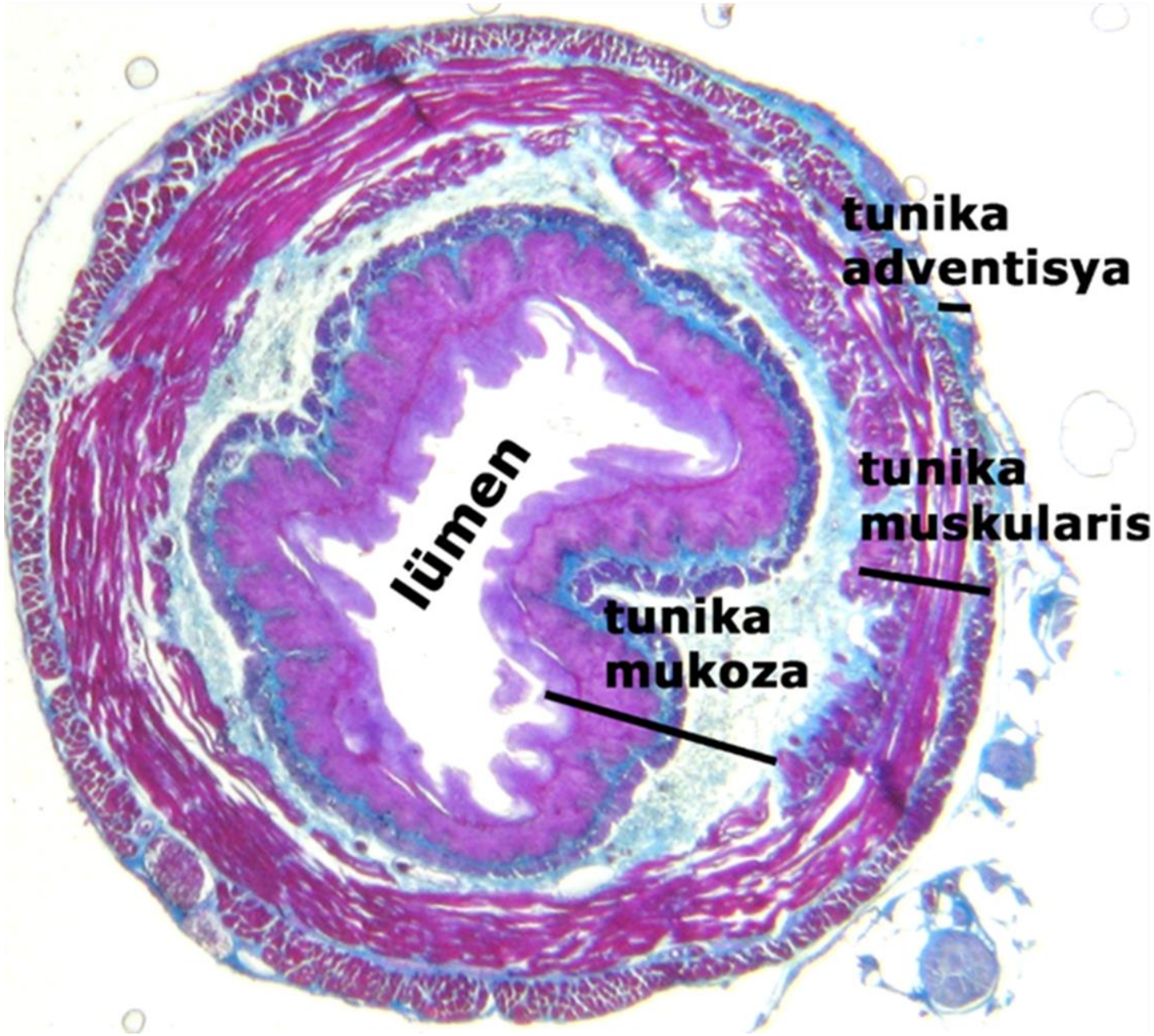
ESOPHAGUS

- The tunica muscularis of pigs is similar to that horses except that the middle third has mixed smooth and skeletal muscle.
- In cats, the skeletal muscle may extend four fifths of the length of the esophagus before changing to smooth muscle.



ESOPHAGUS

- At the cranial end of the esophagus, there is some interdigitation and spiraling of the two muscle layers, but more caudally, these layers change orientation to inner circular and outher longitudinal.

