MINISTRY OF HEALTH OF UKRAINE

NATIONAL PIROGOV MEMORIAL MEDICAL UNIVERSITY
VINNYTSIA

GUIDANCE
OF HISTOLOGY OF DIGESTIVE, RESPIRATORY, URYNARY, MALE AND FEMALE REPRODUCTIVE SYSTEMS

part III
SPECIAL HISTOLOGY

TRAINING AND TEACHING MANUAL
FOR SECOND COURSE STUDENTS
OF MEDICAL FACULTY

Student _____

_____

Group _____

VINNYTSIA – 2022

Training and teaching manual was approved at the methodological meeting of the histology department (protocol № 1 from 28.8.2022) and at the meeting of Guidance Council of comprehensive and theoretical subjects (protocol № 1 from 31.8.2022).

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Training and teaching manual is recommended for the first course medical students for practical classes and extracurricular activity of histology.

DIGESTIVE SYSTEM. ORGANS OF THE ORAL CAVITY. LIPS. TONGUE. PALATINES. GINGIVA.

Checking your primary level of the knowledge:

1. **Digestive system compounds**
2. **Components of the oral cavity.**
3. **The lip structure.**
4. **The hard and soft palate structure.**
5. **The tongue - general plan of structure.**
6. **Peculiarities of the papillae of the tongue.**
7. **The gingiva structure.**
8. **General plan of the gastrointestinal tract organization.**
9. **Alimentary canal mucosa structure.**
10. **Alimentary canal submucosa structure.**
11. **Muscularis externa of the gastrointestinal tract.**
12. **Serosa and adventitia of the gastrointestinal tract.**

Standard answers for theoretical questions

1. Digestive system compounds. The digestive system consists of alimentary canal and its associated organs, namely, the tongue, teeth, salivary glands, pancreas, liver and gallbladder.

2. Components of the oral cavity. The oral cavity consists of the mouth and its structures, which include the tongue, teeth and their supporting structures (periodontium), major and minor salivary glands, and tonsils. The oral cavity is divided into a vestibule and the oral cavity proper. The **vestibule** is the space between the lips, cheeks, and teeth. The **oral cavity proper** lies behind the teeth and is bounded by the hard and soft palates superiorly, the tongue and the floor of the mouth inferiorly, and the entrance to the oropharynx posteriorly.

3. **The lip structure.** The lip consists of the external surface, the internal surface and the vermilion margin (red margin) which is located between external and internal zones.

The **external surface** of the lip is covered with thin skin formed of epidermis and dermis with the associated hair follicles, sebaceous glands and sweat glands. Bundles of circular skeletal muscle are present underneath the skin.

The **internal surface** of the lip is lined by mucous membrane which is formed of stratified squamous non-keratinized epithelium. Lamina propria formed of connective tissue contains blood vessels, lymphatic vessels, nerves and group of labial minor salivary glands.

The **vermilion (red) margin** of the lip is the transition zone between the keratinized epithelium of the skin and the non-keratinized epithelium of the mucosa. It is formed of stratified squamous keratinized epithelium without hair follicles, sebaceous glands or sweat glands. This epithelium contains eleidin which is transparent. In the transition zone, long connective tissue papillae extend deep into the epithelium. Capillaries are carried close to the surface in these papillae revealing the "red blood cell" color. At the angles of the mouth, there are sebaceous glands, without hair follicles.

4. **The hard and soft palate structure.**

Separate the oral cavity from nasal cavity. On the nasal side both palates are covered by pseudostratified ciliated columnar epithelium with goblet cells; glands are of mixed type (both mucous and serous). On the oral side **soft palate** is covered by **non-keratinized** stratified squamous epithelium and **hard palate** is covered by stratified squamous **parakeratinized** to stratified squamous **keratinized** epithelium. Glands are purely mucous. At the midline of the hard palate, in the **palatine raphe**, the mucosa adheres firmly to the underlying bone.

Mucous membrane consists of epithelium and underlying lamina propria (thin layer of loose connective tissue) bound by a submucosa of dense connective tissue to the periosteum of bone in the hard palate and bound by a submucosa of dense connective tissue to the perimysium of muscles of the soft palate. Where there is a submucosa underlying the lamina propria on the hard palate, it contains adipose tissue anteriorly (fatty zone) and minor mucous salivary glands posteriorly (glandular zone) that are continuous with those of the soft palate. In the submucosal regions, thick collagenous bands extend from the mucosa to the bone.

5. **The tongue - general plan of structure.**

The tongue is a muscular organ. The striated muscles of the tongue are arranged in bundles that generally run in three planes and usually separated by connective tissue. This form of muscle organization is found only in

the tongue, which allows easy identification of this tissue as lingual muscle. Variable amounts of adipose tissue are found among the muscle fiber groups.
Grossly, the **dorsal surface of the tongue** is divided into an anterior two thirds and a posterior one third by a V-shaped depression, the **sulcus terminalis**.

Lingual tonsils are located in the lamina propria of the root or base of the tongue posterior to the sulcus terminalis. The lingual tonsils contain lymphatic nodules. Epithelial crypts usually invaginate into the lingual tonsil.

Numerous mucosal irregularities and elevations called **lingual papillae** cover the dorsal surface of the tongue anterior to the sulcus terminalis.
The lingual papillae and their associated taste buds constitute the **specialized mucosa** of the oral cavity. Four types of papillae are described: filiform, fungiform, circumvallate, and foliate.

6. Peculiarities of the papillae of the tongue

Filiform papillae are the smallest and most numerous in humans. They are conical, elongated projections of connective tissue that are covered with highly keratinized stratified squamous epithelium. This epithelium does not contain taste buds. The papillae serve only a mechanical role. Filiform papillae are distributed over the entire anterior dorsal surface of the tongue.

Fungiform papillae are mushroom shaped projections located on the dorsal surface of the tongue. They project above the filiform papillae, among which they are scattered. They tend to be more numerous near the tip of the tongue. **Taste buds** are present in the stratified squamous epithelium on the dorsal surface of these papillae.

Circumvallate papillae are the large, dome-shaped structures that reside in the mucosa just anterior to the sulcus terminalis. The human tongue has 8 to 12 of these papillae. Each papilla is surrounded by a moatlike invagination lined with stratified squamous epithelium that contains numerous taste buds.

Foliate papillae consist of parallel low ridges separated by deep mucosal clefts, which are aligned at right angles to the long axis of the tongue. They occur on the lateral edge of the tongue. In aged individuals, the foliate papillae may not be recognized; in younger individuals, they are easily found on the posterior lateral surface of the tongue and contain many taste buds.

7. The gingiva structure. The gingival is the part of the mucous membrane commonly called the gums. The gingival is firmly attached to the teeth and underlying bony tissue. It is composed of stratified squamous epithelium and numerous connective tissue papillae. This epithelium is bound to the tooth enamel by means of a cuticle that resembles a thick basal lamina and forms the epithelial attachment of Gottlieb. Between the enamel and the epithelium is the gingival crevice a small deepening surrounding the crown.

8. General plan of the gastrointestinal tract organization.

The portion of the **alimentary canal** that extends from the proximal part of the esophagus to the distal part of the anal canal is a hollow tube that has the same basic structural organization throughout its length. Its wall is formed by four distinctive layers. From the lumen outward, they are as follows:
• **Mucosa**, consisting of a lining epithelium, an underlying connective tissue called the **lamina propria**, and the **muscularis mucosae**, composed of smooth muscle
• **Submucosa**, consisting of loose connective tissue
• **Muscularis externa**, consisting in most parts of two layers of smooth muscle
• **Serosa**, a serous membrane consisting of a simple squamous epithelium, the mesothelium, and a small amount of underlying connective tissue. An **adventitia** consists only of connective tissue.

9. Alimentary canal mucosa structure.

The structure of the **gastrointestinal tract** varies considerably from region to region; most of the variation occurs within the mucosa. The epithelium differs throughout the alimentary canal and is adapted to the specific function of each part of the tube. The mucosa has three principal functions: **protection**, **absorption**, and **secretion**. The epithelium of the upper and distal portion of the alimentary canal is stratified squamous (oral cavity, esophagus and anal canal) and of the middle part is simple columnar (stomach, small intestine, colon, appendix and rectum). Epithelium can invaginate into underlying connective tissue, forming glands for secretion. Epithelium can evaginate into lumen, forming villi for absorption and secretion.

The glands of the alimentary tract develop from invaginations of the luminal epithelium and include: **mucosal glands** that extend into the lamina propria, **submucosal glands** that either deliver their secretions directly to the lumen of mucosal glands or via ducts that pass through the mucosa to the luminal surface and **extramural glands** that lie outside the digestive tract and deliver their secretions via ducts that pass through the wall of the intestine to enter the lumen. The liver and the pancreas are extramural digestive glands which deliver their secretions into the **duodenum**.

The lamina propria consists of loose connective tissue that contains mucosal glands, vessels that transport absorbed substances, and components of the immune system. In the small intestine, lymphatic capillaries are numerous and receive some absorbed lipids and proteins. The lymphatic tissues in the lamina propria function as an integrated immunologic barrier that protects against pathogens and other antigenic substances.

The **muscularis mucosa**, the deepest portion of the mucosa, consists of smooth muscle cells arranged in an inner circular and outer longitudinal layer. Contraction of this muscle produces movement of the mucosa, forming ridges and valleys that facilitate absorption and secretion. This localized movement of the mucosa is independent of the peristaltic movement of the entire wall of the digestive tract.

10. Alimentary canal submucosa structure.

The submucosa consists of a loose connective tissue layer containing larger blood and lymphatic vessels, a nerve plexus, and occasional glands. The extensive nerve network in the submucosa contains visceral sensory fibers mainly of sympathetic origin, parasympathetic (terminal) ganglia, and preganglionic and postganglionic parasympathetic nerve fibers. In the submucosa, the network of unmyelinated nerve fibers and ganglion cells constitute the **submucosal plexus** (also called **Meissner's plexus**). As noted, glands occur occasionally in the submucosa in certain locations. For example, they are present in the esophagus and the initial portion of the duodenum.

11. Muscularis externa of the gastrointestinal tract.

In most parts of the digestive tract, the **muscularis externa** consists of two concentric and relatively thick layers of smooth muscle. The cells in the inner layer form a tight spiral, described as a **circularly oriented layer**; those in the outer layer form a loose spiral, described as a **longitudinally oriented layer**. Located between the two muscle layers is at thin connective tissue layer. Within this connective tissue lies the **myenteric plexus** (also called **Auerbach's plexus**), containing nerve cell bodies (ganglion cells) of postganglionic parasympathetic neurons and neurons of the enteric nervous system, as well as blood vessels and lymphatic vessels. Contractions of the muscularis externa mix and propel the contents of the digestive tract.

A few sites along the digestive tube exhibit variations in the muscularis externa. For example, in the wall of the proximal portion of the esophagus (pharyngo-esophageal sphincter) and around the anal canal (external anal sphincter), striated muscle forms part of the muscularis externa. In the stomach, a third, obliquely oriented layer of smooth muscle is present deep into the circular layer. Finally, in the large intestine, part of the **longitudinal smooth muscle layer** is thickened to form three distinct, equally spaced longitudinal bands called **teniae coli**.

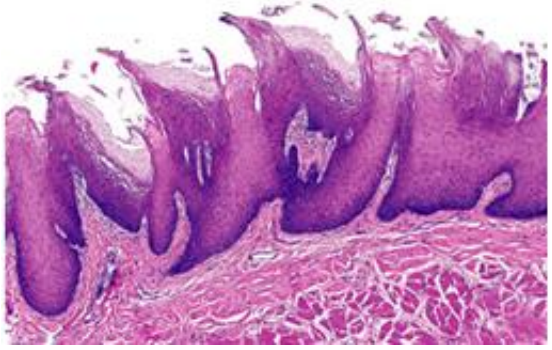
12. Serosa and adventitia of the gastrointestinal tract.

Serosa or adventitia constitutes the outermost layer of the alimentary canal. The **serosa** is a serous membrane consisting of a layer of simple squamous epithelium, called the **mesothelium**, and a small amount of underlying connective tissue. The serosa is the most superficial layer of those parts of the digestive tract that are suspended in the peritoneal cavity. As such, the serosa is continuous with both the **mesentery** and the lining of the abdominal cavity.

Large blood and lymphatic vessels and nerve trunks travel through the serosa to reach the wall of the digestive tract. Large amounts of adipose tissue can develop in the connective tissue of the serosa.

Parts of the digestive tract do not possess a serosa. These include the thoracic part of the esophagus and portions of structures in the abdominal and pelvic cavities that are fixed to the cavity wall—the duodenum, ascending and descending colon, rectum, and anal canal. These structures are attached to the abdominal and pelvic wall by connective tissue, the **adventitia**, which blends with the connective tissue of the wall.

PRACTICAL QUESTIONS



1. Identify the type of papillae in this picture:

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2. Give them short characteristic

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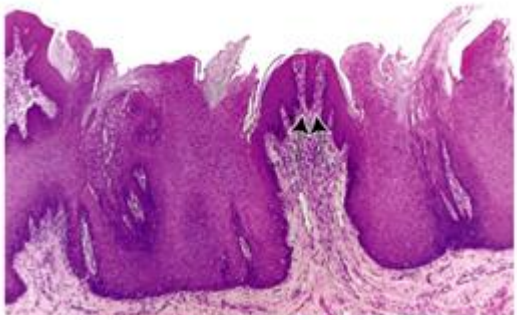
3. Identify the type of papillae in the picture below



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4. Give them short characteristic

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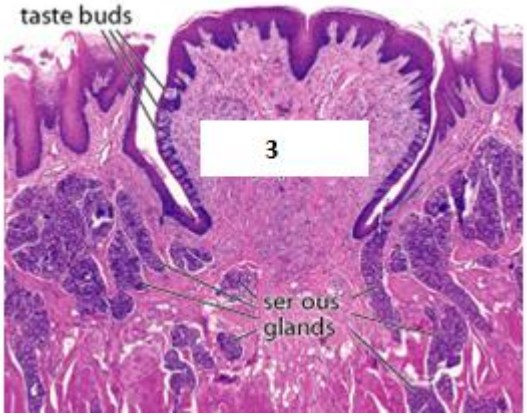

5. What type of papillae are number 3?

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6. Give them short characteristic

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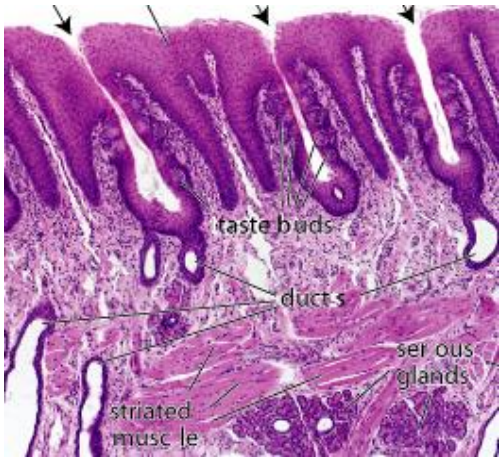
7. Identify the type of papillae in the picture below:



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8. Give them short characteristic

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9. What is the difference between hard and soft palatine?

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10. Why transitional zone of the lip is red?

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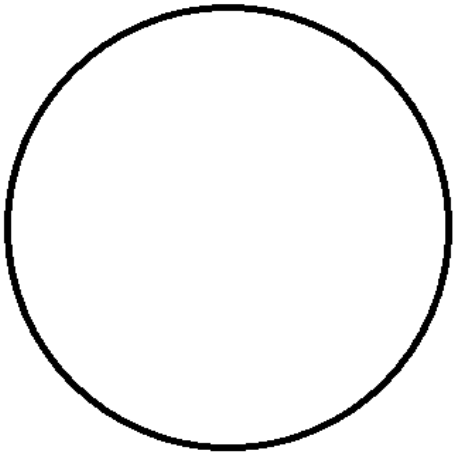
11. In what layers of alimentary canal wall are glands located?

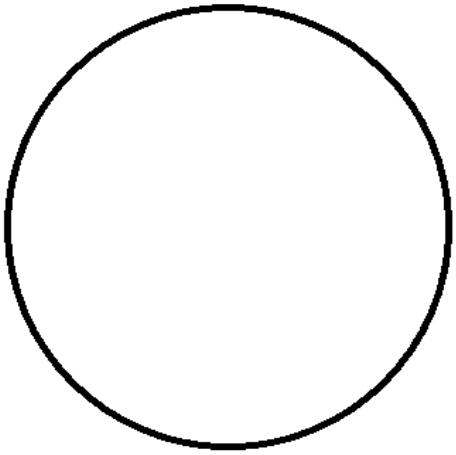
_____
_____
_____
_____



SLIDE 1
Filiform papillae of the tongue.
Stained with hematoxylin and eosin .

SLIDE'S DESIGNATIONS

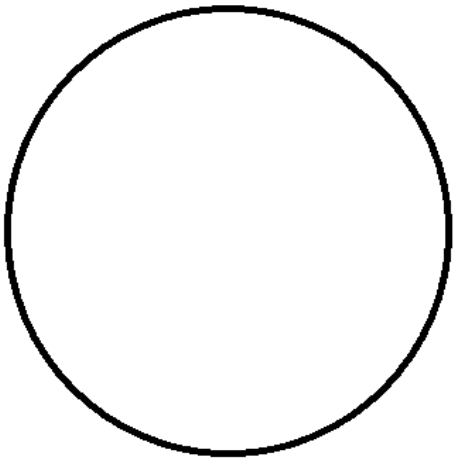
1. Stratified squamous epithelium
2. Lamina propria of the mucosa
3. Tongue's muscles
4. Blood vessels



SLIDE 2
Foliate papillae of the tongue.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Stratified squamous epithelium
2. Lamina propria of the mucosa
3. Tongue's muscles
4. Serous glands
5. Excretory ducts of tongue's glands
6. Mucous glands
7. Taste buds



SLIDE 3
Palatine tonsil.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Mucosa
    a) Stratified squamous epithelium
    b) Lamina propria of the mucosa
    c) Mucous glands
2. Tonsils' crypt
3. Lymphatic nodules
4. Lymphocytes in the crypt**.**

TESTS OF THE "KROK-1" DATABASE.

A 30-year-old patient consulted a doctor with complaints about fever up to 38 C, weakness, sore throat. Objectively: there is white coating on the tongue. What histological structure of the tongue is involved in the formation of this coating?
A. Epithelium of the filiform papillae
B. Epithelium of the foliate papillae
C. Epithelium of the fungiform papillae
D. Epithelium of the circumvallate papillae
E. Connective tissue base of all the lingual papillae

A 22-year-old female student consulted a physician about fever up to 38°C, weakness, sore throat. Objectively: there is white coating on the tongue. What histological structures of the tongue are involved in the formation of this coating?
A *Epithelium of the filiform papillae
B Epithelium of the foliate papillae
C Epithelium of the fungiform papillae
D Epithelium of the circumvallate papillae
E Connective-tissue base of all the lingual papillae

Changes in the uvula and soft palatine were detected during patient examination for diphtheria. What epithelium was damaged?
A. *Stratified squamous
B. Pseudostratified
C. Simple squamous
D. Simple columnar
E. Cuboidal

Crypts of the tonsil, the epithelium of which is infiltrated by leukocytes are identified in histological specimen. What kind of the epithelium does this organ cover?
A. *Stratified squamous nonkeratinized
B. Simple columnar
C. Stratified cuboidal
D. Stratified squamous keratinized
E. Ciliated

In order to speed up healing in the wound of oral mucosa a patient was prescribed a drug. It is thermally stable protein which occurs in tears, saliva, and mothers' milk as well as in a new-laid hen's egg. It is known that this protein is a factor of natural resistance of an organism. How is this protein called?
A *Lysozyme
B Complement
C Interferon
D Interleukin
E Imanine

While examining the oral cavity a dentist revealed inflammation of papillae on the border of the median and posterior third of the back of the tongue. What papillae are inflamed?
A *Papillae circumvallate
B Papillae fungiform
C Papillae foliate
D Papillae filiforme
E Papillae conicae

The reason of occurrence of some diseases of an oral cavity is connected with structural peculiarities of its mucous membrane. What morphological attributes characterize these features?
A *No muscularis mucosa, stratified squamous epithelium
B Transitional epithelium, no submucosa
C Simple columnar ciliated epithelium
D Well developed muscularis, no submucosa
E Transitional epithelium, no muscularis mucosa

Phenomenon of "coated tongue" was revealed in the patient with chronic gastritis during external examination. This phenomenon is caused by cornification process. In what papillae of the tongue does epithelium keratinize?
A. Filiform papillae
B. Fungiform papillae
C. Circumvallate papillae
D. Foliate papillae
E. -

It can be seen the anterior surface is lined with stratified squamous non-keratinized epithelium, and the posterior one – with pseudostratified ciliary epithelium in a histological specimen of an oral cavity organ. What organ is this?
A. Soft palate
B. Gum (gingiva)
C. Hard palate
D. Lip
E. Cheek

Chemical burn of the tongue dorsal surface happened in a 15-year-old girl. What epithelium was damaged?
A. Stratified keratinized
B. Simple low cuboidal
C. Pseudostratified villous
D. Transitional
E. Simple squamous

One of the organs of the oral cavity consists of several folds of the mucosa, in the lamina propria of which there are numerous lymphoid follicles. What is this organ?
A. *Palatine tonsil
B. Tongue
C. Parotid gland
D. Sublingual gland
E. Submandibular gland

The child has damaged a lateral surface of the tongue. Which papillae of the tongue are probably damaged?
A. *Foliate papillae
B. Conical papillae
C. Circumvallate papillae
D. Filiform papillae
E. Fungiform papillae

The student remembered that the epithelium of the oral cavity mucosa is stratified squamous nonkeratinized. In a histological specimen of cheeks he saw that on both sides of them epithelium are keratinized. What should a student remember?
A. *The intermediate zone of buccal mucosa may be keratinized
B. The maxillary zone of buccal mucosa may be keratinized
C. The cheek area near the excretory duct of the parotid gland may be keratinized
D. The entire epithelium of the cheek mucosa may be keratinized
E. -

The cause of some diseases of the oral cavity is connected with structural features of the mucous membrane. What are the morphological traits which characterize these features?
A. *The absence in some places of the submucosa and muscularis mucosa
B. Mucous membrane is covered with transitional epithelium, the submucosa is absent
C. Mucous membrane is covered with simple columnar ciliated epithelium
D. Well-developed muscularis mucosa, submucosa is absent
E. Mucous membrane is covered with transitional epithelium, muscularis mucosa is absent

An employee of the chemical laboratory burned the right edge of the tongue due to the careless handing with acids. What papillae of the tongue are probably damaged?
A. *Foliate
B. Conical
C. Circumvallate
D. Filiform
E. Fungiform

The dentist instructed the intern to examine the patient areas of the oral cavity mucosa which may be keratinized. Where are these areas?
A. *On the hard palate, free edges of gums and along the intermediate part of the cheek
B. On the hard palate, tongue, gums
C. On the cheeks, lower lip, back of the tongue
D. On the hard palate and diaphragm of the oral cavity
E. On the tongue, gingival papilla, tonsils

Numerous excretory ducts of the minor salivary gland, the topography and location of which are not typical for glands open on the tongue surface. Specify the location of the salivary glands of the tongue.
A. *Muscularis externa
B. Mucous membrane
C. Submucosa
D. Epithelium of the upper surface of the tongue
E. Epithelium of the lower surface of the tongue

What are the structural features of the mucosa of the hard palate?
A. *Tightly adherent to the periosteum
B. Covered with transitional epithelium
C. Well developed muscularis mucosa
D. Well developed submucosa
E. Covered with ciliated columnar epithelium

What are the main structural features of the mucosa of gums?
A. *Tightly adherent to the periosteum
B. Accommodates many small salivary glands
C. Located on the submucosa
D. Lamina propria and muscularis mucosa are absent
E. Covered with transitional epithelium, submucosa is absent

DIGESTIVE SYSTEM. ORGANS OF THE ORAL CAVITY. TEETH AND SUPPORTING TISSUES.

Checking your primary level of the knowledge:

1. **General knowledge of the teeth.**
2. **General plan of enamel structure.**
3. **Notion of the incremental lines.**
4. **Enamel formation (amelogenesis)**
5. **General notion of the cementum**
6. **Physical properties of the cementum**
7. **Difference between acellular and cellular cementum**
8. **Attachment of the periodontal ligament fibres to cementum**
9. **General notion of the dentin**
10. **Physical and chemical properties of the dentin**
11. **Structure of the dentin.**
12. **Types of the dentin**
13. **Dental pulp and pulp cavity general knowledge.**
14. **Alveolar process and alveolar bone.**
15. **Periodontal ligament structure.**

Standard answers for theoretical questions

1. General knowledge of the teeth.

Teeth are a major component of the oral cavity and are essential for the digestive process. Teeth are embedded in and attached to the maxilla and mandible. All teeth have the same basic structure. The adult tooth consists of four distinct structural components, the enamel and the cementum on the outside, the dentin beneath them, and the pulp in a central pulp cavity.

2. General plan of enamel structure.

Enamel covers the crown of the tooth. That part of the crown that is exposed and visible above the gum line is called the clinical crown; the anatomical crown describes all of the tooth that is covered by enamel, some of which is below the gum line. The enamel layer ends at the neck or cervix of the tooth at the cementoenamel junction; the root of the tooth is then covered by cementum. Enamel is the hardest substance in the body. It consists of 95-96% calcium hydroxyapatite. The remainder of the tissue is organic material 1-2% and water 2%. The hydroxyapatite of the enamel is arranged in rods or prisms. The structural and functional unit of the tooth is **rods** or **prisms**.

Each enamel rod spans the full thickness of the enamel layer from the dentino-enamel junction to the enamel surface. The cross-sectional view of enamel reveals the characteristic keyhole arrangement of enamel prisms with the tails pointing cervically and the heads occlusally. Head represents the rod and key shows the interprismatic region. Head of enamel rod is formed by one ameloblast and tail is formed by three ameloblasts. Thus each rod is formed by four ameloblasts.

Hunter-Schreger bands are alternating light and dark bands seen in a section of enamel when cut longitudinally. These bands are visible because the different bands of prisms reflect light in different directions.

3. Notion of the incremental lines.

During development changes in the developing enamel front are recorded as incremental features. Each striation represents the amount of enamel deposited each day during odontogenesis.

In section of enamel cut along the longitudinal axis of the crown the enamel striae (or **striae of Retzius**) are seen as prominent lines that line obliquely across the enamel prisms to the surface. These lines indicate a pause or interruption in the deposition of enamel. The first line of Retzius occurs at birth and it is given a special name, the **neonatal line**. The neonatal line is darker and larger than the rest of the striae of Retzius. The neonatal line is hypocalcified.

In addition to the "hypo-mineralized" dark striae of Retzius, there also exists hypo-mineralized areas perpendicular to the dentino-enamel junction. These are **enamel lamellae** (that traverse the entire thickness of enamel) and **enamel tufts** (that traverse the inner third of enamel adjacent to the dentino-enamel junction).

Enamel spindles are the processes of odontoblasts resting in dentinal tubules projecting into the enamel. **Amelodentinal junction**: the enamel and dentine meet at the amelodentinal junction; this junction has a scalloped appearance. The enamel in a mature tooth is acellular and nonreplaceable.

4. Enamel formation (amelogenesis)

Enamel is produced by ameloblasts with the close cooperation of other enamel organ cell. The major stages of amelogenesis are the period of matrix production, or the secretory stage, and the period of maturation. In the formation of mineralized tissues of the tooth, dentin is produced first. Then, partially mineralized enamel matrix is deposited directly on the surface of the previously formed dentin. The cells producing this partially mineralized organic matrix are referred to as secretory ameloblasts. The **secretory ameloblasts** continue to produce enamel matrix until the full thickness of the future enamel is achieved. Maturation of the partially mineralized enamel matrix involves the removal of organic material as well as continued influx of calcium and phosphate into the maturing enamel. Cells involved in this second stage of enamel formation are referred to as maturation ameloblasts. **Maturation ameloblasts** differentiate from secretory ameloblasts and function primarily as a transport epithelium, moving substances into and out of the maturing enamel.

The maturation of the developing enamel results in the continued mineralization of enamel, so that it becomes the hardest substance in the body. The ameloblasts degenerate after the enamel is fully formed, at about the time of tooth eruption from the gum.

5. General notion of the cementum

Cementum is the thin layer of calcified tissue covering the dentine of the root. Cementum varies in thickness at different levels of the root. It is thickest at the root apex and in the interradicular areas of multi rooted teeth, and thinnest cervically.

Cementum is contiguous with the periodontal ligament on its outer surface and is firmly adherent to dentine on its deep surface. Its prime function is to give attachment to collagen fibres of the periodontal ligament. Developmentally, cementum is said to be derived from the investing layer of the dental follicle. Like dentine, there is always a thin layer (3–5 μm) of uncalcified matrix on the surface of the cellular variety of cementum. This layer of uncalcified matrix is called **precementum**.

Similar in chemical composition and physical properties to bone, cementum is, however, avascular and has no innervation.

6. Physical properties of the cementum

Cementum is pale yellow with a dull surface. It is softer than dentine. Cementum contains on a wet-weight basis 65% inorganic material, 23% organic material and 12% water. The principal inorganic component is hydroxyapatite.

7. Difference between acellular and cellular cementum

Classification of cementum types is based on the presence or absence of cells – cellular and acellular cementum.

Cellular cementum contains cells (cementocytes); **acellular cementum** does not. In the most common arrangement, acellular cementum covers the root adjacent to the dentine, whereas cellular cementum is found mainly in the apical area and overlying the acellular cementum. Cellular cementum is especially common in interradicular areas. Acellular cementum appears relatively structure less. The usual arrangement at the apical region of the root is of a layer of cellular cementum overlying acellular cementum. The spaces that the cementocytes occupy in cellular cementum are called **lacunae**, and the channels that their processes extend along are the **canaliculi**. Adjacent canaliculi are often connected, and the processes within them exhibit gap junctions.

Cementum is deposited in an irregular rhythm, resulting in unevenly spaced **incremental lines** of Salter. In acellular cementum, incremental lines tend to be close together, thin and even. In the more rapidly formed cellular cementum, the lines are further apart, thicker, and more irregular.

8. Attachment of the periodontal ligament fibres to cementum

The fibres of the periodontal ligament run into the organic matrix of precementum that is secreted by cementoblasts. Subsequent mineralisation of precementum will incorporate the extrinsic fibres as Sharpey's fibres into cementum.

9. General notion of the dentin

Dentin underlies the enamel in the crown area and is covered by the cementum in the root area. Physically and chemically the dentin closely resembles the bone.

Dentin is secreted by odontoblasts that form an epithelial layer over the inner surface of the dentin, i.e., that surface that is in contact with the pulp. Odontoblasts, too, are elongated cylindrical cells that contain a well-developed rER, a large Golgi apparatus, and other organelles associated with the synthesis and secretion of large amounts of protein.

10. Physical and chemical properties of the dentin

Dentin is light yellowish in color, becoming darker with age. It is elastic and subject to slight deformation. Dentin is harder than bone but softer than enamel.

Dentin consists of 30% organic matter and water and 70% inorganic material. Organic material constitutes 20%. The main organic component is collagen fibres embedded in amorphous ground substance of mucopolysaccharides. The remaining 10% (by weight) is water. The inorganic component consists of hydroxyapatite.

11. Structure of the dentin.

The bodies of the odontoblasts are arranged in a layer on the pulpal surface of the dentin, and only their cytoplasmic processes are included in the tubules in the mineralized matrix. The course of dentinal tubules follows a gentle curve in the crown, less so in the root, where it resembles S in shape. The dentin that immediately surrounds the dentinal tubules is called **peritubular dentin**. It is more highly mineralized than **intertubular dentin**. Intertubular dentin forms the main body of dentin. It is located between the dentinal tubules or more specifically, between the zones of peritubular dentin.

There is a zone adjacent to the cementum that appears granular. This is known as **Tomes' granular layer**. It slightly increases in amount from the cementoenamel junction to the root apex. Tomes' granular layer is caused by coalescing and looping of the terminal portions of the dentinal tubules.

The incremental lines (von Ebner) appear as striations in dentin. They run at right angles to the dentinal tubules. These lines reflect the daily rhythmic, recurrent deposition of dentin matrix. Some of the incremental lines are accentuated because of disturbances in the matrix and mineralization process. Such lines are known as **contour lines of Owen**.

12. Types of the dentin

Predentin is located adjacent to the pulp tissue. It is the first formed dentin and is not mineralized yet. As the collagen fibers undergo mineralization at the predentin-dentin front, the predentin then becomes dentin and a new layer of predentin forms circumpulpally.

Mantle dentin and **circumpulpal dentin** are two types of the **primary dentin**. **Mantle dentin** is the first formed dentin in the crown underlying the dentinoenamel junction. It is the most peripheral part of the primary dentin. The fibrils found in this zone are perpendicular to the dentinoenamel junction. **Circumpulpal dentin** forms the remaining primary dentin or bulk of the tooth. Represents all of the dentin formed prior to root completion. The fibrils are much smaller in diameter and are more closely packed together.

Secondary dentin is a narrow band of dentin bordering the pulp and representing the dentin formed after root completion. Secondary dentin contains fewer tubules than primary dentin.

Sometimes mineralization of dentin begins in small globular areas that fail to fuse into a homogenous mass. This results in zones of hypomineralization between the globules. These zones are called **interglobular dentin**. Interglobular dentin refers to organic matrix that remains unmineralized. The dark staining spherules of mineralization in the section of predentin are referred as **globular dentin.**

Reparative dentin is also known as **tertiary or response dentin**. If by extensive abrasion, erosion, caries, or operative procedures the odontoblast processes are exposed or cut, the odontoblasts die or, if they live, deposit reparative dentin. The tubule lumen is obliterated with mineral forming a sclerotic dentin. **Sclerotic or transparent dentin** found especially in roots.

13. Dental pulp and pulp cavity general knowledge.

The dental pulp cavity is a connective tissue compartment bounded by the tooth dentin. The pulp cavity is the space within a tooth that is occupied by pulp, a loose connective tissue that is richly vascularized and supplied by abundant nerves. The pulp cavity has the general shape of the tooth. The blood vessels and nerves enter the pulp cavity at the tip (apex) of the root, at a site called the apical foramen.

14. Two types of the pulp.

Coronal pulp occupies the crown of the tooth. Pulp horns are protrusions of the pulp that extend up into the cusps of the tooth.

Radicular pulp extends from the cervix down to the apex of the tooth. Molars and premolars exhibit multiple radicular pulps. This pulp is tapered and conical.

The blood vessels and nerves extend to the crown of the tooth where they form vascular and neural networks beneath and within the layer of odontoblasts. Some bare nerve fibers also enter the proximal portions of the dentinal tubules and contact odontoblast processes. In teeth with more than one cusp, pulpal horns extend into the cusps and contain large numbers of nerve fibers. Because dentin continues to be secreted throughout life, the pulp cavity decreases in volume with age.

15. Alveolar process and alveolar bone.

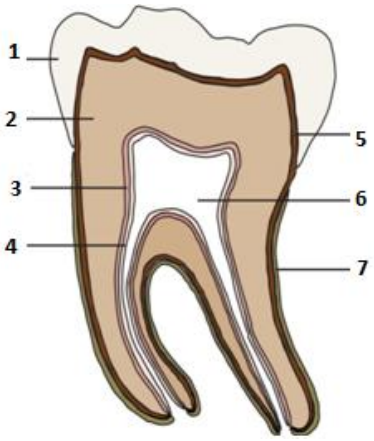
The alveolar processes of the mandible and maxilla contain the sockets or alveoli for the roots of the teeth. The alveolar bone proper, a thin layer of compact bone, forms the wall of the alveolus and is the bone to which the periodontal ligament is attached. The rest of the alveolar process is supporting bone.

16. Periodontal ligament structure.

The periodontal ligament is the fibrous connective tissue joining the tooth to its surrounding bone. The periodontal ligament provides for: attachment, support**,** bone remodeling (during movement of a tooth)**,** nutrition of adjacent structures**,** proprioception and tooth eruption. Attachment and support are the most apparent functions.

A histological section of the periodontal ligament shows it to contain areas of both dense and loose connective tissue. The dense connective tissue contains collagen fibers and fibroblasts. The loose connective tissue in the periodontal ligament contains blood vessels and nerve endings in addition to the cells and thin collagenous fibers. The periodontal ligament also contains longitudinally disposed oxytalan fibers which resemble developing elastic fibers. They are attached to bone or cementum at each end.

PRACTICAL QUESTIONS



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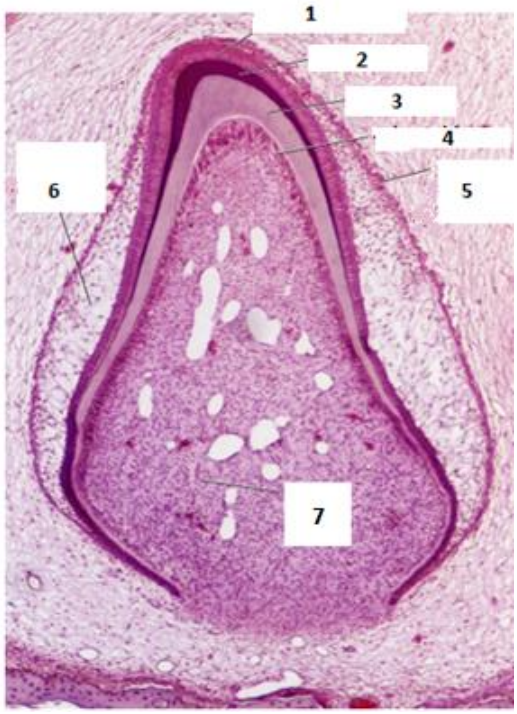

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12. Identify the structure labeled 5.

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13. Identify the structure labeled 6.

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14. Identify the structure labeled 7.

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15. What is the difference between cellular and acellular cementum?

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16. What types of the pulp do you know? Give them short characteristic.

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17. What is the difference between predentin and dentin?

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_____

18. What functions of the periodontal ligament do you know?

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19. Describe the structure of the structural and functional unit of the enamel.

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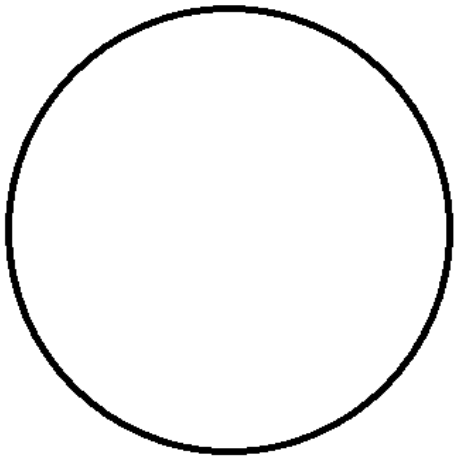
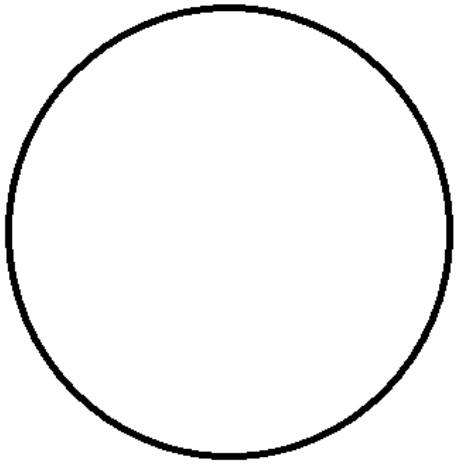


SLIDE 1
Tooth development during enamel organ formation
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Oral epithelium
2. Dental lamina
3. Pulp of the enamel organ
4. Inner enamel epithelium
5. Outer enamel epithelium
6. Odontoblastic layer
7. Dental papilla
8. Corner of the enamel organ
9. Wall of the bone alveola



SLIDE 2
Tooth development during histogenesis
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Ameloblasts
2. Enamel
3. Oral epithelium
4. Dentin
5. Odontoblasts
6. Stellate reticulum
7. Dental papilla

TESTS OF THE "KROK-1" DATABASE.

What is the structural component of the tooth that provides the trophic function for dentin?
A. *Pulp
B. Periodontum
C. Enamel
D. Cellular cementum
E. Acellular cementum

Dark areas of the dentin were found on the section of the extracted tooth. Which process formed these sites?
A. *Destruction of dentinoblasts
B. Proliferation of dentinoblasts
C. Hypertrophy of dentinoblasts
D. Atrophy of dentinoblasts
E. Proliferation of fibroblasts

Radial light bands were found in the dentin on the tooth section of elderly person. Such sites in the dentin are called:
A. *Transparent dentin
B. "Dead ways"
C. Secondary dentin
D. Tertiary dentin
E. Irregular dentin

The dentin tubules are visible on the section of tooth crown. What is contained in these tubules?
A. *Processes of dentinoblasts
B. Processes of enameloblasts
C. Bodies of dentinoblasts
D. Fibroblasts
E. Elastic fibers

Dental caries is characterized by a decalcification of the enamel. What is the sequence of the process of decalcification?
A. *Shell of enamel rods, interred enamel, enamel rods
B. Enamel rods, interred substance, shell of enamel rods
C. Interrod substance, enamel rods, shell of enamel rods
D. Enamel rods, interrod substance
E. Interrod substance, enamel rods

The cuboidal shape cells with well-developed rough endoplasmic reticulum are determined in a histological specimen in the area of the tooth root on the outer surface of the dentine. What tissue do they form?
A. *Cementum
B. Dentin
C. Enamel
D. Loose connective tissue
E. Dense connective tissue

There is adding of calcium into enamel after the eruption of the tooth. What stage of enamel formation has these characteristics?
A. *Tertiary mineralization
B. Secondary mineralization
C. Secretion stage
D. Primary mineralization
E. Maturation

The interprismatic enamel is represented in a histological specimen. What cells form it?
A. *Secretory active ameloblasts
B. Secondary ameloblasts
C. Preodontoblasts
D. Primary ameloblasts
E. Secretory active odontoblasts

The germ of the tooth is presented in the histological specimen of the embryo oral cavity. Specify from what elements it consists of?
A. *Enamel organ, dental papilla, dental follicle
B. Enamel organ and dental papilla
C. Dental papilla and dental follicle
D. Enamel organ and dental follicle
E. Enamel organ

Linear striation in the form of concentric circles, which are directed at the angle to dentinoenamel junction, was found during histological examination of enamel cross-section during histological examination of enamel cross-section. Name these structures.
A. *Contour lines of Retzius
B. Hunter-Schreger bands
C. Enamel lamellae
D. Enamel tufts
E. Enamel spindles

In the process of development of the tooth in the periodontum are stored the remains of the embryonic Hertwig's root sheath that are called epithelial cells rests of Malassez. They can be a source of development of cysts or tumors in the tooth root region. What cells formed Hertwig's root sheath?
A *Cells of enamel organ
B Mesenchyma cells
C Cells of the pulp
D Odontoblasts
E Cementoblasts

DIGESTIVE SYSTEM. ORGANS OF THE ORAL CAVITY. SALIVARY GLANDS.

Checking your primary level of the knowledge:

1. **Development of the salivary gland.**
2. **Types of the salivary glands.**
3. **General plan of the salivary glands acini structure.**
4. **Description of the protein-secreting serous cells.**
5. **Description of the mucin-secreting mucous cells.**
6. **Description of the myoepithelial cells**
7. **Salivary ducts types.**
8. **Description of the intercalated ducts.**
9. **Description of the striated (intralobular) ducts.**
10. **Description of the excretory ducts**
11. **Parotid gland structure**
12. **Submandibular gland structure**
13. **Sublingual gland structure**

Standard answers for theoretical questions

1. Development of the salivary gland.

Each salivary gland arises from the developing oral cavity epithelium. Initially, the gland takes the form of a solid cord of cells that enters the mesenchyme. The proliferation of epithelial cells eventually produces highly branched epithelial cords with bulbous ends. Degeneration of the innermost cells of the cords and bulbous ends leads to their canalization. The cords become ducts, and the bulbous ends become **secretory acini**.

2. Types of the salivary glands.

The **minor salivary glands** are located in the submucosa of different parts of the oral cavity. They include the lingual, labial, buccal, molar and palatine glands.

The **major salivary glands** are paired glands with long ducts. They consist of parotid, submandibular and sublingual glands. These glands consist of two general types of secretory cells-serous and mucous one and a duct system.

3. General plan of the salivary glands acini structure.

The major salivary glands are surrounded by a capsule of moderately dense connective tissue from which septa divide the secretory portions of the gland into lobes and lobules. The septa contain the larger blood vessels and excretory ducts. The connective tissue associated with the groups of secretory acini blends imperceptibly into the surrounding loose connective tissue. The minor salivary glands do not have a capsule. Numerous lymphocytes and plasma cells populate the connective tissue surrounding the acini in both the major and minor salivary glands.

The basic secretory unit of salivary glands consists of the acinus, intercalated duct, and excretory duct. The **acinus** is a blind sac composed of secretory cells. The acini of salivary glands contain either **serous cells** (protein secreting), **mucous cells** (mucin secreting), or both.

The relative frequencies of the three types of acini are a prime characteristic by which the acini are described:

• **Serous acini**, which contain only serous cells and are generally spherical

• **Mucous acini**, which contain only mucous cells and are usually more tubular

• **Mixed acini**, which contain both serous and mucous cells. In routine H&E preparations, mucous acini have a cap of serous cells that are thought to secrete into the highly convoluted intercellular space between the mucous cells. Because of their appearance in histologic sections, such caps are called **serous demilunes.**

Exocrine glands in the mouth produce saliva, which has digestive, lubricating and immunologic functions.

4. Description of the protein-secreting serous cells.

They have a pyramidal shape, with a relatively wide basal surface facing the basal lamina and a small apical surface facing the lumen of the acinus. They contain rounded nucleus, large amounts of rER, free ribosomes, a prominent Golgi apparatus, and numerous spherical secretory granules. As in most protein-secreting cells that store their secretions in **zymogen granules**, the granules are located in the apical cytoplasm. Most other organelles are located in the basal or perinuclear cytoplasm. The serous cells are joined near their apical surface by junctional complexes to neighboring cells of the acinus.

5. Description of the mucin-secreting mucous cells.

The **mucous cells** of the mucous salivary acini undergo cyclic activity. During part of the cycle, mucus is synthesized and stored within the cell as **mucinogen granules**. When the product is discharged the cell begins to resynthesize mucus. After discharge of most or all of the mucinogen granules, the cell is difficult to distinguish from an inactive serous cell. However, most mucous cells contain large numbers of mucinogen granules in their apical cytoplasm, and because the mucinogen is lost in H&E–stained paraffin sections, the apical portion of the cell usually appears empty. The rER, mitochondria, and other components are seen chiefly in the basal portion of the cell; this part of the cell also contains the nucleus, which is typically flattened against the base of the cell. The apical portion of the mucous cell contains numerous mucinogen granules and a large Golgi apparatus, in which large amounts of carbohydrate are added to a protein base to synthesize the glycoprotein of the mucin. Mucous cells possess apical junctional complexes, the same as those seen between serous cells.

6. Description of the myoepithelial cells

They are contractile cells with numerous processes that embrace the basal aspect of the acinar secretory cells. They lie between the basal plasma membrane of the epithelial cells and the basal lamina of the epithelium. Myoepithelial cells also underlie the cells of the proximal portion of the duct system. In both locations, the myoepithelial cells are instrumental in moving secretory products toward the excretory duct. The nucleus of the cell is often seen as a small round profile near the basement membrane.

7. Salivary ducts types.

The lumen of the salivary acinus is continuous with that of a **duct system** that may have as many as three sequential segments: **intercalated duct, striated duct** and **excretory ducts**.

8. Description of the intercalated ducts.

Intercalated ducts are located between a secretory acinus and a larger duct**.** They are lined by low cuboidal epithelial cells. Several of these ducts join to form an intralobular duct, the striated duct. Intercalated ducts are most prominent in those salivary glands that produce a watery serous secretion. In mucus-secreting salivary glands, the intercalated ducts, when present, are short and difficult to identify.

9. Description of the striated (intralobular) ducts.

Striated ducts are lined by a simple cuboidal epithelium that gradually becomes columnar as it approaches the excretory duct. Striated duct cells have numerous infoldings of the basal plasma membrane which are seen in histologic sections as “striations.” Longitudinally oriented, elongated mitochondria are enclosed in the infoldings. The nucleus typically occupies a central (rather than basal) location in the cell. The diameter of striated ducts often exceeds that of the secretory acinus. Striated ducts are located in the parenchyma of the glands (they are **intralobular ducts**) but may be surrounded by small amounts of connective tissue in which blood vessels and nerves can be seen running in parallel with the duct. The striated ducts of each lobule converge and drain into the connective tissue septae separating the lobules, where they become interlobular or excretory. Mucous glands do not display striated ducts.

10. Description of the excretory ducts

Excretory ducts travel in the interlobular and interlobar connective tissue. Excretory ducts constitute the principal ducts of each of the major glands. They ultimately connect to the oral cavity. The epithelium of small excretory ducts is simple cuboidal. It gradually changes to pseudostratified columnar or stratified cuboidal. As the diameter of the duct increases, stratified columnar epithelium is often seen, and as the ducts approach the oral epithelium, stratified squamous epithelium may be present.

11. Parotid gland structure

The parotid glands are branched, acinar and totally serous. The paired parotid glands are the largest of the major salivary glands. The parotid duct travels from the gland, which is located below and in front of the ear, to enter the oral cavity opposite the second upper molar tooth. The secretory units in the parotid glands are serous and surround numerous, long, narrow intercalated ducts. Striated ducts are large. Large amounts of adipose tissue may be one of its distinguishing features.

12. Submandibular gland structure

The submandibular glands are branched tubuloacinar gland; its secretory portion consists of both **serous** and **mucous** acini (some also have serous demilunes). Serous cells are the main component of this gland. They are classified as mixed. The paired, large, mixed submandibular glands are located under either side of the floor of the mouth, close to the mandible. A duct from each of the two glands runs toward and medially to a papilla located on the floor of the mouth just lateral to the frenulum of the tongue. Intercalated ducts are less extensive than in the parotid gland.