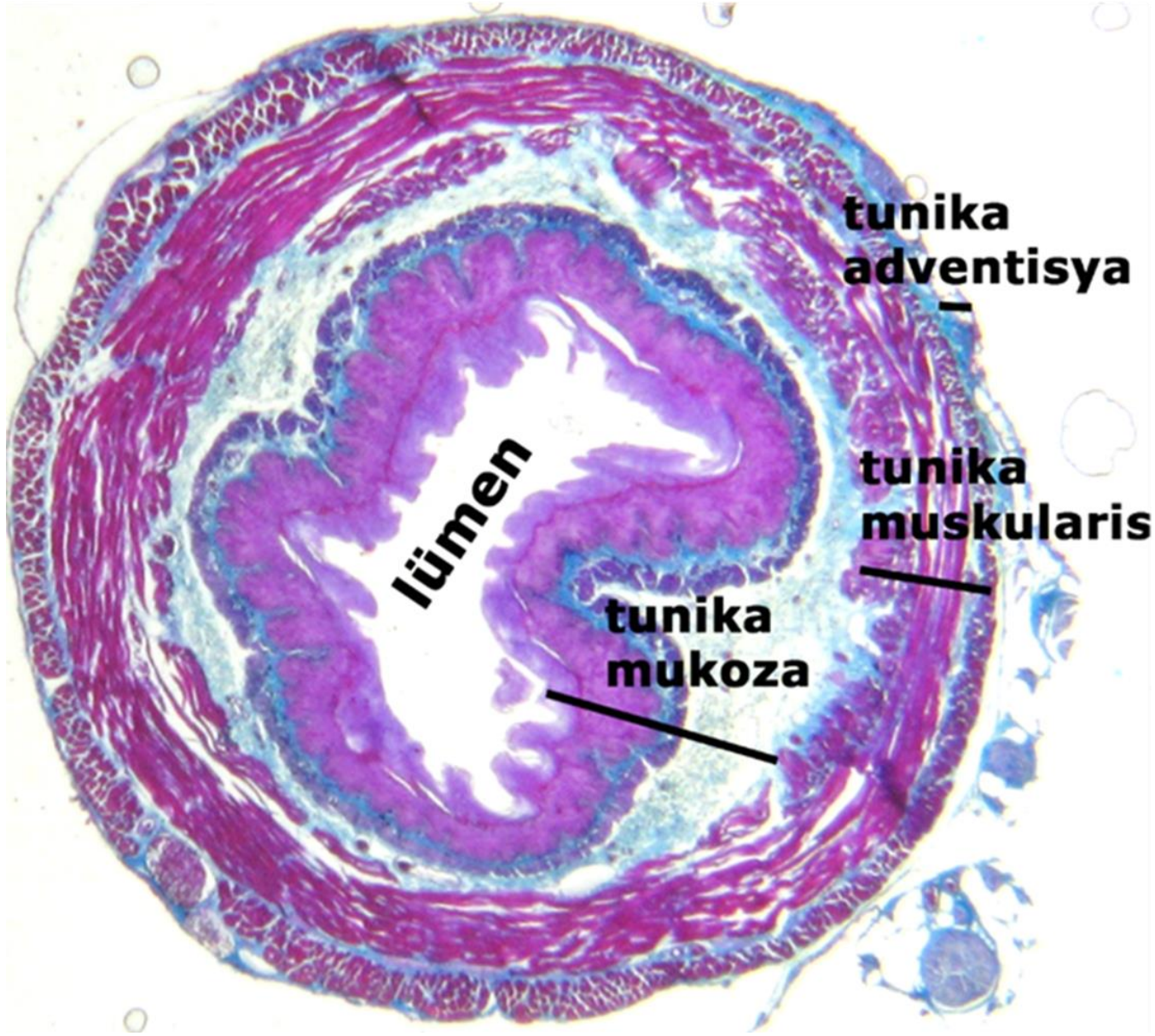


ESOPHAGUS

- The inner circular muscle layer thickens at the cardiac ostium of the stomach in all domestic mammals, forming the **cardiac sphincter muscle**.
- This muscle is especially prominent in horses, where it is 10 to 15 mm thick.
- In ruminants, skeletal muscle extends from the esophagus into the wall of the **reticular sulcus (groove).**

ESOPHAGUS

- In the cervical part of the esophagus, the tunica muscularis is surrounded by an adventitia, a loose connective tissue containing blood vessels, lymp vessels, and nerves.
- The thorasic part of the esophagus is largely invested by a serosa (the mediastinal pleura) in most species.



ESOPHAGUS

- In horses, the abdominal part of the esophagus is approximately 2.5 cm in length and is also covered by a serosa (visceral peritoneum).
- In carnivores, the abdominal part is shorter but is also covered by visceral peritoneum, whereas in other species, the esophagus-stomach junctions is at or near the diaphragm, and mesothelial covering is lacking.

CROP

- The crop is a muscular pouch that is an extension of a bird's esophagus used to store excess food prior to digestion.
- Parent birds store partially digested food in their crop before regurgitating it to feed nestlings.
- The crop is a muscular chamber. It is a fusiform enlargement of the ventral wall of the esophagus at the thoracic inlet. It bulges and lies against the breast muscles.

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