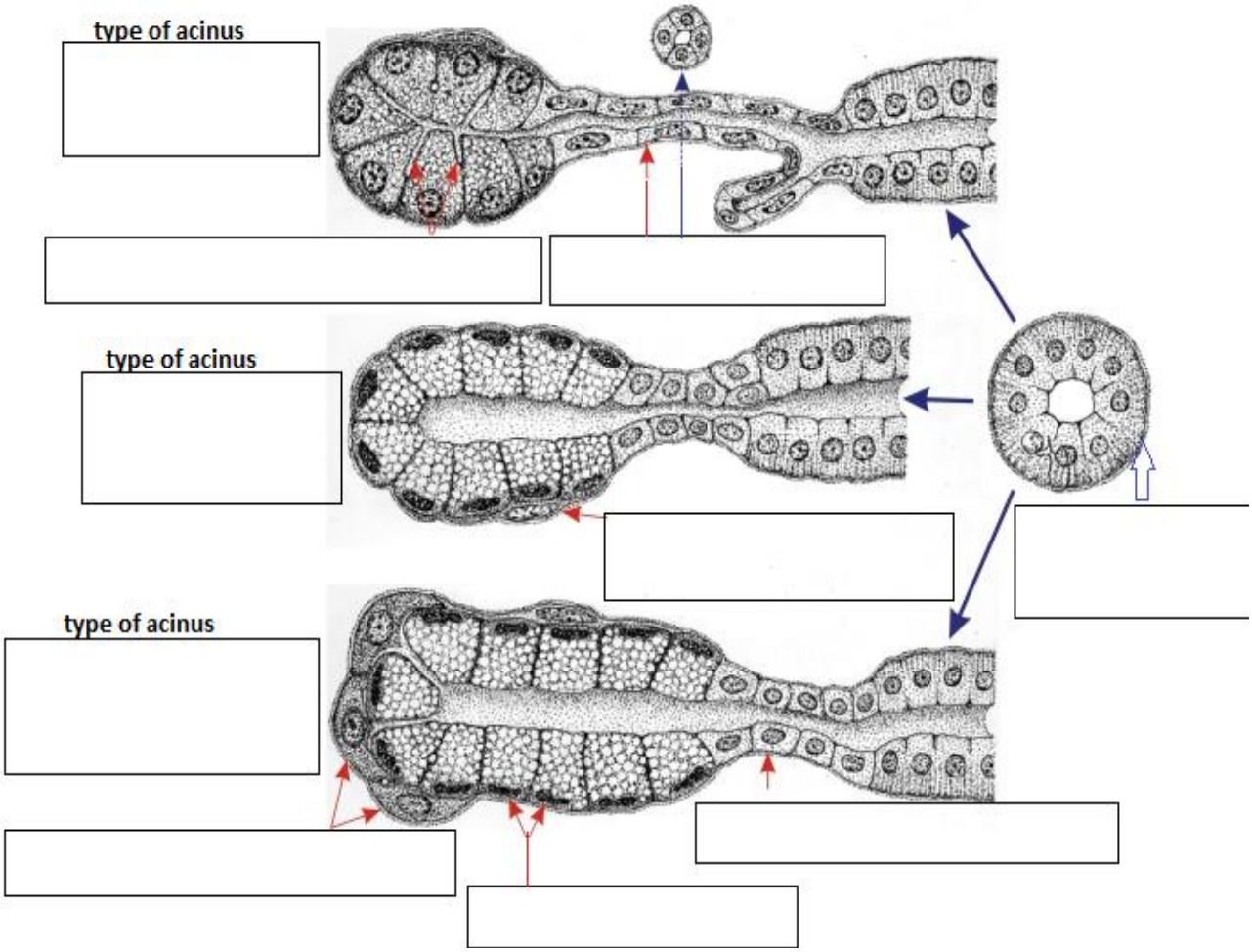
13. Sublingual gland structure

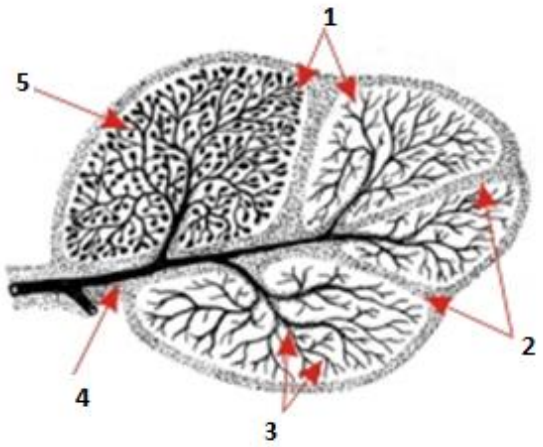
The small sublingual glands are branched tubuloacinar gland; its secretory portion consists mostly of **mucous** acini capped with **serous demilunes.** They are classified as mixed. The sublingual gland the

smallest of the paired major salivary glands, are located in the floor of the mouth anterior to the submandibular glands. Their multiple small sublingual ducts empty into the submandibular duct as well as directly onto the floor of the mouth. Intercalated ducts and striated ducts are difficult to locate or may be absent.

PRACTICAL QUESTIONS

1. Fill in the white gaps with designations in the picture below.





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7. Give the description of the serous demilunes. What salivary glands have them?
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8. Where in the oral cavity do excretory ducts of the parotid glands open?
_____
9. Where in the oral cavity do excretory ducts of the sublingual glands open?
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10. Where in the oral cavity do excretory ducts of the submandibular glands open?

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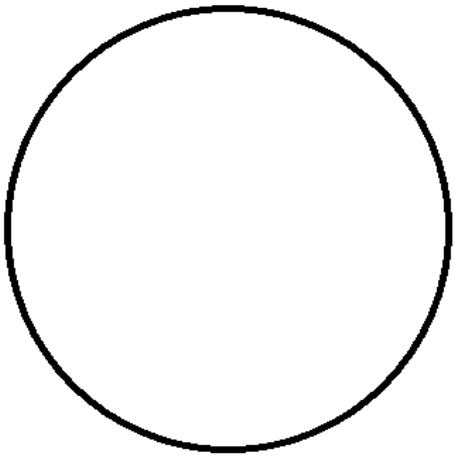
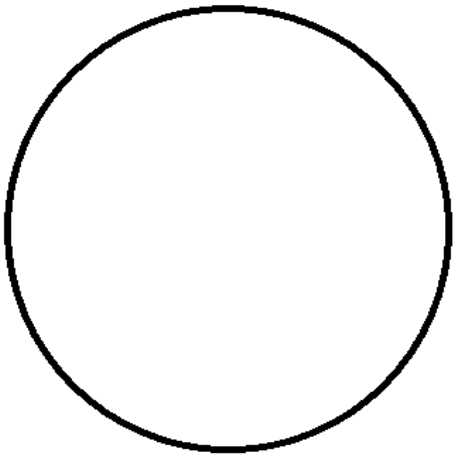


SLIDE 1
Parotid gland
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Connective tissue septa
2. Blood vessel
3. Lobule of the gland
4. Intercalated duct
5. Striated duct
6. Adipose cells
7. Interlobular duct



SLIDE 2
Sublingual gland.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Loose connective tissue
2. Mucous secretory portion
3. Mixed acini
    a) Mucous cells
    b) Serous cells
4. Striated duct
5. Interlobular duct

TESTS OF THE "KROK-1" DATABASE

Only serous end parts are detected in a histological specimen of the glandular organ. In interlobular connective tissue ducts are seen, lined with stratified epithelium. Determine this structure.
A *Parotid gland
B Submandibular salivary gland
C Pancreas
D Sublingual salivary gland
E Liver

A microspecimen of the submandibular salivary gland shows some basket-shaped cells concentrated around the acinus and excretory ducts. These cells surround bases of the serous cells and are called myoepitheliocytes. These cells relate to the following tissue:
A *Muscle tissue
B Epithelial tissue
C Nervous tissue
D Special connective tissue
E Loose fibrous connective tissue

Parotid salivary gland has acinar pieces which are formed by serous cells. What organelles of these cells provide synthesis and secretion of the saliva components?
A. Granular endoplasmic reticulum and Golgi complex
B. Golgi complex
C. Smooth endoplasmic reticulum and Golgi complex
D. Mitochondria, Golgi complex
E. Lysosomes

Damage of the epithelium of excretory ducts is observed in chronic inflammatory processes of the salivary glands. What kind of epithelium will be damaged in the striated ducts of the major salivary glands?
A. *Columnar epithelium with basal striations
B. Squamous epithelium with basal striations
C. Cuboidal epithelium with basal striations
D. Pseudostratified epithelium with basal striations
E. Stratified cuboidal epithelium

Lobules ducts with a large number of orderly arranged mitochondria in the basal part of the epithelium are visible in a histological specimen of the parotid gland. What kind of ducts is this?
A. *Striated ducts
B. Common ducts
C. Interlobular ducts
D. Intercalated ducts
E. Intralobular ducts

Terminal secretory acini with serous cells that synthesize mostly enzymes are distinguished in a histological specimen of the parotid gland. What kind of glands according to chemical composition of their secretion are they?
A *Protein
B Mucous
C Protein and mucous
D Sebaceous
E Sweat

It is known that submandibular salivary gland has mucous secretory acini consisting of mucous cells. What features are characteristic for these cells?
A *Flattened nucleuses and light cytoplasm
B Basophilic cytoplasm
C Rounded nucleus in the center of the cell
D Microvilli
E Basal striations

Processes of secretion and excretion are violated during acute inflammation of the parotid gland. Which cells are suffered in this case?
A *Serous and myoepithelial cells
B Protein, serous, mucous cells
C Serous cells, cells with basal striations, stellate cells
D Protein and mucous cells
E Cells with basal striations

It is known that submandibular salivary gland has mucous secretory acini consisting of mucous cells. What feature is characteristic for mucous cells?
A. *Oxyphilic cytoplasm
B. Basophilic cytoplasm
C. Rounded nucleus in the cell center
D. Microvilli
E. Basal striations

The secret of paired parotid glands is realized into the mouth. What acini is the part of parotid gland?
A. *Protein secretory acini
B. Mucous secretory acini
C. Epithelial trabeculae
D. Follicles
E. Mixed secretory acini

The protein synthesizing system of salivary gland cells was blocked using actinomycin D. What component will be absent in saliva? What cells will cease to secrete its secret?
A. *Enzyme amylase, serous cells
B. Enzyme amylase, mucous cells
C. Enzyme lipase, serous cells
D. Enzyme pepsin, serous cells
E. Enzyme lipase, mucous cells

Cells with round nuclei and basophilic cytoplasm are presented in a specimen of parotid glands secretory acini. What structures of the gland do they form?
A. *Protein secretory acini
B. Mucous secretory acini
C. Sebaceous secretory acini
D. Follicles
E. Mixed secretory acini

The damage of the epithelium of excretory ducts is observed during chronic inflammatory processes in the parotid gland. What kind of epithelium covers interlobular ducts of the parotid gland in normal condition?
A. *Pseudostratified, then – stratified squamous
B. Simple cuboidal, then - columnar
C. Simple columnar, then – simple squamous
D. Stratified ciliated, then - glandular
E. Stratified squamous, then – stratified columnar

The student was asked a test about the structure of the salivary glands. In the test says that in the salivary gland except secretory cells there are myoepithelial cells, which are able to contract. What is the source of development for myoepithelial cells?
A *Epidermal
B Neural
C Mesenchymal
D Celomic
E Somatic

Secretory acini are visible in a histological specimen. It is known that these cells synthesize and secrete protein. How is stained cytoplasm of these cells?
A *Basophilic
B Oxyphilic
C Not stained
D Metachromatic
E Polychromatic

DIGESTIVE SYSTEM. ESOPHAGUS. STOMACH.

Checking your primary level of the knowledge:

1. **Structure of the esophageal mucosa.**
2. **The submucosa of the esophagus structure.**
3. **Peculiarities of the muscularis externa of the esophagus**
4. **Outer layer of the esophagus.**
5. **Glands of the esophagus**
6. **General plan of the stomach structure.**
7. **Gastric mucosa of the stomach.**
8. **Description of surface mucous cells which line the inner surface of the stomach and the gastric pits.**
9. **Fundic glands of the gastric mucosa peculiarities.**
10. **Content of the gastric juice produced by fundic glands.**
11. **Cell types of the fundic glands.**
12. **Characteristic of the mucous neck cells.**
13. **Characteristic of the chief cells.**
14. **Characteristic of the parietal cells.**
15. **Peculiarities of the enteroendocrine cells and undifferentiated cells.**
16. **Peculiarities of the cardiac glands of the gastric mucosa.**
17. **Peculiarities of the pyloric glands of the gastric mucosa.**
18. **Description of the lamina propria and muscularis mucosae of the stomach.**
19. **Peculiarities of the gastric submucosa.**
20. **Characteristic of the gastric muscularis externa and gastric serosa.**

Standard answers for theoretical questions

1. **Structure of the esophageal mucosa.**

The esophagus is a fixed muscular tube that delivers food and liquid from the pharynx to the stomach. The esophagus courses through the neck and mediastinum, where it is attached to adjacent structures by connective tissue. The submucosa along with the muscularis mucosae forms a number of longitudinal folds and creates a highly irregular luminal profile.

The **mucosa** that lines the length of the esophagus has a nonkeratinized stratified squamous epithelium. The underlying lamina propria is similar to the lamina propria throughout the alimentary tract; diffuse lymphatic tissue is scattered throughout, and lymphatic nodules are present. The deep layer of the mucosa, the muscularis mucosae, is composed of longitudinally organized smooth muscle that begins near the level of the cricoid cartilage.

2. **The submucosa of the esophagus structure.**

The **submucosa** consists of loose connective tissue that contains the larger blood and lymphatic vessels, nerve fibers, and ganglion cells. The nerve fibers and ganglion cells make up the submucosal plexus (Meissner's plexus). Glands are also present. In addition, diffuse lymphatic tissue and lymphatic nodules are present mostly in the upper and lower parts of the esophagus where submucosal glands are more prevalent.

3. **Peculiarities of the muscularis externa of the esophagus**

The **muscularis externa** consists of two muscle layers, an inner circular layer and an outer longitudinal layer. It differs from the muscularis externa found in the rest of the digestive tract in that the upper one third is striated muscle. Striated muscle and smooth muscle bundles are mixed and interwoven in the muscularis externa of the middle third of the esophagus; the muscularis externa of the distal third consists only of smooth muscle, as in the rest of the digestive tract. A nerve plexus, the **myenteric plexus (Auerbach's plexus)**, is present between the outer and inner muscle layers. The muscle of the esophageal wall is innervated by both autonomic and somatic nervous systems.

4. **Outer layer of the esophagus.**

The outer layer of esophagus in the thoracic cavity is composed of adventitia. After entering the abdominal cavity it is covered by serosa.

5. **Glands of the esophagus**

Mucosal and submucosal glands of the esophagus secrete mucus to lubricate and protect the luminal wall. Glands are present in the wall of the esophagus and are of two types. Both secrete mucus, but their locations differ.

• **Esophageal glands proper** lie in the submucosa. These glands are scattered along the length of the esophagus but are somewhat more concentrated in the upper half. They are small, compound, tubuloalveolar glands. The excretory duct is composed of stratified squamous epithelium.
• **Esophageal cardiac glands** are named for their similarity to the cardiac glands of the stomach and are found in the lamina propria of the mucosa. They are present in the terminal part of the esophagus and frequently, though not consistently, in the beginning portion of the esophagus. They are simple tubular gland. The mucus produced by the esophageal glands proper is slightly acidic and serves to lubricate the luminal wall. The esophageal cardiac glands produce neutral mucus.

6. General plan of the stomach structure.

The **stomach** is an expanded part of the digestive tube that lies beneath the diaphragm. Mixing and partial digestion of the food in the stomach by its gastric secretions produce a pulpy fluid mix called **chyme**. The stomach is divided histologically into three regions based on the type of gland that each contains. The histologic regions are as follows:
• **Cardiac region (cardia)**, the part near the esophageal orifice, which contains the cardiac glands
• **Pyloric region (pylorus)**, the part proximal to the pyloric sphincter, which contains the pyloric glands
• **Fundic region (fundus)**, the largest part of the stomach, which is situated between the cardia and pylorus and contains the fundic or **gastric glands**

7. Gastric mucosa of the stomach.

The **stomach** has the same general structural plan throughout, consisting of a mucosa, submucosa, muscularis externa, and serosa. Examination of the **inner surface** of the empty stomach reveals a number of longitudinal folds or ridges called **rugae**. When the stomach is fully distended, the rugae, composed of the mucosa and underlying submucosa, virtually disappear.

There are numerous openings in the mucosal surface. These are the **gastric pits** or **foveolae**. The gastric glands open into the bottom of the gastric pits.

A view of the stomach's surface with a hand lens shows that smaller regions of the mucosa are formed by grooves or shallow trenches that divide the stomach surface into bulging irregular areas called **mamillated areas**. These grooves provide a slightly increased surface area for secretion.

8. Description of surface mucous cells which line the inner surface of the stomach and the gastric pits.

The epithelium that lines the surface and the gastric pits of the stomach is simple columnar. The columnar cells are designated **surface mucous cells**. Each cell possesses a large, apical cup of **mucinogen granules**, creating a glandular sheet of cells. The mucous cup occupies most of the volume of the cell. The nucleus and Golgi apparatus of the surface mucous cells are located below the mucous cup. The basal part of the cell contains small amounts of rough endoplasmic reticulum (rER). The mucous secretion from the surface mucous cells is described as **visible mucus** because of its cloudy appearance. It forms a thick, viscous, gel-like coat that adheres to the epithelial surface; thus, it protects against abrasion from rougher components of the chyme.

Additionally, its **high bicarbonate and potassium concentration** protects the epithelium from the acidic content of the gastric juice. The bicarbonate that makes the mucus alkaline is secreted by the surface cells but is prevented from mixing rapidly with the contents of the gastric lumen by its containment within the mucous coat.

9. Fundic glands of the gastric mucosa peculiarities.

The **fundic glands**, also called **gastric glands**, are present throughout the entire gastric mucosa except for the relatively small regions occupied by cardiac and pyloric glands. The **fundic glands** are simple, branched, tubular glands that extend from the bottom of the gastric pits to the muscularis mucosae. Located between the **gastric pit** and the gland below is a short segment known as the **isthmus**.

The isthmus of the fundic gland contains a reservoir of tissue stem cells that undergo mitotic activity, providing for continuous cell renewal. Cells destined to become mucous surface cells migrate upward in the gastric pits to the stomach surface. Other cells migrate downward, maintaining the population of the fundic gland epithelium. Typically, several glands open into a single gastric pit. Each gland has a narrow, relatively long **neck segment** and a shorter and wider base or **fundic segment**.

10. Content of the gastric juice produced by fundic glands.

The cells of the gastric glands produce gastric juice (about 2 L/day), which contains a variety of substances. In addition to water and electrolytes, gastric juice contains four major components.

Hydrochloric acid (HCL) initiates digestion of dietary protein. It also converts inactive pepsinogen into the active enzyme pepsin. **Pepsin** is a potent proteolytic enzyme. **Mucus** is an acid-protective coating for the stomach. **Intrinsic factor** binds to vitamin B12. In addition, **gastrin** and other hormones and hormone like

secretions are produced by **enteroendocrine cells** in the fundic glands and secreted into the lamina propria, where they enter the circulation or act locally on other gastric epithelial cells.

11. Cell types of the fundic glands.

Fundic glands are composed of next cells: mucous neck cells, chief cells, parietal cells, enteroendocrine cells and undifferentiated adult stem cells.

12. Characteristic of the mucous neck cells.

Mucous neck cells are localized in the neck region of the fundic gland and are interspersed with parietal cells. The mucous neck cell is much shorter than the surface mucous cell and contains considerably less mucinogen in the apical cytoplasm. Consequently, these cells do not exhibit a prominent mucous cup. Also, the nucleus tends to be spherical compared with the more prominent, elongated nucleus of the surface mucous cell.

The mucous neck cells secrete the **soluble mucus** compared with the **insoluble** or **cloudy mucus** produced by the surface mucous cell.

13. Characteristic of the chief cells.

Chief cells located in the deeper part of the fundic glands. Chief cells are typical protein-secreting cells. The abundant rER in the basal cytoplasm gives this part of the cell a basophilic appearance, whereas the apical cytoplasm is eosinophilic owing to the presence of the secretory vesicles, also called zymogen granules because they contain enzyme precursors.

Chief cells secrete **pepsinogen** and a weak **lipase**. On contact with the acid gastric juice, pepsinogen is converted to pepsin, a proteolytic enzyme. Pepsin hydrolyzes proteins into small peptides.

14. Characteristic of the parietal cells.

Parietal (oxyntic) cells are found in the neck of the fundic glands, among the mucous neck cells, and in the deeper part of the gland. They are large cells, sometimes binucleate, and appear somewhat triangular in sections, with the apex directed toward the lumen of the gland and the base resting on the basal lamina. The nucleus is spherical, and the cytoplasm stains with acidic dyes.

Parietal cells have an extensive **intracellular canalicular system** that communicates with the lumen of the gland. Parietal cells secrete **HCl** and **intrinsic factor**. HCl is produced in the lumen of the intracellular canaliculi. Intrinsic factor, a glycoprotein secreted by parietal cells that binds to vitamin B12. It is essential for its absorption, which occurs in the distal part of the ileum. Lack of intrinsic factor leads to pernicious anemia and vitamin B-12 deficiency.

15. Peculiarities of the enteroendocrine cells and undifferentiated cells.

Enteroendocrine cells secrete their products into either the lamina propria or underlying blood vessels.

Enteroendocrine cells are found at every level of the fundic gland, although they tend to be somewhat more prevalent in the base. Because enteroendocrine cells closely resemble neurosecretory cells of the central nervous system (CNS) that secrete many of the same hormones, signaling molecules, and regulatory agents, they are also called **neuroendocrine cells**. Enteroendocrine cells are distributed singly throughout the gastrointestinal epithelium. For that reason, they are described as constituting part of a **diffuse neuroendocrine system (DNES)**. Enteroendocrine cells produce not only gastrointestinal hormones such as gastrin, secretin, cholecystokinin (CCK), gastric inhibitory peptide (GIP), and motilin, but also **paracrine hormones.**

Undifferentiated cells present in the upper neck region of the gland that give rise to the mature cells listed

16. Peculiarities of the cardiac glands of the gastric mucosa.

Cardiac glands are limited to a narrow region of the stomach (the cardia) that surrounds the esophageal orifice. Their secretion, in combination with that of the esophageal cardiac glands, contributes to the gastric juice and helps protect the esophageal epithelium against gastric reflux. The glands are tubular, somewhat tortuous, and occasionally branched. They are composed mainly of mucus-secreting cells, with occasional interspersed enteroendocrine cells. The mucus-secreting cells are similar in appearance to the cells of the esophageal cardiac glands. They have a flattened basal nucleus, and the apical cytoplasm is typically filled with mucin granules. A short duct segment containing columnar cells with elongate nuclei is interposed between the secretory portion of the gland and the shallow pits into which the glands secrete. The duct segment is the site at which the surface mucous cells and the gland cells are produced.

17. Peculiarities of the pyloric glands of the gastric mucosa

Pyloric gland cells are similar to surface mucous cells and help protect the pyloric mucosa. Pyloric glands are located in the pyloric antrum (the part of the stomach between the fundus and the pylorus). They are branched, coiled, tubular glands. The lumen is relatively wide, and the secretory cells are similar in appearance to the surface mucous cells, suggesting a relatively viscous secretion. Enteroendocrine cells are

found interspersed within the gland epithelium along with occasional parietal cells. The glands empty into deep gastric pits that occupy about half the thickness of the mucosa.

18. Description of the lamina propria and muscularis mucosae of the stomach.

The **lamina propria** of the stomach is relatively scant. The stroma is composed largely of reticular fibers with associated fibroblasts and smooth muscle cells. Other components include cells of the immune system, namely, lymphocytes, plasma cells, macrophages, and some eosinophils. Occasional lymphatic nodules are also present.

The **muscularis mucosa is** composed of two relatively thin layers, usually arranged as an inner circular and outer longitudinal layer. In some regions, a third layer may be present; its orientation tends to be in a circular pattern.

19. Peculiarities of the gastric submucosa.

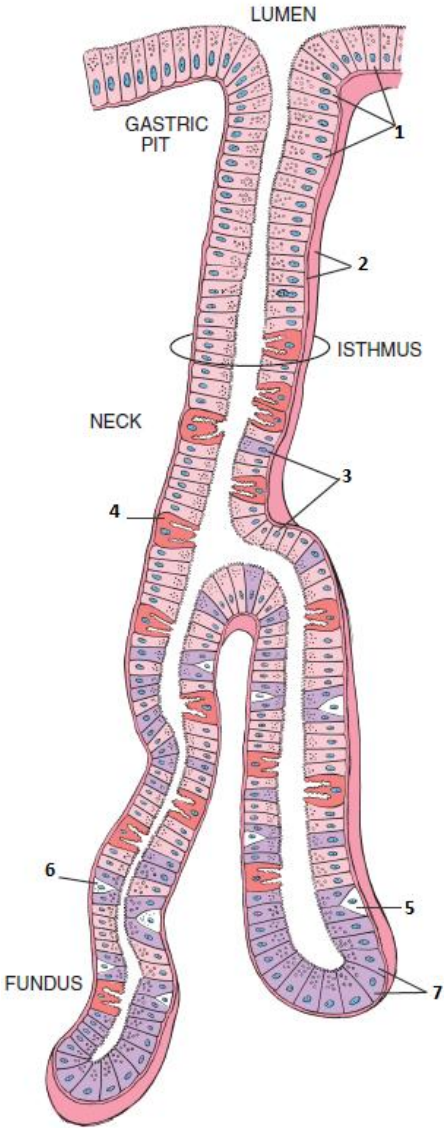
The **submucosa** is composed of a loose connective tissue containing variable amounts of adipose tissue and blood vessels, as well as the nerve fibers and ganglion cells that compose the **submucosal (Meissner's) plexus**.

20. Characteristic of the gastric muscularis externa and gastric serosa.

The **muscularis externa** of the stomach consists of an outer longitudinal layer, a middle circular layer, and an inner oblique layer. Groups of ganglion cells and bundles of unmyelinated nerve fibers are present between the muscle layers. Collectively, they represent the **myenteric (Auerbach's) plexus**, which provides innervation of the muscle layers.

The **serosa** of the stomach is as described above for the alimentary canal in general.

PRACTICAL QUESTIONS



1. In this diagram of a gastric gland identify the structure labeled 1.

_____

2. Identify the structure labeled 2.

_____

3. Identify the structure labeled 3.

_____

4. Identify the structure labeled 4.

_____

5. Identify the structure labeled 5.

_____

6. Identify the structure labeled 6.

_____

7. Identify the structure labeled 7.

_____

8. What functions of the parietal cells do you know?

_____
_____
_____
_____

9. Give them short characteristic.

_____
_____
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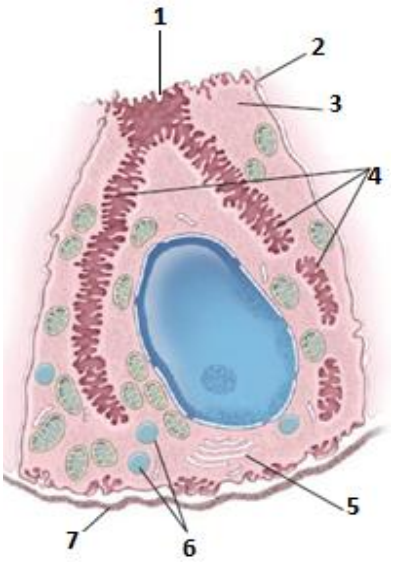
10. How does cell content of the cardiac and pyloric gland differ from the fundic gland?

_____
_____



11. In this diagram of a parietal cell identify the structure labeled 1.

_____

12. Identify the structure labeled 2.

_____

13. Identify the structure labeled 3.

_____

14. Identify the structure labeled 4.

_____

15. Identify the structure labeled 5.

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16. Identify the structure labeled 6.

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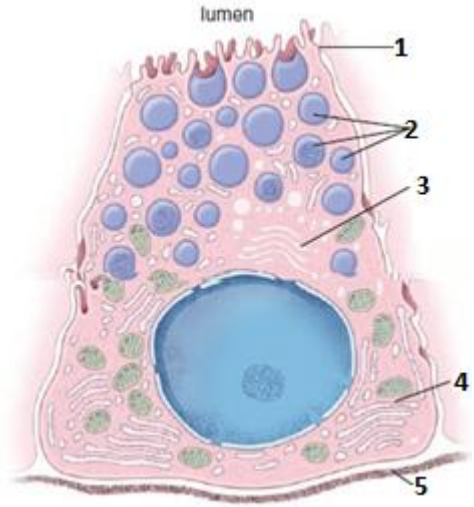
17. Identify the structure labeled 7.

_____



18. In this diagram of a chief cell identify the structure labeled 1.

_____

19. Identify the structure labeled 2.

_____

20. Identify the structure labeled 3.

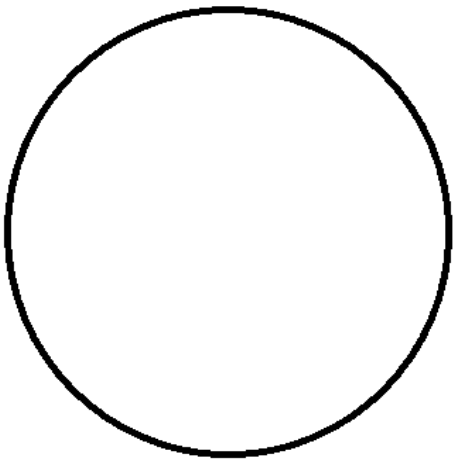
_____

21. Identify the structure labeled 4.

_____

22. Identify the structure labeled 5.

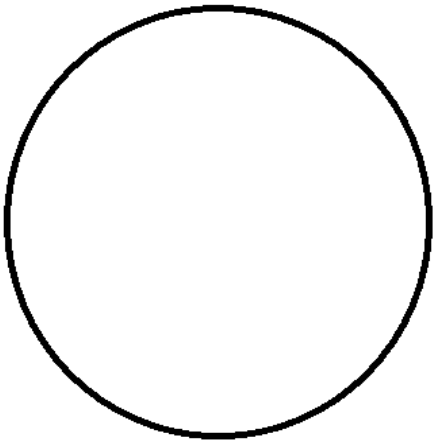
_____



SLIDE 1
Cross section of the esophagus.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

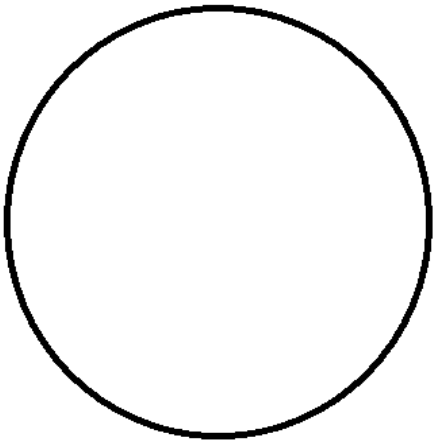
1. Stratified squamous epithelium
2. Lamina propria of the mucosa
3. Muscularis mucosae
4. Submucosa
5. Esophageal glands proper
6. Muscularis externa
7. Adventitia



SLIDE 2
Fundus of the stomach.
Stained with red congo.

SLIDE'S DESIGNATIONS

1. Simple columnar epithelium of the mucosa
2. Lamina propria of the mucosa
3. Gastric pit
4. Fundic glands of the fundus of the stomach
5. Submucosa
6. Muscularis externa
7. Serosa



SLIDE 3
Pyloric region of the stomach.
Stained with hematoxylin and eosin.

1. Mucosa
    a) Epithelial layer
    b) Lamina propria of the mucosa
    c) Muscularis mucosae
2. Pyloric glands of the stomach
3. Submucosa
4. Muscularis externa
5. Serosa

DATA BASE TESTS OF THE "KROK-1" DATABASE.

There is presented a transverse section of the wall of a hollow organ whose mucosa is covered with stratified squamous non-keratinized epithelium in a histological specimen. What organ is this?
A. Esophagus
B. Duodenum
C. Large intestine
D. Uterus
E. Appendix

The process of epithelium cornification is detected during the morphological analysis of the mucous coat of esophagus biopsy material. What epithelium covers the mucous coat of esophagus?
A. Stratified squamous non-keratinized
B. Simple squamous
C. Pseudostratified villous
D. Simple columnar
E. Stratified squamous keratinized

Mucosal epithelium was damaged in the patient as a result of burns of the esophagus by vinegar. What cellular structure of the epithelium is the source of reparative regeneration?
A *Basal cells
B Squamous cells
C Spiny cells
D Ciliated cells
E Endocrine cells

It was found that in 78% of cases the location of ulcers was typical in patients with ulcers of the esophagus in the surgical department during the retrospective study of case histories. The researches attributed this to the presence in these areas of cardiac glands. What areas of the esophagus are often damaged?
A. *Level of cricoid cartilage of the larynx
B. Level of the sixth cervical vertebra
C. At the transition of striated muscle tissue into smooth muscle tissue
D. In place of the esophagus passage through the diaphragm
E. -

Microscopic examination of a hollow organ revealed that its mucous membrane is covered with stratified squamous nonkeratinized epithelium and the lamina propria contains simple tubular gland, secretory acini of which consist mainly of mucous cells and small amount of parietal cells. What organ is this?
A *Esophagus
B Stomach
C Small intestine
D Trachea
E Urethra

Striated muscle tissue of the hollow organ of the digestive system is represented for microscopic study. What organ was taken for biopsy?
A. *Esophagus
B. Stomach
C. Small intestine
D. Ileum
E. Appendix

Relatively large cells with acidophilic cytoplasm in the glands of the histological section of the stomach bottom can be seen. One can see in these cells complicate system of intercellular canaliculi in electron microscopy. What gastric juice component is formed due these cells activity?
A. Hydrochloric acid
B. Mucus
C. Pepsinogen
D. Gastrin
E. Serotonin

A first-year-old child has disorders of mother's milk suction. With activity disorder of what gastric proper (fundic) glands cells is it connected?
A. Chief cells
B. Mucous neck cells
C. Enteroendocrine cells
D. Parietal cells
E. Undifferentiated cells

Areal damaging of gastric epithelium happened under influence of harmful factors. With what cells help possible its regeneration?
A. Mucous neck cells
B. Parietal cells
C. Chief cells
D. Enteroendocrine cells
E. Mucous cells of the glands (Undifferentiated cells)

The damage of endothelial layer of mucous membrane was found during endoscopic examination of the stomach. What cells provide the reparative regeneration?
A *Undifferentiated cells
B Accessory cells
C Chief cells
D Parietal cells
E Glandular epithelium

A patient has malignant anemia developing after gastrectomy. Absence of what gastric glands cells causes this pathology?
A. Parietal cells
B. Chief cells
C. Neck mucous cells
D. Enteroendocrine cells
E. Goblet cells

A patient with chronic gastritis went for endogastric pH-metry that reveal decreased acidity of the gastric juice. It indicates diminished function of the following cells:
A *Parietal cells
B Chief cells
C Enteroendocrine cells
D Mucous neck cells
E Accessory cells

Examination of a 43 y.o. patient revealed that his stomach has difficulties with digestion of protein food. Gastric juice analysis revealed low acidity. Which gastric cells function is disturbed in this case?
A *Parietal cells
B Chief cells
C Mucous neck cells
D Enteroendocrine cells
E Mucous neck cells

It was found out that glands contain very small amount of parietal cells or they are totally absent during histological examination of the stomach. What part of the stomach mucosa was studied?
A *Pyloric part
B Fundus of stomach
C Cardiac part
D Body of stomach
E -

Section of alimentary canal organ was revealed in the histological specimen. Relief of this organ is represented by foveolae (gastric pits). Pits surface were covered with epithelium in which all the cells lays on the basal membrane, have columnar shape and apical part of the cells is filled with droplets of mucous secrete. Determine, which organ has this epithelium?
A. *Stomach
B. Small intestine
C. Large intestine
D. Esophagus
E. Appendix

Alimentary canal organ is revealed in the histological specimen. Wall of this organ constitutes 4 layers: mucosa, submucosa, muscularis externa and serosa. Mucosa has fields and rugae (folds). Determine which organ has this relief.
A. Stomach
B. Duodenum
C. Large intestine
D. Esophagus
E. Appendix

An organ was revealed in the histological specimen. Simple tubular glands located in the lamina propria of this organ mucosa. These glands include mainly chief, parietal, mucous neck and endocrine cells. Name the type of glands.
A. *Fundic glands of the stomach
B. Pyloric glands of the stomach
C. Cardiac glands of the stomach
D. Esophageal glands propria
E. Esophageal cardiac glands

Signs of hypochromic anemia were found in the patient with chronic atrophic gastritis. Disorder of what stomach glands cells function can explain development of anemia?
A. *Parietal
B. Chief
C. Mucous neck
D. Endocrine
E. Undifferentiated

A 20-year-old patient has been prescribed a prolonged aspirin intake because of rheumatism. What structural component of the stomach mucosa mostly provides its defense from the damage?
A. *Simple cuboidal glandular epithelium
B. Connective
C. Muscle
D. Stratified villous
E. Stratified squamous non keratinized

Large oval shaped cell is detected in the electron microphotography of the stomach fundic gland. There is a lot of intercellular secretory canaliculus, huge amount of mitochondria. Name this cell.
A. *Parietal
B. Chief
C. Undifferentiated
D. Mucous
E. Exocrine

Mucosal epithelium is damaging in the stomach during inflammatory diseases. What epithelium is damaged?
A. *Simple columnar glandular
B. Simple squamous
C. Simple cuboidal microvillous
D. Simple cuboidal
E. Stratified cuboidal

Amount of glandulocytes (cells of the stomach) with oxiphylic cytoplasm were increased in the bioptat of patient suffering from ulcer during histological examination of the stomach mucosa. What component of gastric juice provides these cells?
A. *Hydrochloric acid
B. Mucus
C. Pepsinogen
D. Gastrin
E. Secretin

Surgical removal of a part of stomach resulted in disturbed absorption of vitamin BI 12. It is excreted with feces. The patient was diagnosed with anemia. What factor is necessary for absorption of this vitamin?
A *Gastromucoprotein
B Gastrin
C Hydrochloric acid
D Pepsin
E Folic acid

A newborn develops dyspepsia after the milk feeding. When the milk is substituted by the glucose solution the dyspepsia symptoms disappear. The newborn has the subnormal activity of the following enzyme:
A *Lactase
B Invertase
C Maltase
D Amylase
E Isomaltase

Pernicious anemia caused by the damage of cells that produce antianemic factor was developed in 48-year-old patient after radiotherapy for cancer of the stomach. What cells of the gastric glands are affected in this case?
A *Parietal cells
B Chief cells
C Mucous neck cells
D Endocrine cells
E Accessory cells

A 45-year-old patient is hospitalized with the complaint about pain in the stomach. Gastroscopy has detected small ulcers in the area of gastric fundus. What cells of the stomach impairment function became a reason for damage of mucosa?
A. Cells of superficial epithelium with mucous secretion (mucous neck cells)
B. Parietal cells of stomach glands that secrete chlorides and ions of hydrogen
C. Chief cells that secret pepsinogen
D. Endocrine cells which secrete somatostatin
E. Endocrine cells which secrete serotonin

Total hyperacidity was identified in a 56-year-old woman during pH-metry of the gastric juice. What cells of the gastric glands have impaired function?
A *Parietal cells
B Chief cells
C Mucous neck cells
D Accessory cells
E Endocrine cells

When the pH level of the stomach lumen decreases to less than 3, the antrum of the stomach releases peptide that acts in paracrine fashion to inhibit gastrin release. This peptide is:
A *GIF
B Acetylcholine
C Gastrin-releasing peptide (GRP)
D Somatostatin
E Vasoactive intestinal peptide (VIP)

There is high content of mucus, which impedes digestion in the stomach. What cells have the violation of the functional activity?
A. *Mucous cells
B. Neck cells
C. Mucous cells of the propria stomach glands
D. Endocrine cells
E. Parietal cells

There is a reduce amount of HCL and pepsin in the analysis of the gastric juice. What hormone of the gastric glands has impaired production?
A *Gastrin
B Somatostatin
C Serotonin
D Histamine
E Glucagon

The patient has ulcerative defect of the stomach wall as a result of uncontrolled intake of nonsteroidal anti-inflammatory drugs. What cells are affected?
A. *Glandular cells
B. Goblet cells
C. Chief cells
D. Parietal cells
E. Ehrlich cells

45-year-old man consulted a doctor with complaints about disorder of the stomach function. It was found a neoformation from epithelial tissue during a comprehensive examination. Which cells most likely given the development of the tumor?
A. *Mucous neck cells
B. Chief cells
C. Endocrine cells
D. Accessory cells
E. Parietal cells

Insulin injection to assess completeness of vagotomy is accompanied by a significant increase of acidity of gastric juice. What cells of the gastric glands provide this phenomenon?
A. *Parietal cells
B. Endocrine cells
C. Chief cells
D. Mucocytes
E. Neck cells

Insufficient amount of mucus covering the mucosa was revealed in the patient during gastroscopy. What cells of the stomach have impaired function?
A. *Cells of columnar glandular epithelium
B. Parietal cells of the stomach glands
C. Chief cells
D. Neck cells
E. Endocrine cells

Small cells with a high nuclear-cytoplasmic ratio and basophilic cytoplasm are detected during histological examination of the neck of the fundic stomach glands. Specify the function of these cells.
A. *Regeneration of glandular epithelium
B. Protective function
C. Endocrine function
D. Secretion of chloride ions
E. Secretion of pepsinogen

The skin epithelium originates from the ectoderm. It is stratified or pseudostratified epithelium. What localization is not typical for it?
A *Stomach
B Oral cavity
C Esophagus
D Vagina
E Cornea

Analysis of biopsy material of human stomach mucosa in a patient with gastritis showed a sharp decrease in the number of parietal cells. How is it reflected on the following components of gastric juice?
A. *Hypoacidity
B. Hyperacidity
C. Hyperproduction of gastric juice
D. Hypoproduction of gastric juice
E. Reduction of mucus production

60-year-old patient treated chronic gastritis for a long time. Changes in the epithelium of the mucosa are revealed during endoscopy of the stomach. What kind of epithelium was changed?
A. *Simple columnar glandular
B. Simple columnar ciliated
C. Pseudostratified
D. Simple squamous
E. -

The patient, who among other complaints has heartburn, was made a biopsy of the gastric mucosa. Numerous cells with oxyphilic cytoplasm with some cells containing two nuclei are determined in a histological specimen. What are these cells?
A *Parietal cells
B Chief cells
C Mucocytes
D Epithelial cells
E Endocrine cells

Large irregular, spherical cell in the cytoplasm of which one can determine the intracellular canaliculi, surrounded by a large number of mitochondria is presented in electron micrographs of a fragment of the fundic stomach gland. What does this cell produce?
A *Ions of Cl- i H+
B Mucus
C Pepsinogen
D Renin
E Gastrin

Muscularis externa consisting of three layers of smooth muscle cells is identified in the preparation of a hollow organ. The mucous membrane is covered with a simple columnar glandular epithelium and has a three-layer muscular plate. Name this organ.
A *Stomach
B Heart
C Uterus
D Esophagus
E Urinary bladder

DIGESTIVE SYSTEM. SMALL INTESTINE.

Checking your primary level of the knowledge:

1. **General knowledge about small intestine.**
2. **Small intestine functions.**
3. **Essential features of the small intestine mucosa.**
4. **Structure of the villi.**
5. **Features of the intestinal glands.**
6. **Characteristic of the lamina propria and muscularis mucosae.**
7. **Five types of cells that are found in intestinal mucosal epithelium.**
8. **Enterocytes structure and functions.**
9. **Goblet cells structure and functions.**
10. **Paneth cells structure and functions.**
11. **Enteroendocrine cells structure and functions.**
12. **M cells (microfold cell) structure and functions.**
13. **Intermediate cells peculiarities.**
14. **Intermediate cells peculiarities.**
15. **Muscularis externa structure and two types of contractions.**
16. **Serosa description.**

Standard answers for theoretical questions

1. **General knowledge about small intestine.**

The small intestine is the longest component of the digestive tract, measuring over 6 m, and is divided into three anatomic portions: **duodenum** (~25 cm long) is the first, shortest, and widest part of the small intestine, **jejunum** (~2.5 m long) constitutes the upper two fifths of the small intestine and **ileum** (~3.5 m long) constitutes the lower three fifths of the small intestine.

The absorptive surface area of the small intestine is amplified by tissue and cell specializations of the submucosa and mucosa which form **plicae circulares, villi, and microvilli**.

Plicae circulares are permanent transverse folds that contain a core of submucosa. Each semilunar fold is circularly arranged and extends about one-half to two-thirds around the circumference of the lumen.

Villi are finger-like and leaf-like projections of the mucosa that extend into the intestinal lumen and completely cover the surface of the small intestine.

Microvilli of the enterocytes provide the major amplification of the luminal surface. They give the apical region of the cell a striated appearance, the so-called striated border.

2. **Small intestine functions.**

The small intestine is the principal site for the digestion of food and absorption of the products of digestion. Chyme from the stomach enters the duodenum, where enzymes from the pancreas and bile from the liver are also delivered to continue the digestion process. Enzymes are also located in the glycocalyx of the microvilli of the **enterocytes**. These enzymes contribute to the digestive process by completing the breakdown of most sugars and proteins to monosaccharides and amino acids, which are then absorbed. Water and electrolytes that reach the small intestine with the chyme and pancreatic and hepatic secretions are also reabsorbed in the small intestine, particularly in the distal portion.

3. **Essential features of the small intestine mucosa.**

The villi and intestinal glands (crypts), along with the lamina propria, associated GALT (Gut Associated lymphoid tissue), and muscularis mucosae, constitute the essential features of the small intestinal mucosa.

4. **Structure of the villi.**

Villi are projections of the mucosa. They consist of a core of loose connective tissue covered by a simple columnar epithelium. The core of the villus is an extension of the lamina propria, which contains numerous fibroblasts, smooth muscle cells, cells of the immune system, and a network of fenestrated blood capillaries located just beneath the epithelial basal lamina. In addition, the lamina propria of the villus contains a central, blind-ending lymphatic capillary, the **lacteal**. Smooth muscle cells derived from the muscularis mucosae extend into the villus and accompany the lacteal.

5. **Features of the intestinal glands.**

The **intestinal glands**, or **crypts of Lieberkühn**, are simple tubular structures that extend from the muscularis mucosae through the thickness of the lamina propria, where they open onto the luminal surface of the intestine at the base of the villi. The glands are composed of a simple columnar epithelium that is continuous with the epithelium of the villi.

6. Characteristic of the lamina propria and muscularis mucosae.

The lamina propria also contains numerous nodules of lymphatic tissue that represent a major component of the GALT. They are large and numerous in the ileum, where they are located on the side of the intestine opposite the mesenteric attachment. It is called aggregated nodules or Peyer's patches.

The **muscularis mucosae** consist of two thin layers of smooth muscle cells, an inner circular and an outer longitudinal layer. Strands of smooth muscle cells extend from the muscularis mucosae into the lamina propria of the villi.

7. Five types of cells that are found in intestinal mucosal epithelium.

The mature cells of the intestinal epithelium are found both in the intestinal glands and on the surface of the villi. They include the following: **enterocytes**, whose primary function is absorption, **goblet cells**, unicellular mucin-secreting glands, **Paneth cells**, whose primary function is to maintain mucosal innate immunity by secreting antimicrobial substances, **enteroendocrine cells**, which produce various paracrine and endocrine hormones and **M cells (microfold cells)**, modified enterocytes that cover enlarged lymphatic nodules in the lamina propria.

8. Enterocytes structure and functions.

Enterocytes are specialized for the transport of substances from the lumen of the intestine to the circulatory system. They are tall columnar cells with a basally positioned nucleus.

Microvilli of the enterocytes increase the apical surface area as much as 600 times. They are formed striated border on the luminal surface. Each microvilli has a core of vertically oriented actin microfilaments.

Enterocytes are bound to one another and to the other cells of the epithelium by junctional complexes. The junction establishes a barrier between the lumen and the intercellular compartment. The lateral membranes of the enterocytes show elaborate development of flattened processes (plications) that implicate with processes of adjacent cells. During active absorption, especially of electrolytes, water, and lipids the lateral plications separate, allowing the development of an enlarged intercellular compartment.

Elongated mitochondria are concentrated in the apical cytoplasm. Tubules and cisternae of the sER, which are involved in the absorption of fatty acids and glycerol and in the resynthesis of neutral fat, are found in the apical cytoplasm.

Enterocytes are also secretory cells producing glycoprotein enzymes needed for terminal digestion and absorption. Small secretory vesicles containing glycoproteins destined for the cell surface are located in the apical cytoplasm along the lateral plasma membrane. Free ribosomes, rER, and Golgi complex provide the secretory function of the enterocytes.

9. Goblet cells structure and functions

Goblet cells increase in number from the proximal to the distal small intestine and are most numerous in the terminal ileum. As in other epithelia, goblet cells produce mucus. There are a large accumulation of mucinogen granules in the apical cytoplasm that distends the apex of the cell and distorts the shape of neighboring cells. An extensive array of flattened Golgi saccules forms a wide cup around the newly formed mucinogen granules near the basal part of the cell.

Goblet cells have microvilli that are restricted to a thin rim of cytoplasm (the theca) that surrounds the apical-lateral portion of the accumulation of mucinogen granules. The large apical accumulation of mucinogen granules leaves the rest of the cell as a narrow stem forming the basal portion of the cell.

10. Paneth cells structure and functions

Paneth cells are found in the bases of the mucosal glands. They are occasionally found in the normal colon in small numbers. The acidophilic secretory granules contain the antibacterial enzyme lysozyme, other glycoproteins, an arginine rich protein and zinc. Lysozyme digests the cell walls of certain groups of bacteria. This antibacterial action and the phagocytosis of certain bacteria and protozoa by Paneth cells suggest that Paneth cells have a role in regulating the normal bacterial flora of the small intestine.

11. Enteroendocrine cells structure and functions

They are concentrated in the lower portion of the intestinal crypt but migrate slowly and can be found at all levels of the villus unit.

Cholecystokinin, secretin and gastric inhibitory peptide are the most active regulators of gastrointestinal physiology that are released in this portion of the gut.

These three hormones increase pancreatic and gallbladder activity and inhibit gastric secretory function and motility.

12. M cells (microfold cell) structure and functions

The epithelial cells that overlie Peyer's patches and other large lymphatic nodules are different from the surrounding intestinal cells.

They are nearly squamous have microfolds rather than microvilli on their apical surface and take up macromolecules from the lumen in endocytic vesicles.

13. Intermediate cells peculiarities.

Intermediate cells constitute the majority of the intestinal stem cells in the lower half of the intestinal crypt. Intermediate cells have characteristics of both immature absorptive cells and goblet cells. These cells are still capable of cell division. These cells have short, irregular microvilli and small mucin-like secretory droplets which form a column in the center of the supranuclear cytoplasm.

14. Submucosa peculiarities

A distinguishing characteristic of the duodenum is the presence of submucosal glands. The submucosa consists of a loose connective tissue and localized sites that contain aggregates of adipose cells. A conspicuous feature in the duodenum is the presence of **submucosal glands (of Brunner).**

The branched tubuloalveolar submucosal glands of the duodenum have secretory cells with characteristics of both zymogen-secreting and mucus-secreting cells.

The secretion of these glands has a pH of 8,1-9,3 and contains neutral and alkaline glycoproteins and bicarbonate ions. This probably serves to protect the proximal small intestine by neutralizing the acid-containing chime that is delivered to it and serves to bring the Ph of the intestinal contents close to the optimal pH for the pancreatic enzymes that are also delivered to the duodenum.

15. Muscularis externa structure and two types of contractions.

The muscularis externa consists of an inner layer of circularly arranged smooth muscle cells and an outer layer of longitudinally arranged smooth muscle cells.

Two kinds of muscular contraction occur in the small intestine. Local contractions displace intestinal contents both proximally and distally are designated as **segmentation**. These contractions are primarily of the circular muscle layer.

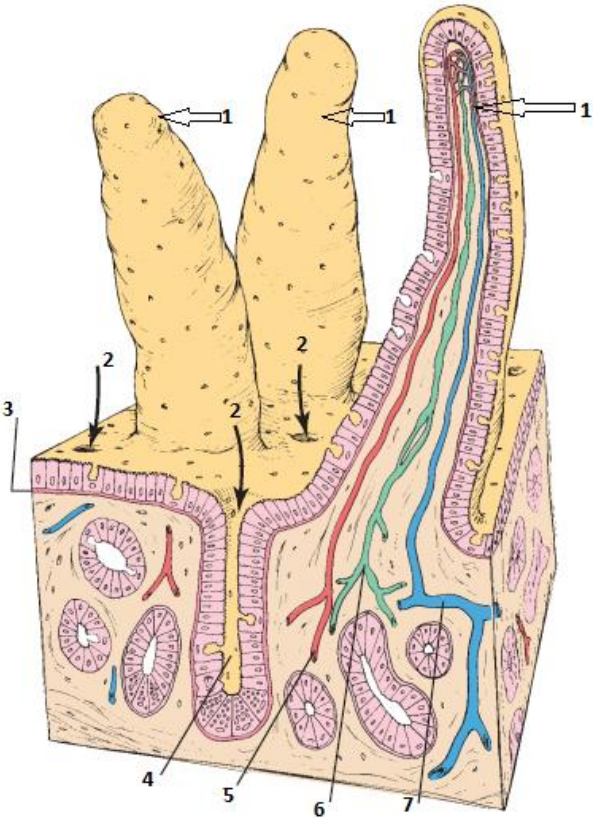
They serve to circulate the chime locally, mixing it with digestive juices and moving it into contact with the mucosa for absorption.

Peristalsis, the second type of contraction, largely involves the longitudinal muscle layer and moves the intestinal contents distally.

16. Serosa description.

The **serosa** of the parts of the small intestine that are located intraperitoneally in the abdominal cavity corresponds to the general description of the gastrointestinal tract.

PRACTICAL QUESTIONS



1. In this diagram of intestinal villi in the small intestine identify the structure labeled 1.

_____

2. Identify the structure labeled 2.

_____

3. Identify the structure labeled 3.

_____

4. Identify the structure labeled 4.

_____

5. Identify the structure labeled 5.

_____

6. Identify the structure labeled 6.

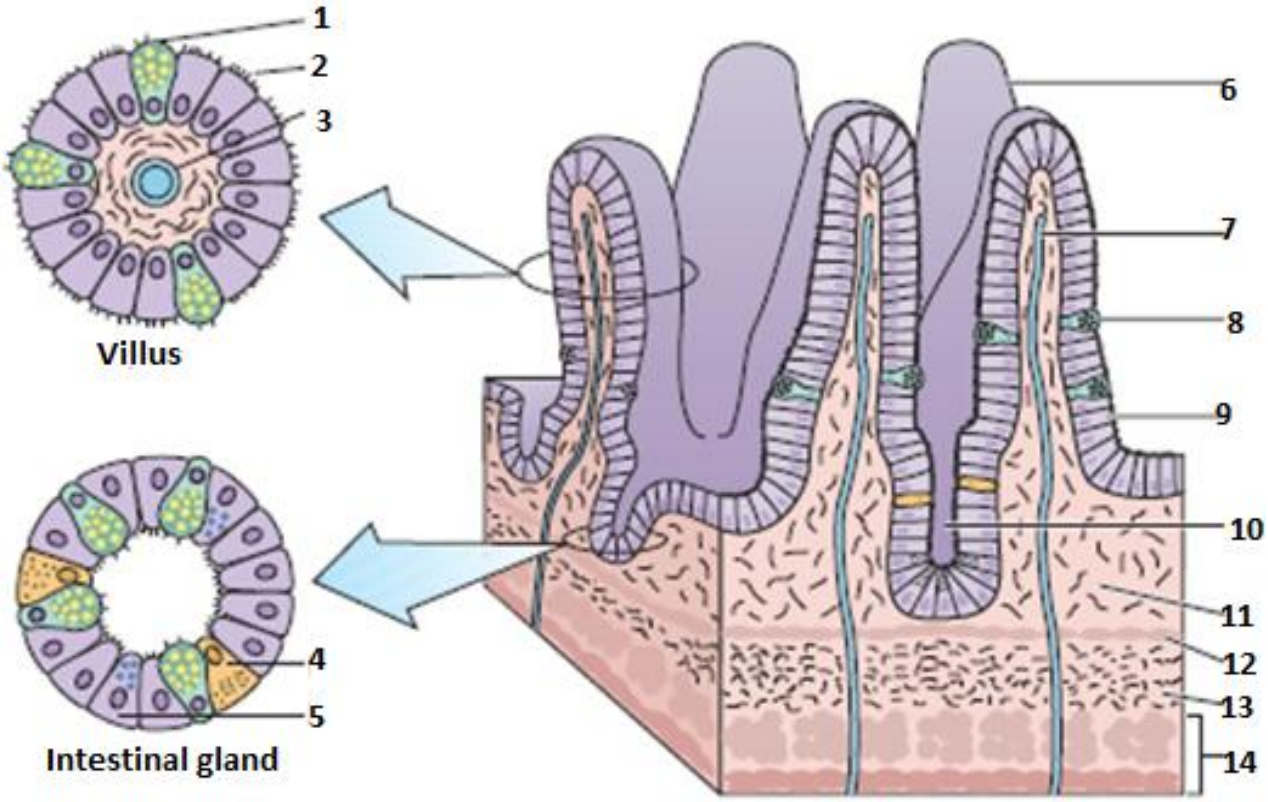
_____

7. Identify the structure labeled 7.

_____

8. Describe the structure of the crypts of Lieberkühn.

_____
_____
_____
_____
_____
_____



9. Identify the structure labeled 1 in the above diagram of intestine wall.

10. Identify the structure labeled 2.

11. Identify the structure labeled 3.

12. Identify the structure labeled 4.

13. Identify the structure labeled 5.

14. Identify the structure labeled 6.

15. Identify the structure labeled 7.

16. Identify the structure labeled 8

17. Identify the structure labeled 9.

18. Identify the structure labeled 10.

19. Identify the structure labeled 11.

20. Identify the structure labeled 12.

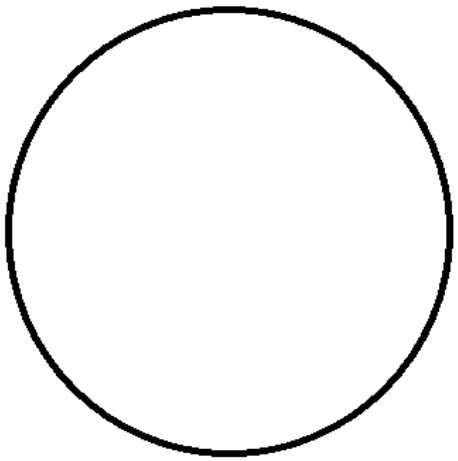
21. Identify the structure labeled 13.

22. Where do submucosa GLANDS exist in GIT?

23. What is the type of epithelium of mucosa of duodenum?

24. Mention two features about Paneth cells?

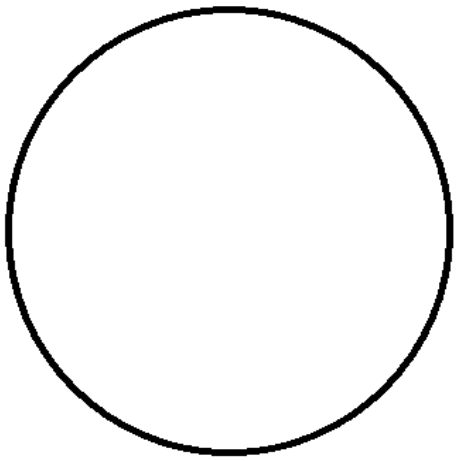
25. What does submucosa of duodenum contain?



SLIDE 1
Small intestine.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Mucosa epithelium
2. Lamina propria of the mucosa
3. Villi
4. Crypt
5. Muscularis mucosae
6. Submucosa
7. Muscularis externa
8. Serosa



SLIDE 2
Duodenum.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Mucosa epithelium
2. Lamina propria of the mucosa
3. Villi
4. Crypt
5. Muscularis mucosae
6. Submucosa
7. Glands of Brunner
8. Muscularis externa
9. Serosa

DIGESTIVE SYSTEM. LARGE INTESTINE.

Checking your primary level of the knowledge:

1. **General knowledge about large intestine.**
2. **Characteristic of large intestine mucosa.**
3. **Epithelial cell renewal in the large intestine**
4. **Peculiarities of the lamina propria, muscularis mucosa and submucosa of the large intestine.**
5. **Muscularis externa of the colon and rectum - peculiarities.**
6. **Large intestine serosa characteristic**
7. **Description of the cecum and appendix**
8. **Description of the rectum and anus**

Standard answers for theoretical questions

1. General knowledge about large intestine.

The large intestine is composed of the cecum, ascending colon, sigmoid colon, rectum, and anal canal. The principal functions of the colon are reabsorption of electrolytes and water and elimination of undigested food and waste. The four layers characteristics of the alimentary canal are present throughout. There are, however several distinctive features at the gross level.

-The mucosa has a smooth surface; neither plicae circulares nor villi are present.

-The outer longitudinal layer of the muscularis externa exhibits three equally spaced bands.

2. Characteristic of large intestine mucosa.

The mucosa appears smooth at the gross level because it has no villi. Numerous straight, tubular glands are present. They extend all the way to the muscularis mucosae. Crypts are deeper in the rectum and sigmoid colon than in the proximal part of the colon. The glands and the surface are lined with simple columnar epithelium whose cell types are as described for the small intestine. However Paneth cells are usually absent in the adult human and enteroendocrine cells are rare. Columnar absorptive cells and goblet cells are abundant. The reabsorption of water and electrolytes is the primary function of the columnar absorptive cells. Goblet cells are more prevalent in the crypts than along the surface, and their number increases distally toward the rectum thus they are more numerous in the large intestine than in the small intestine. Goblet cells produce mucin that is secreted continuously to lubricate the bowel, facilitating the passage of the increasingly more solid colonic contents.

Columnar absorptive cells predominate (4:1) over goblet cells in most of the colon, only near the rectum the number of goblet cells increasing (1:1).In the luminal surface the secretion rate exceeds the synthesis rate, and “exhausted” goblet cells appear in the epithelium between crypts. The caveolated “tuft” cell, has also been described in the colonic epithelium, this cell may, however, be one form of exhausted goblet cell.

3. Epithelial cell renewal in the large intestine

As in the small, all of the mucosal epithelial cells of the colon arise from stem cells located at the bottom of the crypt or gland. The lower third of the crypt constitutes the normal replicative zone.

4. Peculiarities of the lamina propria, muscularis mucosa and submucosa of the large intestine.

The lamina propria is highly cellular loose connective tissue layer. It is particularly rich in lymphoid cells and lymph nodules may interrupt the regular spacing of the crypts and extend into the submucosa (this is particularly evident in the appendix).

The extensive development of GALT reflects the abundance and variety of microorganisms and noxious end products of metabolism. As in the small intestine, lymphatic vessels form a network around the muscularis mucosae. However, no lymph vessels extend into the lamina propria between colonic crypts. **The muscularis mucosa** has a circular and longitudinal layer.

Submucosa is loose connective tissue containing blood and lymphatic vessels, lymphatic nodules and nerve plexus. Considerable amounts of fat may be found here.

5. Muscularis externa of the colon and rectum - peculiarities.

In the **colon**, the muscularis externa consists of an inner circular and outer longitudinal layer. The inner circular layer is typical, but the outer longitudinal layer of the colon is very thin, except for three extremely thick longitudinal bands, called **teniae coli**. Bundles of muscle from the teniae coli penetrate the circular layer at irregular intervals. These discontinuities in the muscularis externa allow segments of the colon to contract independently. The lumen may almost be occluded during a contraction, allowing all the fecal matter to be in touch with the colon wall. The longitudinal layer contracts at the same time as the circular layer. Unstimulated portions between the contracting segments bulge outward, forming saccules or **haustra**.

The next contraction would be in another area. Peristaltic movements in the colon (longitudinal layer) result in mass movements distally of colonic contents.
In the **rectum**, the outer longitudinal layer of smooth muscle is a uniformly thick layer, as in the small intestine.
The muscularis externa of the large intestine produces two major types of contraction: segmentation and peristalsis.

6. Large intestine serosa characteristic

Where the large intestine is directly in contact with other structures, its outer layer is adventitia; elsewhere, the outer layer is a typical serosa. The adventitia forms small pouches filled with fatty tissue along the large intestine.

7. Description of the cecum and appendix

The cecum forms a blind pouch just distal to the ileocecal valve; the appendix is a thin, finger-like extension of this pouch, described as worm like structure. The histology of cecum closely resembles that of the rest of the colon;
Mucosa of the appendix is lined with simple columnar epithelium with goblet cells and enterocytes. **The lamina propria** sometimes invaginates into submucosa and muscularis mucosae (which is barely visible in some areas, and is discontinuous). It does not form villi but possesses **shallow crypts of Lieberkühn** with some goblet cells, surface columnar cells, regenerative cells, occasional Paneth cells, and numerous enteroendocrine cells, especially deep in the crypts. The most conspicuous feature of the appendix is the large number of lymphatic nodules that fuse and extend into the submucosa.
Submucosa is loose connective tissue containing confluent lymphoid nodules, associated cell populations and Meissner's plexus. **Muscularis externa** has inner circular and outer longitudinal layer. There are no teniae, layers are continuous the whole way around, and they unite at origin of appendix. Myenteric plexus is present between 2 layers. Appendix is intraperitoneal, so is totally covered with **serosa**.

8. Description of the rectum and anus

The rectum is dilated distal portion of the alimentary tract. The **rectum** is similar to the colon but contains fewer and deeper crypts of Lieberkühn with many goblet cells and its upper part has folds called transverse rectal folds.

The most distal portion of the alimentary canal is the **anal canal**. It extends from the anorectal junction to the anus. The upper part of the anal canal mucosa has longitudinal folds called **anal columns** (or **rectal columns of Morgagni**) which join each other to form **anal valves**. Depressions between the anal columns are called **anal sinuses**.
The anal canal is divided into three zones according to the character of the epithelial lining:
• **Colorectal zone**, which is found in the upper third of the anal canal and contains simple columnar epithelium.
• **Anal transitional zone** possesses a stratified columnar epithelium.
• **Squamous zone**, which is found in the lower third of the anal canal. This zone is lined with stratified squamous epithelium that is continuous with that of the perineal skin.
The **lamina propria** is composed of **fibroelastic** connective tissue and contains sebaceous glands, circumanal glands, hair follicles, and large veins. In the anal canal, anal glands extend into the submucosa and even into the muscularis externa. These are branched, straight tubular glands that secrete mucus onto the anal surface through ducts lined with stratified columnar epithelium. Large apocrine glands, the **circumanal glands**, are found in the skin surrounding the anal orifice.
The **muscularis mucosae** consist of an inner circular and an outer longitudinal layer of smooth muscle, both of which terminate at the anal valves.
The **anal submucosa** is composed of loose connective tissue that houses large veins.
The **anal muscularis externa** is composed of an inner circular and an outer longitudinal layer of smooth muscle. The inner circular layer forms the **internal anal sphincter.** The **external anal sphincter** is formed by the striated muscles of the perineum.
Anal adventitia attaches the anus to surrounding structures.

PRACTICAL QUESTIONS

1. What is the difference between colon and appendices?

_____

_____

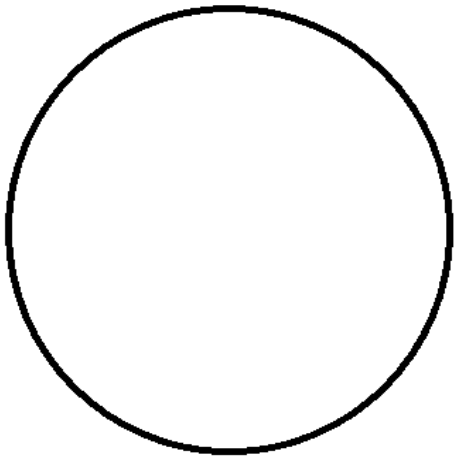
2. What is the difference between small and large intestines mucosa?

_____

3. What is the difference between types of cells in small and large intestines crypts?

4. What is the difference between small and large intestines submucosa?

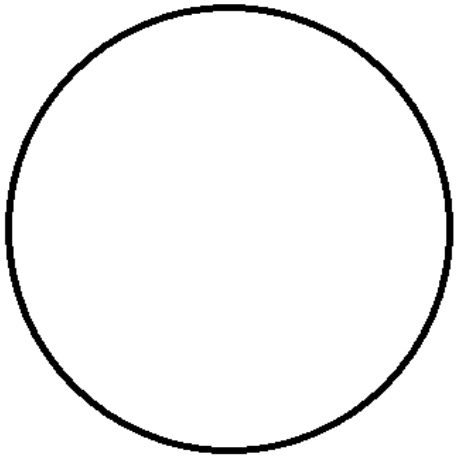
5. What is the difference between small and large intestines muscularis externa?



SLIDE 1
Large intestine.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Mucosa epithelium
2. Lamina propria of the mucosa
3. Crypts
4. Muscularis mucosae
5. Submucosa
6. Muscularis externa
7. Serosa
8. Lymphatic nodules



SLIDE 2
Appendix.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Lumen of the appendix
2. Mucosa epithelium
3. Crypts
4. Submucosa
5. Muscularis externa
6. Lymphatic nodules
7. Serosa

It was revealed during autoradiography examination that total regeneration of small intestine epithelium has been taking place during 3 days as a result of active proliferation of undifferentiated cells. Indicate their localization.
A. Bottom of crypts
B. Villi apex
C. Villi base
D. Lateral side of villi
E. Lamina propria of mucosa

Clustered cells were found in a histological specimen of small intestine wall at the bottom of crypts. There are large acidophilic secretory granules in the apical part of the cells. Cytoplasm is colored basophilic. What cells are these?
A. Paneth cells
B. Intermediate cells
C. Endocrine cells
D. Goblet cells
E. Enterocytes

Terminal parts of serous glands are located in a histological specimen of small intestine in the submucosal base. What part of the intestine is presented in the specimen?
A. Duodenum
B. Small intestine
C. Ileum
D. Appendix
E. Jejunum

Disorder of digestion and absorption of proteins in the small intestine has been found in the patient with chronic enterocolitis (intestine inflammation) as a result of insufficient quantity of dipeptidase in the intestine juice. In what cells synthesis of these enzymes are disordered?
A. *Paneth cells
B. Enterocytes
C. Intermediate cells
D. Goblet cells
E. Enteroendocrine cells

Absorptive function suffers during diseases of small intestine mucosa. What epithelium is responsible for this function?
A. *Simple columnar with striated border
B. Simple cuboidal
C. Simple columnar villous
D. Stratified squamous
E. Stratified cuboidal

Disorder of parietal and membranous digestion was found during examination of the patient with small intestine disease. What function cells disorder is connected with this?
A. *Enterocytes
B. Intermediate cells
C. Goblet cells
D. Paneth cells
E. Enteroendocrine cells

Absence of specific structures of small intestine relief has been seen in the patient with chronic enterocolitis (intestine inflammation) during endoscopic examination. What components designate peculiarities of this organ mucosa relief?
A. *Plicae circulares, villi and crypts
B. Fields, rugae and pits
C. Haustrae, villi and crypts
D. Obliquely circular folds
E. Fields, villi

Certain diseases of small intestine are connected with the function disorder of exocrine cells with acidophil granules (Paneth cells). Where are these cells located?
A. *In the bottom of intestinal glands (crypts)
B. In the apical part of intestinal villi
C. On lateral surfaces of intestinal villi
D. In the apical part of intestinal glands (crypts)
E. In the place of villi transition into the glands

The proportion between epithelial cells of mucosa changed in case of certain diseases of large intestine. What types of cells dominate in crypts epithelium of large intestine in normal condition?
A. *Goblet cells
B. Enterocytes
C. Enteroendocrine cells
D. Paneth cells
E. Undifferentiated cells

Proctoscopy has shown a tumor proceeding from the mucosa of caudal part of rectum. Of what epithelium has this tumor formed?
A. *Stratified squamous non-keratinized
B. Simple columnar glandular
C. Simple cuboidal
D. Simple cuboidal with microvilli
E. Transitional

An accumulation of spherical cells with large basophilic nuclei, which are surrounded by a narrow rim of cytoplasm were found in the preparation of small intestine in the lamina propria of the mucosa. The central part is light and contains fewer cells than peripheral in most of these clusters. What morphological structures are these clusters?
A *Lymphatic nodules
B Nerve ganglion
C Adipose cells
D Blood vessels
E Lymphatic vessels

Ulcer of small intestine was developed in 39-year-old patient after radiotherapy because of the hepatoma. Ulcer was caused by the inhibition of mytotic activity of the cells, which are responsible for regeneration of small intestine surface epithelium. Inhibition of what cells mitotic activity does this patient have?
A. *Crypt columnar cells without margins
B. Columnar cells
C. Endocrine cells
D. Goblet cells
E. Enterocytes with acidophilic granules

The rate of small intestine epithelium renovation of a patient is reduced. With the damage of what cells is it connected?
A. Columnar non-border epithelial cells (intermediate cells)
B. Paneth cells
C. Endocrine cells
D. Goblet cells
E. Enterocytes

An infectionist has detected an acute enterocolitis syndrome with infringement of the processes of breakdown and absorption of nutritive materials of a patient. Damage of what intestinal epithelium cells cause this disorder?
A. Columnar epitheliocytes with microvilli (enterocytes)
B. Non-microvilli epitheliocytes (intermediate cells)
C. Goblet cells
D. Paneth cells
E. Endocrine cells

Significant infringement of the regeneration process of the small intestine mucosa epithelial layer of a cancer patient is detected by means of morphological research after X-ray therapeutics. What epithelial layer cells are damaged?
A. Columnar non-border epithelial cells (intermediate cells)
B. Enterocytes
C. Goblet cells
D. Endocrine
E. Paneth cells

There are mucosal layer of an organ in the histological specimen. Enterocytes and goblet cells can be detected on the villi surface of epithelial lining. What organ consists from these cells?
A. Small intestine
B. Stomach
C. Large intestine
D. Urethra
E. Bronchi

A 70-year-old patient for a long time treated chronic duodenitis. Changes in the mucosal epithelium of the duodenum were revealed during endoscopic examination. What kind of epithelium was changed?
A *Simple columnar
B Stratified squamous nonkeratinized
C Simple squamous
D Pseudostratified ciliated
E Simple columnar glandular

Histological slice of the small intestine was made. Simple columnar epithelium covering the villi is defined in the preparation. What functions of the small intestine will be violated by its damage?
A *Covering, absorption
B Excretion
C Pinocytosis
D Bowel motility
E Gas exchange

A part of mucosa was taken during biopsy research of the small intestine wall. What kind of epithelium covers the surface of this organ mucosa?
A. *Simple columnar epithelium with striated border
B. Simple cuboidal
C. Simple columnar ciliated
D. Simple columnar glandular
E. Stratified squamous nonkeratinized

Granules in which by histochemical methods were identified dipeptidase and lysozyme were found in the cytoplasm of crypts epithelial cells of the small intestine. Specify these cells.
A. *Paneth cells
B. Enterocytes
C. Goblet cells
D. A- cells
E. S- cells

Electron-dense granules at the basal pole of the cell are detected in the electron micrographs of duodenum enterocytes. What do they contain?
A. *Secretin
B. Trypsin
C. Absorbed proteins
D. Adipose inclusions
E. Lipofuscin

Electron-dense granules at the basal pole are clearly defined in electron micrographs of the duodenal epithelium cells. What are these cells?
A. *Endocrine cells
B. Columnar cells with striated border
C. Undifferentiated cells
D. Goblet cells
E. Parietal cells

The wall of an organ of the digestive system, in the lamina propria and submucosa of which there are numerous lymphoid nodules is presented in a histological specimen. Name this organ.
A. *Appendix
B. Stomach
C. Duodenum
D. Jejunum
E. Colon

Intramural ganglion of the Auerbach's plexus of the small intestine was removed in the experiment. What changes will occur in the functional activities of the small intestine?
A *Disorder of the motor function
B Disorder of malabsorption of nutrients
C Disorder of the endocrine function
D Disorder of the secretory function
E Disorder of all functions

A portion of the small intestine was removed from the patient during surgery for tumor. What cells will provide the regeneration of muscle tissue of the intestinal wall in the region of the seam?
A *Smooth muscle cells
B Adipose cells
C Myosatellitocytes
D Fibrocytes
E Fibroblast

It was revealed that most often the inflammation of the appendix (appendicitis) happens after viral infections. What morphological features of the appendix wall structure contribute to it?
A. *Contains many clusters of lymphoid tissue
B. Contains a large number of goblet cells in the epithelium
C. Has a highly developed muscular layer
D. Absence of the muscularis mucosa
E. Has a well-developed villi

DIGESTIVE SYSTEM. LIVER.

Checking your primary level of the knowledge:

1. **Liver general characteristic and functions.**
2. **Blood supply to the liver**
3. **Four structural components of the liver.**
4. **Functional and structural units of the liver.**
5. **Classic lobule structure.**
6. **Liver acinus structure.**
7. **Portal lobule structure.**
8. **Hepatic sinusoids cells peculiarities.**
9. **Perisinusoidal space (space of Disse)**
10. **Hepatocytes structure and functions.**
11. **Biliary tree components.**
12. **Bile compounds**
13. **Gall bladder structure.**

Standard answers for theoretical questions

1. **Liver general characteristic and functions.**

The liver is one of the largest and most important organs in the body. The bulk of the liver consists of hepatocytes, which are epithelial cells with a unique configuration.

The **liver** is essentially an **exocrine gland**, secreting bile into the intestine. But, the liver is also and significantly so an **endocrine gland** and a **blood filter**. The endocrine secretions of the liver are released directly into the blood that supplies the liver parenchyma. These secretions include substances synthesized by the liver cells, i.e., albumins, lipoproteins, prothrombin and fibrinogen, glycoproteins, nonimmune α and β globulins, numerous glycoproteins including fibronectin and glycogen. **Several vitamins** such as vitamin A, D, K are taken up from the bloodstream and are then stored or biochemically modified by the liver.

Other functions of the liver include all of the following: synthesis of urea, metabolism of cholesterol and fat, detoxification of many drugs and other poisons, cleansing of bacteria from blood, processing of several steroid hormones, the storage, metabolism, and homeostasis of iron and volume reservoir for blood.

Much of the liver's organization is conditioned by its central role in removing unwanted materials from blood and otherwise maintaining the blood's normal composition.

2. **Blood supply to the liver**

The liver receives a dual vascular supply. The **hepatic portal vein** carries about 75% of the blood supply to the liver. The hepatic portal vein (hpv) carries venous blood from the digestive tube, pancreas and spleen into liver.

The **hepatic artery**, a branch of the celiac trunk, carries oxygenated blood to the liver.

Both vessels enter the liver at a hilum. Their branches form the **interlobular vessels** which branch into **distributing vessels** that are located at the periphery of the lobule.

The interlobular vessels that form the smallest **portal triads** (the distributing branches of the hpv, hepatic artery and the draining branches of the bile duct system course together in a relationship termed the portal triad) send blood into the **sinusoids**. Portal venous blood from the intestine and spleen and arterial blood from the aorta mix together in hepatic sinusoids. Here the blood flows centripetally toward the **central vein**. The central vein courses through the central axis of the classic liver lobule and empties into a **sublobular vein**. Several sublobular veins converge to form larger **hepatic veins** that empty into the **inferior vena cava**.

3. **Four structural components of the liver.**

Parenchyma consists of organized plates of hepatocytes, which in the adult are normally one cell thick and are separated by sinusoidal capillaries. In young individuals up to 6 years of age, the liver cells are arranged in plates two cells thick;

Connective tissue stroma that is continuous with the fibrous capsule of Glisson. Blood vessels, nerves, lymphatic vessels, and bile ducts travel within the connective tissue stroma;

Sinusoidal capillaries (sinusoids) are the vascular channels between the plates of hepatocytes.

Perisinusoidal spaces (spaces of Disse) lie between the sinusoidal endothelium and the hepatocytes.

4. **Functional and structural units of the liver.**

There are three ways of describing the structure of the liver in terms of a functional unit: the “classic” lobule, the portal lobule, and the liver acinus.

5. **Classic lobule structure.**

The classic lobule is the traditional description of the organization of the liver parenchyma. The classic hepatic lobule is a roughly hexagonal block of tissue.

The classic lobule consists of stacks of anastomosing plates of hepatic cells, separated by the anastomosing system of sinusoids that perfuse the cells with the mixed portal and arterial blood. At the center of the lobule is the terminal hepatic venule (central vein) into which the sinusoids drain. The plates of cells radiate from the central vein to the periphery of the lobule, as do the sinusoids. At the angles of the hexagon are the portal areas (portal canals), loose stromal connective tissue characterized by the presence of the portal triads. At the edges of the portal canal between the connective tissue stroma and hepatocytes is a small space called the space of Mall. This is one of the sites where lymph originates in the liver.

6. Liver acinus structure.

The liver acinus described as diamond shaped, is the smallest functional unit in the hepatic parenchyma. The short axis of the acinus is defined by the terminal branches of the portal triad that lie along the border between two "classic" lobules. The long axis is a line drawn between the two central veins closest to the short axis. The hepatocytes in each liver acinus are described as being arranged in three concentric elliptical zones surrounding the short axis. The liver acinus provides the best correlation among blood perfusion, metabolic activity, and liver pathology.

7. Portal lobule structure.

The portal lobule emphasizes the exocrine functions of the liver. The morphologic axis of the portal lobule is the interlobular duct of the portal triad of the "classic" lobule. Its outer margins are imaginary lines between the three central veins that are closest to that portal triad. This defines a roughly triangular block of tissue that includes those portions of three classic lobules that secrete the bile that drains into its axial bile duct.

8. Hepatic sinusoids cells peculiarities.

Hepatic sinusoids are lined with a thin discontinuous endothelium. Hepatic sinusoids differ from other sinusoids in that a second cell type, the stellate sinusoidal macrophage or **Kupffer** cell is a regular part of the vessel lining.

Kupffer cells belong to the mononuclear phagocytic system. Processes of Kupffer cells often seem to span the sinusoidal lumen and may even partially occlude it. The Kupffer cells may be involved in the final breakdown of some damaged or senile red blood cells that reach the liver from the spleen.

Natural killer (NK) cells in the liver, also called **pit cells**, constitute a unique resident population in the liver sinusoids. The name pit cell was introduced because of the characteristic cytoplasmic granules, which in Dutch language are called pit, resembling the pits in a grape. The pit cell shows a polarity with an eccentric nucleus. As a member of the NK cell family, pit cells have demonstrated cytotoxic activity against various tumor cells. Pit cells inhabit the liver sinusoids and often adhere to endothelial cells, although they incidentally contact Kupffer cells. Pseudopodia of pit cells can penetrate the fenestrae of the endothelial cells and enter the space of Disse, and can directly contact the microvilli of hepatocytes.

9. Perisinusoidal space (space of Disse)

The perisinusoidal space is the site of exchange of materials between blood and liver cells. The perisinusoidal space lies between the basal surfaces of the hepatocytes and the basal surfaces of the endothelial cells and Kupffer cells that line the sinusoids.

Irregular microvillous processes project into this space from the basal plasma membrane of the hepatocytes. Because of the large gaps in the endothelial layer and the absence of a continuous basal lamina, there is no significant barrier between the blood plasma in the sinusoid and the hepatocyte plasma membrane that forms the parenchymal border of the perisinusoidal space. A third cell type, the lypocyte or adipose cell (commonly called an **Ito cell**) is found in the perisinusoidal space. These stellate cells have been shown to be the primary storage site for fat and vitamin A, the vitamin A is transported from the liver to the retina, where it is used in the synthesis of visual pigments.

10. Hepatocytes structure and functions.

Hepatocytes make up the anastomosing cell plates of the liver lobule. Hepatocytes are large polygonal cells that constitute about 80% of the cell population of the liver. Nuclei of hepatocytes are large and spherical and occupy the center of the cell. Liver cells are capable of considerable regeneration when liver substance is lost to hepatotoxic processes, disease, or surgery. The hepatocyte cytoplasm is generally acidophilic. Specific cytoplasmic components include: rER and free ribosomes, numerous mitochondria, glycogen**,** lipid droplets, small Golgi complexes (elements of the Golgi complex concentrated near the bile canaliculus are believed to be associated with "exocrine" secretion of bile and a lot of peroxisomes.

Peroxisomes have specific oxidative functions in: gluconeogenesis, metabolism of purines, metabolism of alcohol and metabolism of lipids.

The sER contains enzymes involved in degradation and conjugation of toxins and drugs as well as enzymes responsible for synthesizing cholesterol and the lipid portion of lipoproteins. Hepatocyte lysosomes may also be a normal storage site for iron.

11. Biliary tree components.

The biliary tree is the conduit between the hepatocellular parenchyma of the liver and the gut. Loss of patency of this conduit is incompatible with life, in the neonate or at any other time in life.

The biliary system is made up of a series of intra-hepatic and extra-hepatic ducts and a storage bag, the gall bladder. The basal faces of adjoining hepatocytes are welded together to form **bile canaliculi**, the first part in the **intrahepatic biliary system**.

A **bile canaliculus** is not a duct, but rather, the dilated intercellular space between adjacent hepatocytes. They form a complete loop around four sides of the idealized six-sided hepatocytes. Microvilli of the two adjacent hepatocytes extend into the canalicular lumen. Hepatocytes secrete bile into the canaliculi, and those secretions flow parallel to the sinusoids opposite the direction of flow of blood in the classic liver lobule.

Near the portal canal but still within the lobule, bile canaliculi transform into the short **canals of Hering**. The **canal of Hering** is a channel partially lined by hepatocytes and partially by cuboidal shaped cholangiocytes.

The bile from the canal of Hering continues to flow into the **intrahepatic bile ductule**, which is lined entirely by cholangiocytes.

The bile ductules drain into **interlobular bile ducts** that form part of the portal triad. These ducts are lined by cholangiocytes. As the bile ducts get larger, they gradually acquire a dense connective tissue investment containing numerous elastic fibers. Smooth muscle cells appear in this connective tissue as the ducts approach the hilum.

Interlobular bile ducts join to form the **right and left lobar hepatic ducts** that in turn join at the hilum to form the **common hepatic duct**.

Extrahepatic bile ducts carry the bile to the gallbladder and duodenum.

The cystic duct connects the common hepatic duct to the gallbladder and carries bile both into and out of the **gallbladder**. Distal to the junction with the cystic duct, the fused duct is called the **common bile duct**. A thickening of the muscularis externa of the duodenum at the ampulla constitutes the **sphincter of Oddi**, which surrounds the openings of both the common bile duct and the **pancreatic duct** and acts as a valve to regulate the flow of bile and pancreatic juice into the duodenum.

12. Bile compounds

About 90% of the bile salts a component of bile is reabsorbed and resecreted by the hepatocytes. Bile also consists of cholesterol, lecithin, bile pigments, water and electrolytes.

13. Gall bladder structure.

The gall bladder is a specialized portion of the bile duct. The gall bladder is shaped like a small sack to store bile, it has an absorptive epithelial lining to concentrate bile, and it has a muscular wall to expel bile.

In its absorptive function, the gall bladder epithelium is a highly exaggerated striated duct. The gall bladder has a wrinkled **mucosa**, with sections across the wrinkles resembling villi. The epithelial lining of the gall bladder consists of simple columnar cells specialized for absorption, with an apical brush border of microvilli, very similar to intestinal absorptive cells. **Lamina propria** of the gall bladder includes mucin-secreting glands and large number of lymphocyte and plasma cells. The gall bladder has no muscularis mucosae, and no distinct submucosa.

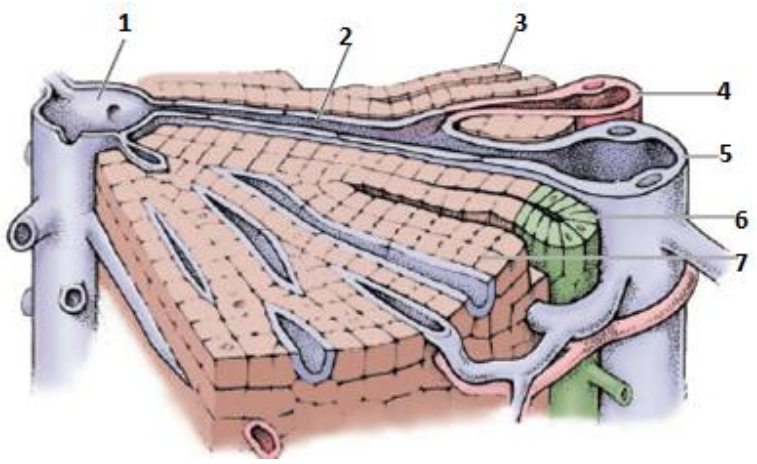
The smooth muscle bundles are somewhat randomly oriented in the **muscularis externa**. Contraction of the smooth muscle reduces the volume of the bladder, forcing its contents out through the cystic duct.

External to the muscularis externa is a thick layer of dense connective tissue.

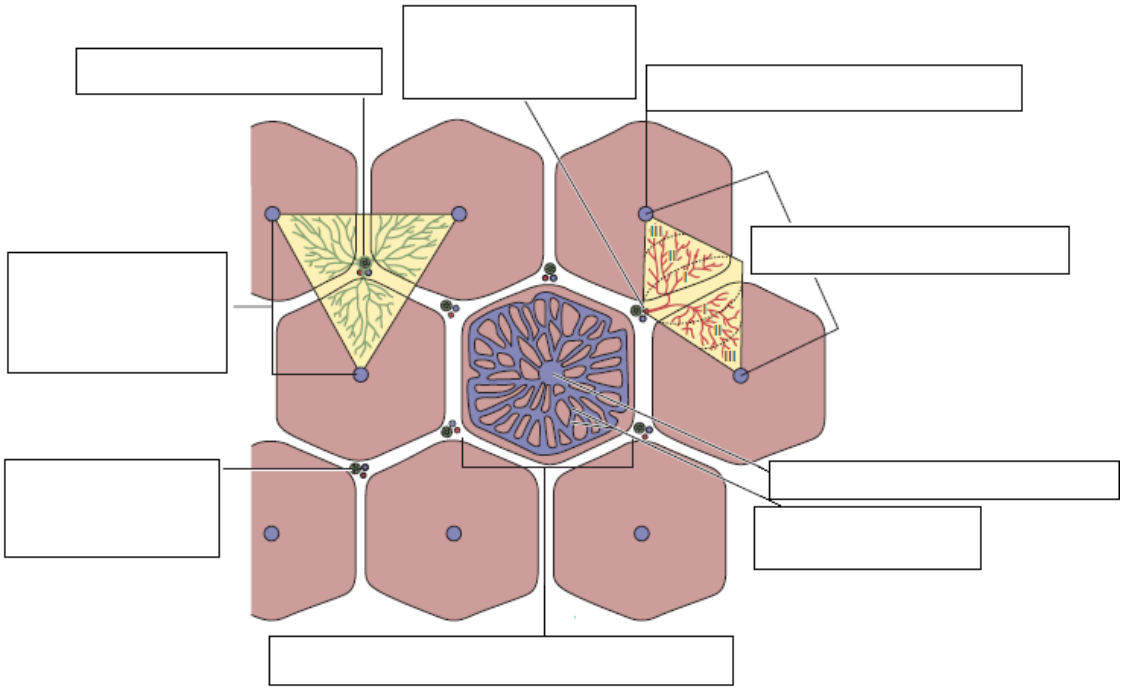
Where the gall bladder is attached to the liver surface, this layer is referred to as the **adventitia**. The unattached surface is covered by a **serosa** of visceral peritoneum consisting of a layer of mesothelium and a thin layer of loose connective tissue.

PRACTICAL QUESTIONS

1. In this diagram below of classic liver lobule identify the structure labeled 1.



2. Identify the structure labeled 2.
3. Identify the structure labeled 3.
4. Identify the structure labeled 4.
5. Identify the structure labeled 5.
6. Identify the structure labeled 6.
7. Identify the structure labeled 7.
8. What cell content of the hepatic sinusoid do you know? Describe it.
9. Fill in the white gaps with designations in the picture below.



10. Identify the structure labeled 1 in the below diagram of a plate of hepatocytes interposed between hepatic sinusoids.

_____

11. Identify the structure labeled 2.

_____

12. Identify the structure labeled 3.

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13. Identify the structure labeled 4.

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14. Identify the structure labeled 5.

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15. Identify the structure labeled 6.

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16. Identify the structure labeled 7.

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17. Identify the structure labeled 8

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18. Identify the structure labeled 9

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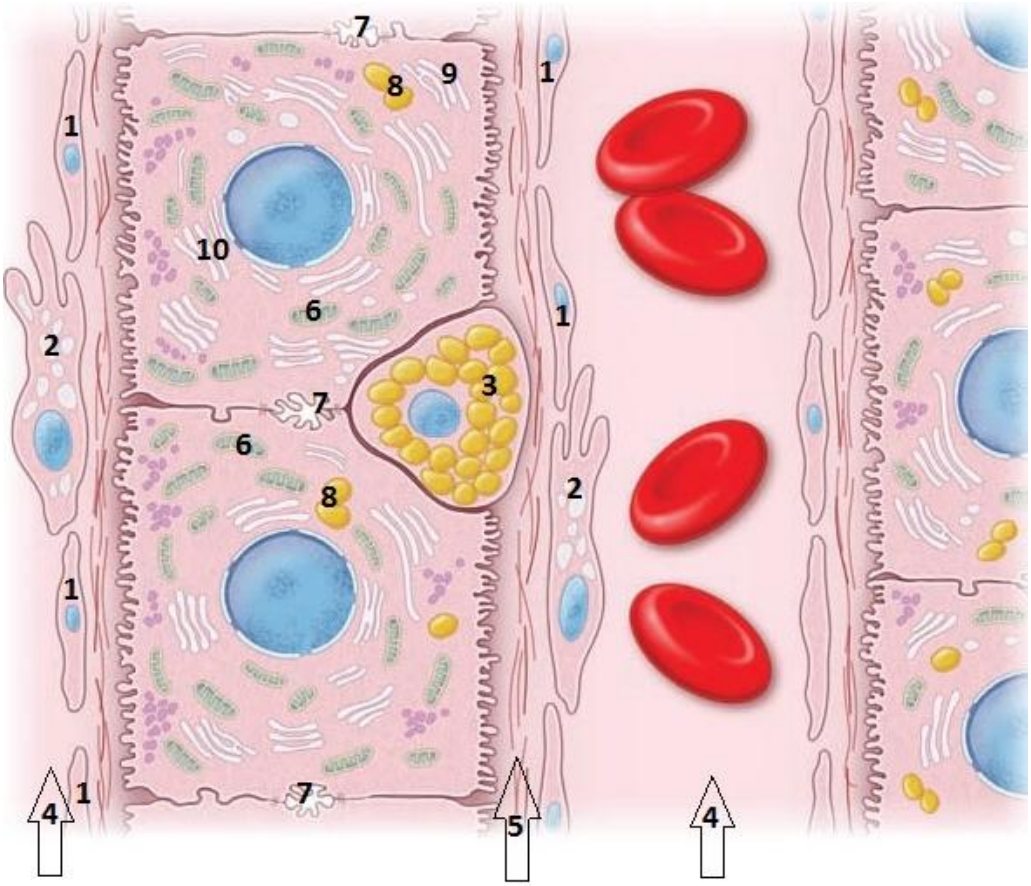

19. Identify the structure labeled 10.

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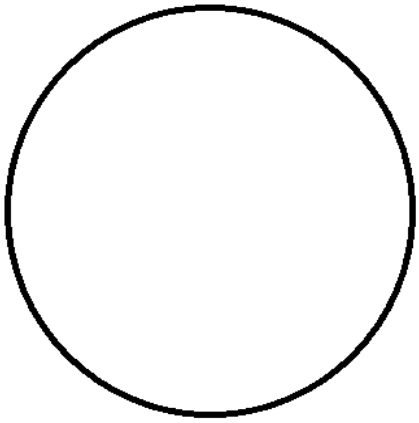


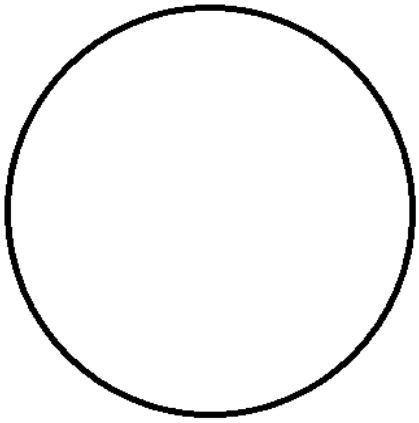
SLIDE 1

Human liver.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Liver lobules
2. Hepatic plate
3. Central vein
4. Hepatic sinusoid
5. Portal triad

a) distributing branches of the hpv,
b) distributing branches of hepatic artery
c) the draining branches of the bile duct



SLIDE 2

Pig liver.
Stained by Van Gizon.

SLIDE'S DESIGNATIONS

1. Liver lobules
2. Central vein
3. Interlobular connective tissue stroma

Cells of a healthy liver actively synthesize glycogen and proteins. What organelles are the most developed in these cells?
A. Granular and agranular endoplasmic reticulum
B. Cell center
C. Lysosomes
D. Mitochondria
E. Peroxisomes

A specimen of a parenchymal organ shows poorly delineated hexagonal lobules surrounding a central vein, and the interlobular connective tissue contains embedded triads (an artery, a vein and an excretory duct). What organ is this?
A. Liver
B. Pancreas
C. Thymus
D. Spleen
E. Thyroid

A parenchymal organ with lobular structure is presented in a histological specimen. Each lobule is roughly hexagonal block of tissue consisting of anastomosing plates with sinusoidal capillaries. They are lying between the plates and radially converging to the central vein. What anatomic organ has such morphological structure?
A. *Liver
B. Pancreas
C. Thymus
D. Spleen
E. Lymph node

Ultramicroscopic examination of "dark"; hepatocyte population in the cell cytoplasm detected well developed granular endoplasmic reticulum. What function has this organelle in these cells?
A *Synthesis of blood plasma proteins
B Carbohydrate synthesis
C Detoxification
D Bile production
E Calcium ion depositing

A viral infection has damaged cells that form walls of bile capillaries. This stimulated conditions for inflow of bile into the blood of sinusoidal capillaries. What cells are damaged?
A *Hepatocytes
B Kupffer's cells
C Ito cells
D Pit-cells
E Endotheliocytes

Disorder of blood circulation in classic lobule has been seen in the liver parenchyma during connective tissue overgrowth as a result of chronic diseases. What is the direction of blood circulation in these lobules?
A. *From periphery to the center
B. From center to the periphery
C. Around lobule
D. From apex to the bottom
E. From bottom to the apex

Anomaly of the liver development has been found during examination of the patient. What embryonal source was damaged?
A. *Endoderm of the middle part of the primary gut
B. Endoderm of posterior wall of the gut
C. Endoderm of the anterior gut
D. Mesonephral duct
E. Endoderm of the posterior gut

Parenchymal organ has been seen in the histological slide. Lobules are structural and functional unit of it. They don't have clear margins, possess central vein in the center, radial oriented stacks and intralobular sinusoidal capillaries. Lobule is limited by interlobular arteries, veins and bile ducts. Name, what organ has these morphological signs.
A. *Liver
B. Thyroid gland
C. Pancreas
D. Parotid gland
E. Kidney

There is a large quantity of carbohydrates in the dietary intake of a human. What structures will be seen in the cytoplasm of hepatocytes?
A. *Glycogen granules
B. Lipid droplets
C. One large lipid drop
D. Lipofuscin inclusions
E. Increasing of ribosome quantity

Reduced in size liver, kidneys and heart were found during autopsy of a 67-year-old patient, who died from lung cancer. The liver on the section was with brown shade. The golden-brown granules of lipofuscin were found during microscopic examination of hepatocytes. Name the structure that forms the granules of lipofuscin.
A *Autophagolysosomes
B Golgi apparatus
C Ribosomes
D Endoplasmic reticulum
E Mitochondria

A diffuse growth of connective tissue, dilatation of bile ducts, excessive accumulation of bilirubin granules in the cytoplasm of hepatocytes and its necrosis were found during histological examination of sectioned material (liver) of a 64-year-old patient with diagnosis of cancer of the pancreatic head. What organelles damage can cause the delay of bilirubin excretion by hepatocytes?
A *Golgi apparatus
B Lysosomes
C Plasma membrane
D Endoplasmic reticulum
E Nucleus

Violation of the integrity of the membrane of lysosomes in most cells of the liver is observed in the patient, who was poisoned with CCL4. What will be the effect of the poison on the liver cells?
A. *Developing autolysis that will lead to the cell death
B. Not affected
C. Will occur phagocytosis
D. Will occur pinocytosis
E. Will occur exocytosis

The bile can get into the bloodstream, causing jaundice due to the damage junctions between hepatocytes which arising from some pathological processes. What types of intercellular junctions are damaged in this case?
A. *Zonula occludens, gap junction, desmosomes
B. Plasma membrane infoldings (finger-like) and gap junction
C. Synapses and desmosomes
D. Desmosomes and gap junction
E. Gap junction and zonula occludens

The cell in the cytoplasm of which there are granules with a density similar to the fruit bone is represented in electron micrographs of intralobular sinusoid of the liver. It is known that this cell is a natural killer. What kind of cell is represented?
A. *Pit- cell
B. Hepatocyte
C. Endothelial cell of the sinusoid capillary
D. Stellate macrophage
E. Perisinusoidal lipocyte

Damaged rough endoplasmic reticulum was found in hepatocytes as a result of exposure of hepatotropic poison. Synthesis of what substances will be disordered in the liver epithelium?
A. *Albumins and fibrinogen
B. Phospholipids
C. Glycogen
D. Cholesterol
E. Vitamins

As a result of stab wounds of the liver, hepatic artery was cut, however in liver lobules the blood continued to flow. What vessel provided the flow of blood into lobules?
A. *Perilobular vein
B. Interlobular vein
C. Perilobular artery
D. Sublobular vein
E. Hepatic vein

Intralobular capillaries have wide irregular lumen throughout its length in a specimen of the liver. The basement membrane in most of the capillary wall is absent. What type of capillaries are these?
A *Sinusoidal
B Visceral
C Somatic
D Precapillaries
E Postcapillaries

Golgi apparatus was destroyed in hepatocytes as a result of the damaging effects of hepatotropic poison. Synthesis of what substances will be disordered in the liver?
A *Bile
B Glycogen
C Albumins and fibrinogen
D Vitamins
E Cholesterol

DIGESTIVE SYSTEM. PANCREAS

Checking your primary level of the knowledge:

1. **Pancreas general characteristic.**
2. **Exocrine pancreas structure.**
3. **Functions of the acinar cells.**
4. **Duct system of the pancreas**
5. **Exocrine secretion of the pancreas.**
6. **Hormonal control of exocrine secretion.**
7. **Endocrine pancreas general characteristic.**
8. **Cells of the endocrine pancreas**
9. **B cells structure and functions.**
10. **A cells structure and functions.**
11. **D cells structure and functions.**
12. **The minor islet cells**

Standard answers for theoretical questions

1. Pancreas general characteristic.

The pancreas is an elongated gland which extends from the curve of the duodenum across the midline of the body toward the spleen. It has a head (expanded part lying near the duodenum), body and tail. In the adult the average pancreas is about 12-15 cm in length and weighs 60 to 140 g. A thin layer of loose connective tissue forms an incomplete capsule around the organ. Septa extending from the capsule divide the pancreas into poorly defined lobules. A stroma of loose connective tissue surrounds the lobules. Larger blood vessels, nerves and ducts lying between the lobules are surrounded by more abundant connective tissue.

The pancreas has both an **exocrine** and an **endocrine** component. The exocrine part consists of serous acini that make up most of the organ. The endocrine part consists of distinct masses of cells called islets of Langerhans scattered among the serous acini. The islets vary greatly in size, from a few cells to hundreds of cells.

2. Exocrine pancreas structure.

The **exocrine pancreas** closely resembles the parotid gland. The secretory units are acinar or tubuloacinar in shape and are formed by a simple epithelium of pyramidal serous cells. The cells have a narrow free (luminal) surface and a broad basal surface. Acinar cells are large, pyramidal shaped cells with a single nucleus. The round nucleus with clumped chromatin lies close to the base of the cells that rests on the basal lamina. The apical portion of the cell is filled with eosinophilic **zymogen granules**. The basal portion is strongly basophilic because the cytoplasm is filled with rER and free ribosomes. A well-developed Golgi apparatus is present in the apical cytoplasm and is involved in concentration and packaging of the secretory products. Mitochondria are small and found throughout the cell. The cells secrete directly into acinar lumen though the apical surface. Acinar cells are joined to one another by **junctional complexes** at their apical poles, thus forming an isolated lumen into which small microvilli extend from the apical surfaces of the acinar cells and into which the zymogen granules are released by exocytosis.

3. Functions of the acinar cells.

The serous secretory cells of the acinus produce the digestive enzyme precursors secreted by the pancreas. Pancreatic enzymes contained in zymogen granules are capable of digesting most food substances such as proteins, carbohydrates, lipids and nucleic acids.

4. Duct system of the pancreas

Pancreatic acini are unique among glandular acini, in that the initial duct that leads from the acinus, the **intercalated duct**, actually begins within the acinus. The duct cells located inside the acinus are referred to as **centroacinar cells**. They have a centrally placed, flattened pale nucleus and attenuated cytoplasm. Centroacinar cells are continuous with the cells of the short intercalated duct that lies outside the acinus.

The centroacinar cells are the beginning of the duct system of the exocrine pancreas. The **intercalated ducts** are lined by low cuboidal epithelium. The nucleus is ovoid with inconspicuous nucleoli. The **intralobular ducts** receive secretions from intercalated ducts and drain into interlobular duct. The intralobular ducts vary in diameter and are lined by simple cuboidal epithelium cells. A single rounded nucleus appears to fill each cell. The **interlobular ducts** are found between lobules, within the connective tissue septae. They are larger and are lined by simple columnar epithelium. Enteroendocrine cells and an occasional goblet cell can be found in these ducts. Intralobular ducts transmit secretions from intralobular ducts to the main pancreatic duct. There are no striated (secretory) ducts in the pancreas.

The main pancreatic duct received secretion from interlobular ducts and penetrates through the wall of the duodenum after joining with the common bile duct. A second large duct, the ductus choledochus (accessory pancreatic duct) arises in the head of the pancreas.

5. Exocrine secretion of the pancreas.

The pancreas secretes about 1 liter per day. The acini secrete a small volume of protein-rich fluid. The intercalated ducts secrete a large volume of fluid that is rich in sodium and bicarbonate. The bicarbonate serves to neutralize the acidic chyme that enters the duodenum from the stomach. This establishes the optimum pH in the duodenum for the activity of the major pancreatic enzymes.

6. Hormonal control of exocrine secretion.

Two hormones secreted by enteroendocrine cells in the duodenum are major regulators of exocrine pancreatic activity. **Secretin** stimulates the release of the bicarbonate rich fluid from the intercalated ducts, while **cholecystokinin (CCK)** stimulates the acinar cells to release their proenzymes. The release of secretin and CCK is stimulated by the entry of acidic chyme into the duodenum.

7. Endocrine pancreas general characteristic.

The endocrine pancreas is a diffuse organ that secretes hormones that regulate blood glucose levels. The islets of Langerhans, the endocrine component of the pancreas, are scattered throughout the organ, and are most numerous in the tail. The 1 million to 3 million islets constitute about 1-2% of the volume of the pancreas. Individual islets may contain only a few cells or many hundreds of cells. Each islet is a lightly stained, rounded group which is a multihormonal micro-organ. A small amount of connective tissue accompanies the large fenestrated capillaries that run through each islet. The islets of Langerhans appear as clusters of pale-staining cells surrounded by more intensely staining pancreatic acini.

8. Cells of the endocrine pancreas

It is possible to identify three principal cell types designated A, B and D cells and three minor islet cell types designated PP, D-1 and EC cell.

9. B cells structure and functions.

The B cells constitute about 70% of the total islet cells in humans and are generally located in its central portion. They secrete **insulin.** B cells contain numerous secretory granules about 300 nm in diameter with a dense polyhedral core and a pale matrix. The polyhedral core is believed to be crystallized insulin. Its principal effects are on the liver, skeletal muscle, and adipose tissue. Insulin stimulates uptake of glucose from the circulation, utilization and storage of glucose by all cells, and synthesis of glycogen from the phosphorylated glucose. Absence or inadequate amounts of insulin lead to elevated blood glucose levels and the presence of glucose in the urine, a condition known as diabetes mellitus. In addition, insulin stimulates glycerol synthesis in adipose cells and inhibits lipase activity in these cells.

10. A cells structure and functions.

The A cells constitute about 15-20% of the human islet population and are generally located peripherally in the islets. They secrete **glucagon.** A cells contain secretory granules about 250 nm in diameter that are more uniform in size and more densely packed in the cytoplasm than the granules of B cells. The granule is the site of stored glucagon. Glucagon raises blood glucose.

Glucagon stimulates release of glucose into the blood-stream, and stimulates gluconeogenesis (synthesis of glucose from metabolites of amino acids) and glycogenolysis (breakdown of glycogen) in the liver. Glucagon also mobilizes fats from adipose cells.

11. D cells structure and functions.

The **D cells** constitute about 5-10% of the total pancreatic endocrine tissue and are also located peripherally in the islets. D cells secrete somatostatin, which is contained in secretory granules that are larger than those of the A and B cells (300 to 350 nm). The precise role of somatostatin in the islets is unclear, but it has been shown to inhibit both insulin and glucagon secretion.

12. The minor islet cells

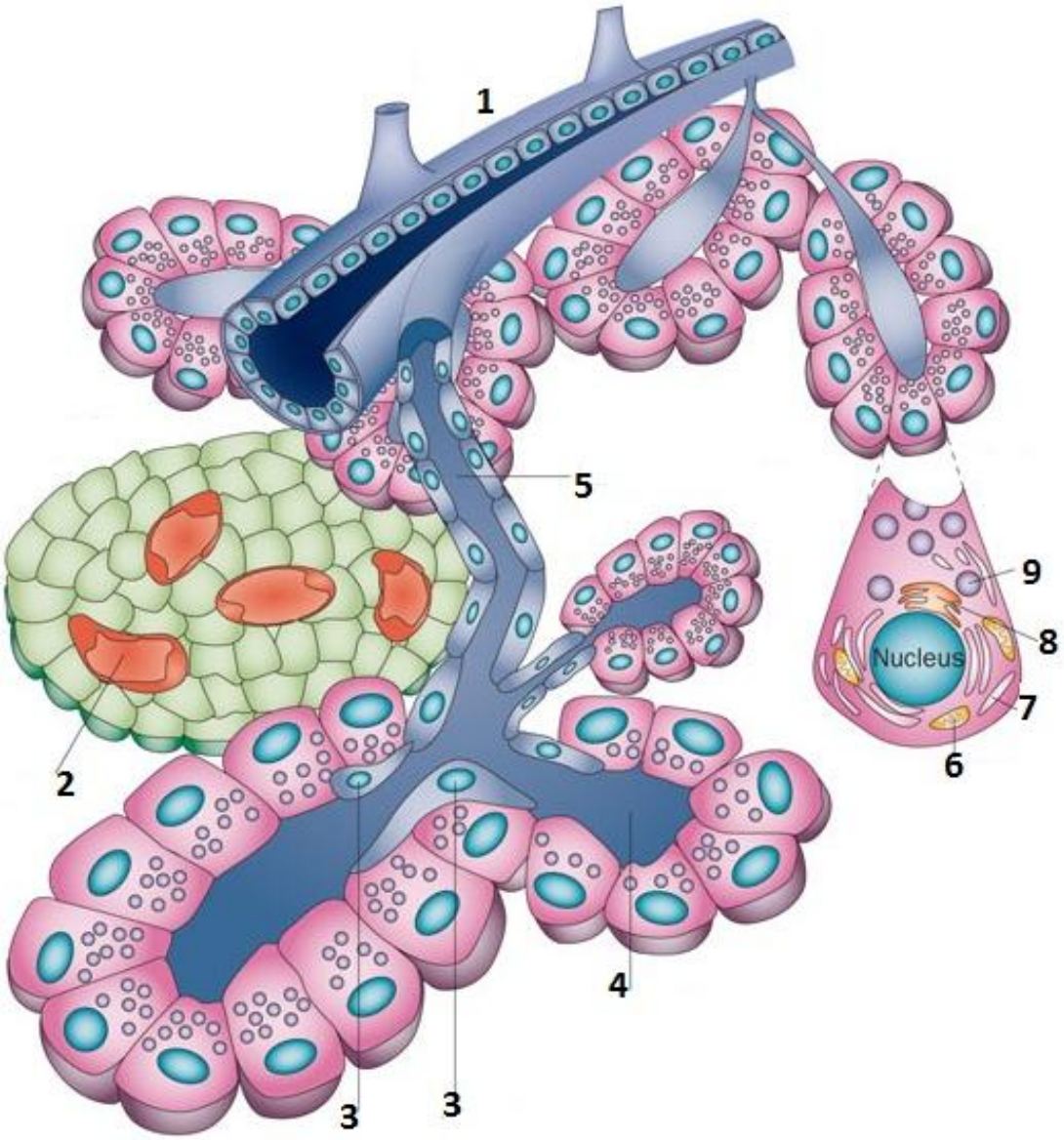
The minor islet cells constitute about 5% of the islet tissue.

The **PP cells** secrete pancreatic polypeptide. It stimulates gastric chief cells, inhibits bile secretion and intestinal motility, inhibits pancreatic enzymes and bicarbonate secretion.

The **D-1 cells** secrete vasoactive intestinal peptide. Its principal effects are similar to those of glucagon plus these cells stimulate pancreatic exocrine secretion.

The **EC cells** secrete secretin, motilin and substance P. Secretin- acts locally to stimulate bicarbonate secretion in pancreatic fluid and pancreatic enzyme secretion, motilin-increases gastric and intestinal motility, substance P-unclear.

PRACTICAL QUESTIONS



1. In the above diagram of the pancreatic acinus and its duct system identify the structure labeled 1.

_____

2. Identify the structure labeled 2.

_____

3. Identify the structure labeled 3.

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4. Identify the structure labeled 4.

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5. Identify the structure labeled 5.

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6. Identify the structure labeled 6.

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7. Identify the structure labeled 7.

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8. Identify the structure labeled 8.

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9. Identify the structure labeled 9.

_____

10. What is the name of the cellular mass for the endocrine portion of the pancreas?

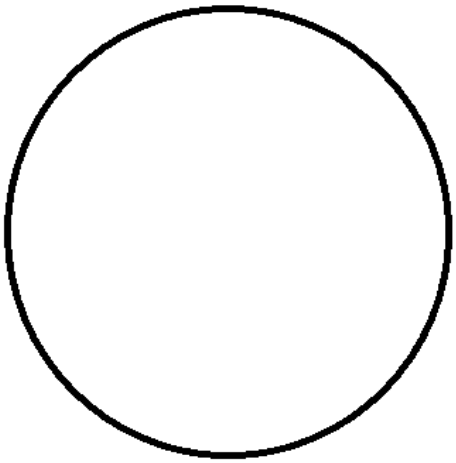
_____

11. What cells of the pancreas secrete somatostatin? Describe them.

_____

_____

_____



SLIDE 1
Pancreas.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Interlobular septa
2. Lobule
3. Islet of Langerhans
4. Acinus
5. Blood vessels
6. Interlobular duct

TESTS OF THE "KROK-1" DATABASE. DIGESTIVE SYSTEM. PANCREAS.

Glucose is transported inside the cell from extracellular space through plasma membrane before it utilization. This process is stimulated by the following hormone:
A. Insulin
B. Glucagon
C. Thyroxin
D. Aldosterone
E. Adrenalin

A 14-year-old patient has diabetes mellitus. What cells of the pancreas do not function?
A *B -cells
B A - cells
C D - cells
D D1- cells
E PP - cells

55-year-old patient is observed by endocrinologist apropos decreased function of the pancreas that manifested by decreasing of hormone glucagon in the blood. What cells function is disturbed in this case?
A. α-cells of Langerhans islets
B. β- of Langerhans islets
C. D-cells of Langerhans islets
D. PP-cells of Langerhans islets
E. EC-cells of Langerhans islets

50-year- old patient complains of increased appetite, thirsty, decreased body weight and fatigue. Increased blood glucose level was revealed during laboratory examination. What cells function disorder is connected with development of this disease?
A. *β-cells
B. α-cells
C. Thyrocytes
D. Acinar cells
E. Lipotropocytes

There is gland in the histological slide. There are acini in the lobules, secretory cells of which have 2 zones: basal – homogeneous basophilic and apical – zymogen oxiphylic. What organ has these morphological signs?
A. *Pancreas
B. Liver
C. Parotid salivary gland
D. Submandibular salivary gland
E. Sublingual salivary gland

Certain cells of pancreas are in the permanent condition of exertion in people that incline to excessive using of sweet. What cells are these?
A. *β-cells
B. α-cells
C. D cells
D. PP cells
E. EC cells

The β cells of endocrine portion of pancreas are selectively damaged by alloxan poisoning. How will it be reflected in blood plasma?
A *The content of sugar increases
B The content of fibrinogen decrease
C The level of sugar decreases
D The content of globulins decreases
E The content of albumins decreases

Massive damage of centroacinar cells was detected in the analysis of a patient after acute pancreatitis. With help of what cells is its regeneration possible?
A. Intercalated duct cells
B. Islets Langerhans cells
C. Cells of the stroma
D. Vessel endothelium
E. Interlobular duct cells

The substance, which selectively damages A-cells of the pancreatic islet (cobalt salts), was injected to the animal. What function will be disrupted?
A. *Synthesis of glucagon
B. Synthesis of insulin
C. Synthesis of somatostatin
D. Synthesis of cholecystokinin
E. Synthesis of pancreozymin

The alloxon, which selectively damage B-cells of pancreatic islets, was injected to the animal. What function of the pancreas will be disrupted?
A *Synthesis of insulin
B Synthesis of glucagon
C Synthesis of somatostatin
D Synthesis of pancreatic polypeptide
E Synthesis of vasointestinal polypeptide

A group of cells is defined in a histological specimen of the pancreas. Some of them are located centrally and have basophilic secretory granules. Their secretion regulates carbohydrate metabolism. Name these cells
A. *B- cells
B. PP- cells
C. A- cells
D. Adipose cells
E. D cells

RESPIRATORY SYSTEM

Checking your primary level of the knowledge:

1. **Components of the respiratory system and functions of it.**
2. **Mucociliary clearance characteristic.**
3. **Nasal cavities structure.**
4. **Vestibule of the nasal cavity structure.**
5. **Respiratory segment of the nasal cavity structure.**
6. **Respiratory epithelium cell types.**
7. **Lamina propria of respiratory segment**
8. **Pharynx structure.**
9. **Larynx structure and function.**
10. **Trachea. General structure of the wall.**
11. **Ciliated cells structure and function**
12. **Mucous cells structure.**
13. **Brush cells structure.**
14. **Small granule cells structure.**
15. **Basal cells structure.**
16. **Structure of the basement membrane and lamina propria of the trachea.**
17. **Submucosa of the trachea peculiarities.**
18. **Cartilaginous layer of the trachea peculiarities.**
19. **The adventitia of the trachea characteristic.**
20. **Bronchi classification.**
21. **Bronchi. Structure of the wall.**
22. **Bronchiolar structure.**
23. **Clara cells structure and function.**
24. **Respiratory bronchioles characteristic.**
25. **Give the definition of pulmonary acinus.**
26. **Alveoli, alveolar ducts and sacs structure.**
27. **Peculiarities of the type I alveolar cells, type II alveolar cells and brush cells.**
28. **Pulmonary surfactant structure and function.**
29. **Pulmonary surfactant structure and function.**
30. **Alveolar macrophages (dust cells) location and function.**

Standard answers for theoretical questions

1. Components of the respiratory system and functions of it.

The respiratory system consists of the paired lungs and a series of air passages that lead to and from the lungs. Three principal functions are performed by this system, namely, **air conduction, air filtration, and gas exchange (respiration).**In addition, air passing through the larynx is used to **produce speech**, and air passing over the olfactory mucosa in the nasal cavities carries the stimuli for the **sense of smell**.

The air passages consist of a conducting portion and a respiratory portion. The **conducting portion** of the respiratory system **external to the lungs** includes nasal cavities, nasopharynx, larynx, trachea and paired (primary) bronchi. The **conducting portion** of the respiratory system **within the lungs** consists of the **internal bronchi**, which undergo extensive branching to give rise to the distributing **bronchioles.** Collectively, the internal bronchi and the bronchioles constitute the bronchial tree.

The **respiratory portion** is that part of the respiratory tract in which gas exchange occurs. The respiratory portion consists of respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli.

Air passing through the respiratory passages must be conditioned before reaching the terminal respiratory units. Conditioning of the air occurs in the conducting portion of the system and consists of warming, moistening, and removal of particulate materials.

2. Mucociliary clearance characteristic.

Mucociliary clearance, also referred to as **mucociliary apparatus**, derived from mucus, cilia and clearance describes the self-clearing mechanism of the bronchi by which particulate matter is removed from the respiratory tract.

The airway surface fluid is present as a bilayer, with a superficial gel or mucous layer and a layer of periciliary fluid interposed between the mucous layer and the respiratory epithelium. The mucous layer

extends from the intermediate airway to the upper airway and is approximately 2-10 μm thick in the trachea. Airway mucus is the secretory product of the goblet cells and the submucosal glands. It is a nonhomogeneous, adhesive, viscoelastic gel composed of water, carbohydrates, proteins, and lipids.

Mucus cleanses the nose and throat. It flushes out invading microorganisms and pollutants through its constant movement down the upper respiratory tract. Mucus and other secretions are transported from the lower respiratory tract into the pharynx by means of coordinated sweeping movements of cilia and are then normally swallowed or expelled via coughing. Mucus also prevents the dehydration of the underlying epithelium by the moving air and moderate temperature on the respiratory tract. Effective mucociliary clearance requires appropriate mucus production and coordinated ciliary activity, their number and structure.

Disruption of normal secretion or mucociliary clearance impairs pulmonary function and lung defense and increases risk of infection.

3. Nasal cavities structure

The nasal cavities are paired chambers separated by a bony and cartilaginous septum. Each chamber is divided into three regions: vestibule (nostril), respiratory segment and olfactory segment.

4. Vestibule of the nasal cavity structure

The vestibule communicates anteriorly with the external environment. It is lined with stratified squamous epithelium, and contains the hairs that filter out large particulate matter before it is carried in the airstream to the rest of the cavity. Sebaceous glands are also present, and their secretions assist in the entrapment of particulate matter.

5. Respiratory segment of the nasal cavity structure

The respiratory segment constitutes most of the volume of the nasal cavities. It is lined by the respiratory mucosa that contains a ciliated, pseudostratified columnar epithelium on its surface. The underlying lamina propria is firmly attached to the periosteum and perichondrium of the adjacent bone or cartilage. The medial wall of the respiratory region, the nasal septum, is smooth, but the lateral walls are thrown into folds by the presence of three shelf-like, bony projections called conchae. The conchae divide each nasal cavity into separate air chambers and play a dual role. They increase surface area and cause turbulence in airflow to allow more efficient conditioning of inspired air.

6. Respiratory epithelium cell types

It is composed of five cell types:

Ciliated columnar cells: most abundant cell type. Cilia beat in unison and move mucus and trapped particles to oropharynx, where it is swallowed or expectorated.

Goblet cells: produce mucus.

Basal cells: stem cells from which the other cell types arise.

Brush cells:, a general name for those cells in the respiratory tract that bear short, blunt microvilli. They are columnar cells.

Neuroendocrine cells (small granule cells): epithelial cells containing hormones. These are enteroendocrine cells of the APUD system

7. Lamina propria of respiratory segment

The lamina propria of the respiratory mucosa has a rich, vascular network that includes a complex set of capillary loops. The arrangement of the vessels allows the inhaled air to be warmed by blood flowing through the part of the loop closest to the surface. The lamina propria also contains mucous glands, many exhibiting serous demilunes. Their secretions supplement that of the goblet cells in the respiratory epithelium. The mucosa of the respiratory segment warms, moistens, and filters inspired air.

8. Pharynx structure

The pharynx connects the nasal and oral cavities to the larynx and esophagus. The pharynx is located posterior to the nasal and oral cavities and is divided regionally into the **nasopharynx** and **oropharynx**, respectively.

The auditory (Eustachian) tubes connect the nasopharynx to each middle ear. Diffuse lymphatic tissue and lymphatic nodules are found in the wall of the nasopharynx. The concentration of such nodules in the posterior wall is called the **pharyngeal tonsil**.

9. Larynx structure and function.

The passageway for air between the oropharynx and trachea is the **larynx**. It is a complex tubular segment of the respiratory system that is formed by irregularly shaped plates of hyaline and elastic cartilage.

The **vocal folds**, also referred to as **vocal cords**, are two folds of mucosa that project into the lumen of the larynx. A supporting ligament and skeletal muscle, the **vocalis muscle,** is contained within each vocal fold. Ligaments and the intrinsic laryngeal muscles join the adjacent cartilaginous plates and are responsible for generating tension in the vocal folds and for opening and closing the glottis.

The ventricular folds located above the vocal folds are the "**false vocal cords**".
The luminal surface of the vocal cords is covered with stratified squamous epithelium. The rest of the larynx is lined with the ciliated, pseudostratified columnar epithelium that characterizes the respiratory tract. The connective tissue of the larynx contains mixed mucoserous glands that secrete through ducts onto the laryngeal surface. Vocal folds control the flow of air through the larynx and vibrate to produce sound.

10. Trachea. General structure of the wall.

The trachea is a short tube. It serves as a conduit for air. The trachea extends from the larynx to about the middle of the thorax, where it divides into the two primary bronchi. The wall of the trachea consists of four layers

Mucosa composed of ciliated, pseudostratified epithelium and an elastic fiber-rich lamina propria. Ciliated columnar cells, mucous (goblet) cells, and basal cells are the principal cell types in the tracheal epithelium. Brush cells are also present but in small numbers, as are the small granule cells.
Submucosa composed of loose connective tissue.
Cartilaginous layer composed of C-shaped hyaline cartilages.
Adventitia binds the trachea to adjacent structures.

11. Ciliated cells structure and function

Ciliated cells, the most numerous of the tracheal cell types, extend through the full thickness of the epithelium. Cilia appear as short, hair-like profiles projecting from the apical surface. Each cell has approximately 250 cilia. Immediately below the cilia is a dark line formed by the aggregated ciliary basal bodies.

Ciliated cells functions

The cilia provide a coordinated sweeping motion of the mucous coat from the farthest reaches of the air passages toward the pharynx. In effect, the ciliated cells function as a "**mucociliary escalator**" that serves as an important protective mechanism for removing small inhaled particles from the lungs.

12. Mucous cells structure.

Mucous cells are similar in appearance to intestinal goblet cells and are thus often referred to by the same name. They are interspersed among the ciliated cells and also extend through the full thickness of the epithelium. They are readily seen in the light microscope after they have accumulated mucinogen granules in their cytoplasm.

The identity of the cell is made apparent by the clear area in the cytoplasm and the lack of cilia at the apical surface. In contrast to ciliated cells, the number of mucous cells increases during chronic irritation of the air passages.

13. Brush cells structure

Brush cells have the same general features as those described for the respiratory epithelium of the nasal cavity. They are columnar cells that bear blunt microvilli.

The basal surface of the cells is in synaptic contact with an afferent nerve ending (epitheliodendritic synapse). Thus, the brush cell is regarded as a receptor cell.

14. Small granule cells structure

Small granule cells are respiratory representatives of the general class of enteroendocrine cells of the gut. Small granule cells usually occur singly in the trachea and are sparsely dispersed among the other cell types. They are difficult to distinguish from basal cells in the light microscope. The nucleus is located near the basement membrane; the cytoplasm is somewhat more extensive than that of the smaller basal cells. A thin, tapering cytoplasmic process is sometimes observed extending to the lumen. The cytoplasm exhibits numerous, membrane-bounded, dense-core granules. In one type of small granule cell, the secretion is a **catecholamine**. A second cell type produces polypeptide hormones such as **serotonin**, **calcitonin**, and gastrin-releasing peptide (**bombesin**).

Some small granule cells are present in groups in association with nerve fibers, forming neuroepithelial bodies, which are thought to function in reflexes regulating the airway or vascular caliber.

15. Basal cells structure

Basal cells serve as a reserve cell population that maintains individual cell replacement in the epithelium. Basal cells tend to be prominent because their nuclei form a row in close proximity to the basal lamina. Although nuclei of other cells reside at this same general level within the epithelium, they are relatively sparse. Thus, most of the nuclei near the basement membrane belong to basal cells.

16. Structure of the basement membrane and lamina propria of the trachea

A thick **basement membrane** is characteristic of tracheal epithelium. The lamina propria of the mucosa has elastic fibers with longitudinal orientation. The lamina propria contains numerous lymphocytes, many of which infiltrate the epithelium. Lymphatic tissue, in both diffuse and nodular forms, is consistently present in

the lamina propria and submucosa of the tracheal wall. This lymphatic tissue is the developmental and functional equivalent of the bronchus-associated lymphatic tissue (BALT).

17. Submucosa of the trachea peculiarities.

In the trachea, the submucosa is a relatively loose connective tissue similar in appearance to the lamina propria. Diffuse lymphatic tissue and lymphatic nodules characteristically extend into this layer from the lamina propria. The submucosa contains the larger distributing vessels and lymphatics of the tracheal wall. Submucosal glands composed of mucus-secreting acini with serous demilunes are also present in the submucosa. The submucosal layer ends where its connective tissue fibers blend with the perichondrium of the cartilage layer.

18. Cartilaginous layer of the trachea peculiarities

The tracheal cartilages, which number about 16 to 20 in humans, and trachealis muscle separate submucosa from adventitia.

A unique feature of the trachea is the presence of the C-shaped hyaline cartilages that are stacked on one another to form a supporting structure.

Fibroelastic tissue and smooth muscle, the trachealis muscle, bridge the gap between the free ends of the C-shaped cartilages at the posterior border of the trachea, adjacent to the esophagus.

19. The adventitia of the trachea characteristic

The adventitia, the outer layer, lies peripheral to the cartilage rings and trachealis muscle. It consists of loose connective tissue mediastinum and contains the largest blood vessels and nerves that supply the tracheal wall, as well as the larger lymphatics that drain the wall. It binds the trachea to adjacent structures in the neck.

20. Bronchi classification

The trachea divides into two branches forming the primary or extrapulmonary bronchi (right and left bronchi). On entering the lungs the bronchi become the intrapulmonary bronchi, which branch immediately to give rise to the lobar bronchi (secondary bronchi). The left and right lung is further divided into eight and ten bronchopulmonary segments.

Thus the lobar bronchi divide to give rise to segmental bronchi (tertiary bronchi); a segmental bronchus and the lung parenchyma that it supplies constitute a bronchopulmonary segment.

21. Bronchi. Structure of the wall.

The bronchi initially have the same general histologic structure as the trachea. At the point where the bronchi enter the lungs to become intrapulmonary bronchi, the structure of the bronchial wall changes. The cartilage rings are replaced by cartilage plates of irregular shape. Bronchi can be identified by their cartilage plates and a circular layer of smooth muscle. The second change observed in the wall of the intrapulmonary bronchus is the addition of smooth muscle to form a complete circumferential layer.

The wall of the bronchus consists of five layers.

Mucosa is composed of a pseudostratified epithelium having the same cellular composition as the trachea. The lamina propria is similar to that of the trachea but is reduced in amount in proportion to the diameter of the bronchi.

Muscularis is a continuous layer of smooth muscle in the larger bronchi. It may appear discontinuous in smaller bronchi. Contraction of the muscle maintains the appropriate diameter of the airway.

Submucosa remains as a relatively loose connective tissue. Glands are present as well as adipose tissue in the larger bronchi.

Cartilage layer consists of discontinuous cartilage plates that become reduced in size as the bronchial diameter diminishes.

Adventitia is dense connective tissue that is continuous with that of adjacent structures.

22. Bronchiolar structure

Bronchioles are air-conducting ducts. The larger bronchioles represent branches of the segmental bronchi. These ducts branch repeatedly, giving rise to the smaller **terminal bronchioles** that also branch. They finally give rise to the **respiratory bronchioles**. Cartilage and glands are not present in bronchioles.

The larger diameter bronchioles initially have a ciliated, pseudostratified columnar epithelium that gradually transforms to a simple ciliated columnar epithelium as the duct narrows. A relatively thick layer of smooth muscle is present in the wall of all bronchioles. Small bronchioles have a simple cuboidal epithelium.

The smallest conducting bronchioles, the **terminal bronchioles**, are lined with a simple cuboidal epithelium in which **Clara cells** are found among the ciliated cells.

A small amount of connective tissue underlies the epithelium, and a circumferential layer of smooth muscle underlies the connective tissue in the conducting portions.

23. Clara cells structure and function.

Clara cells are nonciliated protein-secreting cells that have a rounded or dome-shaped apical surface projection. They have a well-developed basal rER, a Golgi apparatus, secretory granules that stain for protein, and numerous cisternae of sER in the apical cytoplasm. Clara cells secrete a **surface-active agent**, a lipoprotein that prevents luminal adhesion should the wall of the airway collapse on itself, particularly during expiration.

24. Respiratory bronchioles characteristic.

Respiratory bronchioles constitute a transitional zone in the respiratory system concerned with both air conduction and gas exchange between air and blood. They have a narrow diameter and are lined by a cuboidal epithelium. Scattered, thin-walled outpocketings, alveoli, extend from the lumen of the respiratory bronchioles. Respiratory bronchioles are the first part of the bronchial tree that allows gas exchange to occur.

25. Give the definition of pulmonary acinus.

Pulmonary acinus is structural part of the airway consisting of respiratory bronchioles and all of it branches (alveolar sacs, alveolar ducts and alveoli).

26. Alveoli, alveolar ducts and sacs structure.

Alveoli are the terminal air spaces of the respiratory system and are the actual site of gas exchange between the air and the blood. They are separated from each other by **interalveolar septa** that may contain one or more **alveolar pores** (pores of Kohn). These pores permit equalization of pressure between alveoli.

At some point, each alveolus is confluent with a respiratory bronchiole, by means of an alveolar duct, and an alveolar sac.

Alveolar ducts are elongate airways that have almost no walls, only alveoli, as their peripheral boundary with rings of smooth muscle in the knob-like interalveolar septa.

Alveolar sacs are spaces surrounded by clusters of alveoli. The surrounding alveoli open into these spaces. Alveoli are surrounded and separated from one another by a thin connective tissue layer that contains numerous blood capillaries. The tissue between adjacent alveolar air spaces is called the **alveolar septum.**

27. Peculiarities of the type I alveolar cells, type II alveolar cells and brush cells.

Alveolar epithelium is composed of type I and II alveolar cells and occasional brush cells.

Type I alveolar cells, also known as type I pneumocytes**,** comprise only 40% of the entire alveolar lining cells. They are extremely thin squamous cells; they line most (95%) of the surface of the alveoli. These cells are joined to one another and to the other cells of the alveolar epithelium by occluding junctions. The junctions form an effective barrier between the air space and the components of the septal wall. Type I alveolar cells are not capable of cell division.

Type II alveolar cells, also called type II pneumocytes or septal cells, are secretory cells. These cuboidal cells are interspersed among the type I cells. Type II cells account for 60% of the alveolar lining cells, but because of their different shape they cover only about 5% of the alveolar air surface. Like Clara cells, type II cells tend to bulge into the air space. Their apical cytoplasm is filled with granules that are stacks of parallel membrane lamellae, the **lamellar bodies.** They are rich in a mixture of phospholipids, neutral lipids, and proteins that is secreted by exocytosis to form an alveolar lining, surface-active agent called **surfactant.** In addition to secretion of surfactant, type II alveolar cells are progenitor cells for type I alveolar cells.

Brush cells are also present in the alveolar wall, but they are few in number. They may serve as receptors that monitor air quality in the lung.

28. Pulmonary surfactant structure and function.

Pulmonary surfactant consists of **phospholipids** and at least four **proteins**, and lipids account for more than 90% of the surfactant by mass. It forms **tubular myelin** when it is first released from lamellar bodies; it then spreads to produce a **monomolecular film** over the alveolar surface, forming a **lower aqueous phase** and a **superficial lipid phase.**

Function. Pulmonary surfactant **reduces the surface tension** of the alveolar surface, permitting the alveoli to expand easily during inspiration and preventing alveolar collapse during expiration. It also modulates immune responses to viruses, bacteria, and fungi.

29. The air–blood barrier two types structure and function.

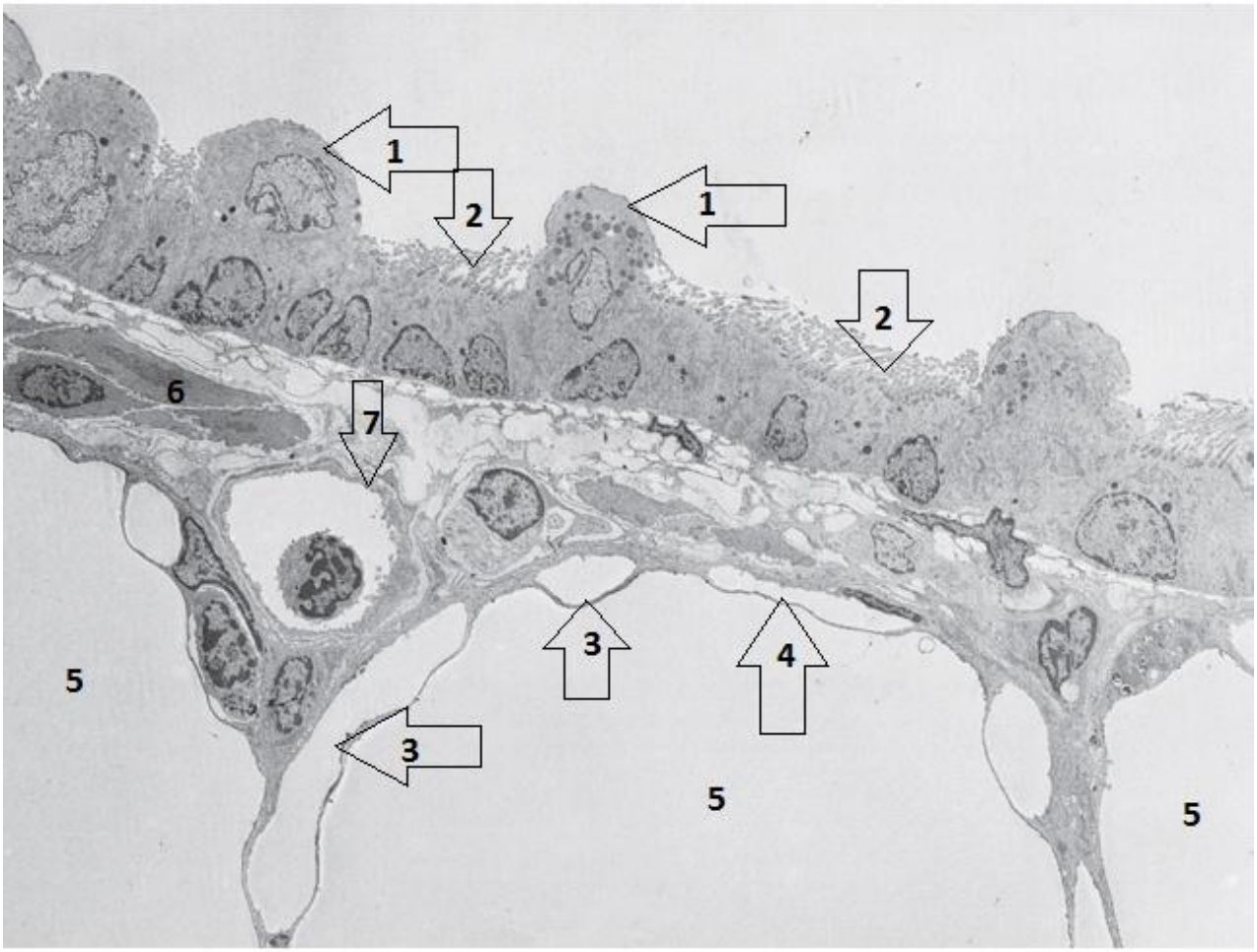
The alveolar septum is the site of the air–blood barrier. The air–blood barrier refers to the cells and cell products across which gases must diffuse between the alveolar and capillary compartments. The thinnest regions of the barrier are 0.2 μm or less in thickness and consist of the following layers: a thin layer of surfactant, a type I pneumocytes, fused basal laminae of type I pneumocytes and capillary endothelial cells and endothelium of the continuous capillaries within the interalveolar septum.

Thicker regions of the barrier measure as much as 0.5 μm across and have an **interstitial area** interposed between the two unfused basal laminae. Connective tissue cells and fibers that may be present between the two basal laminae widen the air–blood barrier.
It is thought that most gas exchange occurs across the thin portion of the barrier.
Function—Blood-gas barrier. The blood-gas barrier permits the **diffusion of gases** between the alveolar airspace and the blood. **Oxygen** passes from the alveolus into the capillary, and **carbon dioxide** passes from the capillary blood into the alveolus.

30. Alveolar macrophages (dust cells) location and function.

Alveolar macrophages (dust cells) found on surface of alveoli, within alveoli and in interstitial connective tissue. Alveolar macrophages are unusual in that they function both in the connective tissue of the septum and in the airspace of the alveolus. In air spaces, they scavenge the surface to remove inhaled particulate matter (e.g., dust and pollen), thus giving them one of their alternative names, dust cells. They phagocytize red blood cells that may enter the alveoli in heart failure. Some engorged macrophages pass up the bronchial tree in the mucus and are disposed of by swallowing or expectoration when they reach the pharynx. Other macrophages return to or remain in the septal connective tissue, where, filled with accumulated phagocytized material, they may remain for much of an individual's life.

PRACTICAL QUESTIONS



1. In the above electron micrograph showing part of a terminal or respiratory bronchiole lined by a simple cuboidal epithelium identify the structure labeled 1.

_____

2. Identify the structure labeled 2.

_____

3. Identify the structure labeled 3.

_____

4. Identify the structure labeled 4.

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5. Identify the structure labeled 5.

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6. Identify the structure labeled 6.

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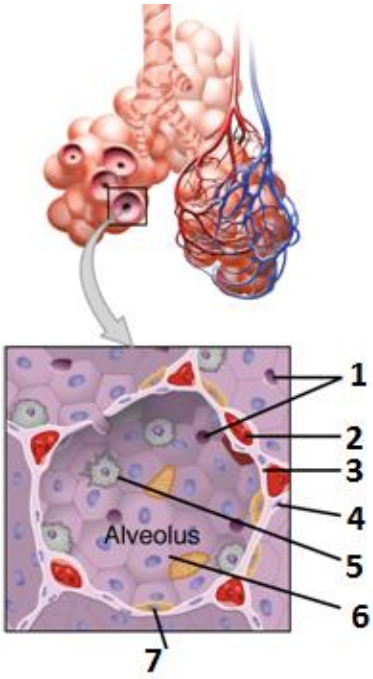
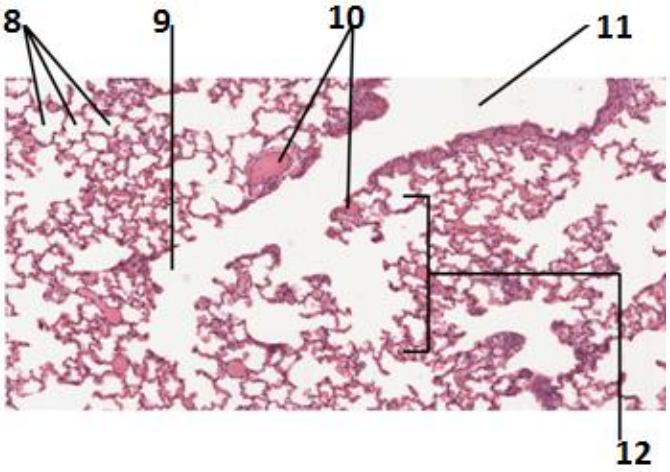
7. Identify the structure labeled 7.

_____





8. Identify the structure labeled 1 in the above diagram of the respiratory portion of the lung.

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9. Identify the structure labeled 2.

_____

10. Identify the structure labeled 3.

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11. Identify the structure labeled 4.

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12. Identify the structure labeled 5.

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13. Identify the structure labeled 6.

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14. Identify the structure labeled 7.

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15. Identify the structure labeled 8

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16. Identify the structure labeled 9

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17. Identify the structure labeled 10.

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18. Identify the structure labeled 11.

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19. Identify the structure labeled 12.

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20. What is the difference between bronchi and bronchioles?

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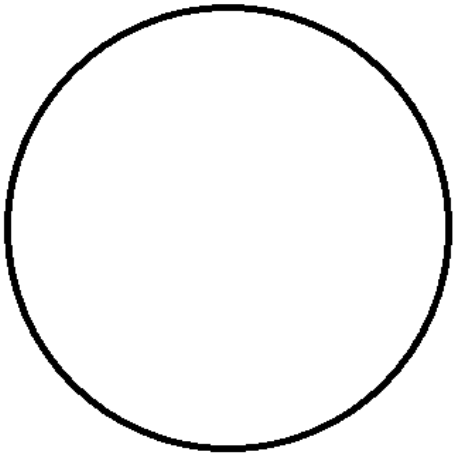
_____

_____

_____

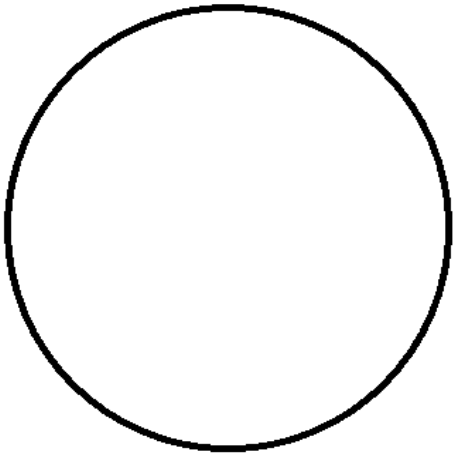


SLIDE 1

Trachea.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Pseudostratified ciliated columnar epithelium
    a) Cilia
    b) Goblet cell
2. Lamina propria of the mucosa
3. Submucosa
4. Perichonrium
5. Cartilaginous layer
6. Blood vessel
7. adventitia



SLIDE 2
Lungs.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Medium sized bronchi wall
    a) Pseudostratified ciliated columnar epithelium
    b) Lamina propria of the mucosa
    c) Muscularis mucosa
    d) Submucosa
    e) Cartilage
    f) Adventitia
2. Small sized bronchi
    a) Pseudostratified ciliated columnar epithelium
    b) Lamina propria of the mucosa
    c) Muscularis mucosa
3. Terminal bronchiole
4. Respiratory bronchiole
5. Alveolar duct
6. Alveolar sac
7. Alveolus
8. Blood vessels

TESTS OF THE "KROK-1" DATABASE.

Cleaning of the mucous membrane of the respiratory tract from dust and microorganisms occurs due to the mucociliary transport – the movement of mucus by the epithelium surface. What cells provide the clearing mechanism?
A. Ciliated and goblet cells
B. Brush cells
C. Bronchiolar exocrinocytes
D. Endocrine and basal cells
E. Dendritic cells

The changes of the epithelium are observed at the patient after prolonged inflammation of the nasal cavity mucous membrane. What epithelium has been changed?
A * Simple pseudostratified
B Simple squamous
C Stratified squamous
D Stratified cuboidal
E Stratified columnar

The glands, cartilage islands and pseudostratified columnar ciliated epithelium were founded during the histological examination of the bronchus wall. What kind of bronchus was examinated?
A * Middle bronchus
B Large bronchus
C Primary bronchus
D Small bronchus
E Terminal bronchioles

Pathological process mainly localized in the bronchus was found during the autopsy of the 65-year-old dead man, who suffered from pulmonary disease. The glands, cartilage islands and pseudostratified columnar ciliated epithelium were clearly visible at the histological examination of the bronchus. What kind of bronchus was injured?
A * Middle bronchus
B Large bronchus
C Primary bronchus
D Small bronchus
E Terminal bronchioles

The mucous membrane that covers the upper part of the upper nasal turbinate was damaged as a result of the nasal trauma of a 30-year-old man. What consequence it will result to?
A * Disorders of odorant perception
B Disorders of air humidification
C Disorders of goblet cells secretory activity
D Disorders of air warming
E Disorders of air warming and humidification

A patient was admitted to the hospital with an asphyxia attack provoked by a spasm of smooth muscles of the respiratory tracts. This attack was mainly caused by alterations in the following parts of the airways:
A *Small bronchi
B Median bronchi
C Large bronchi
D Terminal bronchioles
E Respiratory part

Real diphtheritic croup is accompanied with deposition of fibrous membranes on the true vocal folds which are tightly connected with epithelium. What type of epithelia covers mucosa of these cords?
A. *Stratified squamous nonkeratinized
B. Stratified squamous keratinized
C. Pseudostratified ciliary
D. Simple squamous
E. Simple cuboidal

The child breathed a button, which was removed from the right main bronchus by the bronchoscope. What epithelium of bronchus was probably damaged by the foreign objects?
A * Pseudostratified ciliated
B Stratified squamous nonkeratinized
C Simple cuboidal
D Transitional
E Simple squamous

The ciliary and goblet cells, which form the mucociliary complex, are located in epithelium which covers respiratory airways. What is the function of this complex?
A * Clearing of the air from the dust particles
B Secretion of the hormones
C Warming of the air
D Humidification of the air
E Respiration

There is an increased quantity of slime in respiratory passages of a chemical production worker after breathing with poisonous steams. What of respiratory tract epithelial cells participate in mucosa moistening?
A *Goblet cells
B Fibroblasts
C Endocrine cells
D Langerhans cells
E Intercalated cells

A pathological process in bronchi resulted in epithelium desquamation. What cells will provide regeneration of bronchial epithelium?
A *Basal
B Intercalary
C Ciliate
D Endocrinal
E Goblet

A 35-year-old patient applied to a doctor with complaints about having intense rhinitis and loss of sense of smell for a week. Objectively: nasal cavity contains a lot of mucus that covers mucous membrane and blocks olfactory receptors. In what part of nasal cavity are these receptors situated?
A *Superior nasal turbinate
B Median nasal turbinate
C Inferior nasal turbinate
D Common nasal meatus
E Vestibule of nose

The patient consulted a doctor with complaints of nasal cavity dryness. The dysfunction of the nasal cavity mucous glands was founded during the investigation. What layer of the nasal cavity mucous membrane contains these glands?
A * Lamina propria of mucosa
B Epithelial lamina of mucosa
C Lamina muscularis of mucosa
D Submucosa layer
E Fibrous cartilage lamina

The organ is represented in the histological slide. Its wall consists of mucosa, submucosa, fibro-cartilage and adventitia tunics. It is covered with pseudostratified ciliated epithelium. There are glands with mucous-protein secretion in the submucosa layer. Hyaline cartilage forms large plates. What organ has the same morphological characteristics?
A * Large bronchus
B Esophagus
C Trachea
D Larynx
E Small bronchus

The malignant epithelial tumor of middle bronchus was diagnosed at 66-year-old patient. What kind of epithelium was the source of this tumor?
A * Pseudostratified ciliated
B Stratified squamous nonkeratinized
C Stratified squamous keratinized
D Transitional
E Simple cuboidal

The malignant epithelial tumor of trachea was diagnosed at the patient 56 years old. What kind of epithelium was the source of this tumor?
A * Pseudostratified ciliated
B Stratified squamous nonkeratinized
C Stratified squamous keratinized
D Transitional
E Simple cuboidal

The wall of the trachea was damaged during intubation. What kind of epithelium was damaged?
A * Pseudostratified ciliated
B Stratified squamous nonkeratinized
C Stratified squamous keratinized
D Transitional
E Simple cuboidal

The terminal bronchioles are revealed at the histological examination of the lung. What kind of epithelium covers these bronchioles?
A * Simple cuboidal ciliated
B Stratified squamous nonkeratinized
C Pseudostratified ciliated
D Simple cuboidal
E Transitional

A tubular organ was revealed on the histological preparation of the respiratory system. It is covered with a low epithelium, has well developed muscular layer. The glands and cartilage are absent. Name this organ.
A * Small bronchus
B Trachea
C Larynx
D Main bronchus
E Middle bronchus

A tubular organ was revealed on the histological preparation of the respiratory system. The wall of it consists of simple cuboidal ciliated epithelium, muscle lamina is composed by smooth muscle cells, and mucosa folds are absent. What is the organ?
A *Terminal bronchus
B Small bronchus
C Middle bronchus
D Large bronchus
E Main bronchus

The desquamation of epithelium occurs as result of the pathological process in bronchus. What cell will make the bronchial epithelium regeneration?
A * Basal
B Mucus
C Ciliary
D Endocrine
E Goblet

The death of the bronchus ciliated epithelial cells developed at the chemical industry worker after inhaling of the caustic miasma. What cell will provide the bronchial epithelium regeneration?
A * Basal
B Mucus
C Ciliary
D Endocrine
E Goblet

Low cells of the oval or triangular shape are visible in a histological specimen of the trachea in the structure of pseudostratified ciliated epithelium. Its top does not reach the apical surface of the epithelium in some cells are visible mitotic figures. What is the role of these cells?
A *Source of regeneration
B Part of the mucociliary complex
C Secret mucus
D Secret surfactant
E Produce biologically active substances

The patient was admitted to the hospital with asthma attack that started at night. There are cyanosis and pallor of the patients' face. Name the divisions of the airways, which are associated with disruption of the normal functioning of lungs in this case.
A *Small sized bronchi
B Medium sized bronchi
C Large bronchi
D Terminal bronchioles
E Respiratory part

The patient with bronchial asthma has an attack of difficulty breathing. Where in the bronchial tree one can find a spasm of muscle cells which cause this phenomenon?
A *Small sized bronchi
B Terminal bronchioles
C Medium sized bronchi
D Large bronchi
E Respiratory bronchioles

Inflammation of the lungs is frequently observed in a 2-year-old child. What organelles of the epithelium of bronchi have impaired function?
A *Cilia
B Mitochondria
C Endoplasmic reticulum
D Microvilli
E Lysosomes

A contraction of the muscle wall of one part of the bronchial tree is observed with bronchial asthma under the influence of biologically active substances. Which bronchus responds to this allergic reaction?
A *Small bronchus
B Principal bronchus
C Large bronchus
D Terminal bronchioles
E Alveolar ducts

The loss of ciliated epithelial cells of bronchi has occurred in the worker of chemical manufacture after inhalation of poisonous vapor. What cells of the mucosa will be provide the regeneration of ciliated cells?
A *Basal cells
B Goblet cells
C Endocrine cells
D Langerhans cells
E Fibroblasts

What part of the airways has such characteristic: pseudostratified ciliated epithelium is gradually transformed into simple, cartilaginous islands and glands are absent, well-developed muscularis mucosa?
A *Small bronchi
B Medium sized bronchi
C Large bronchi
D Terminal bronchioles
E Trachea

Attacks that are characterized by difficult expiration – expiratory dyspnoea are observed in the patients with bronchial asthma under the influence of allergens. Specify the place of the action of allergens.
A *Small bronchi
B Terminal bronchioles
C Respiratory bronchioles
D Medium sized bronchi
E Large bronchi

Low cells of oval or triangular shape are detected in the histological preparation of the trachea, in the structure of the surface epithelium of the mucosa. Cells have high nuclear-cytoplasmic ratio, its apex does not reach the surface of the epithelium, and in some cells are detected mitotic figures. Name these cells.
A *Basal cells
B Ciliated cells
C Endocrine cells
D Goblet cells
E Clara cell

Pseudostratified columnar epithelium, composed of cells forming the mucociliary apparatus is determined in a histological specimen of the trachea. Identify these cells.
A *Ciliated and goblet cells
B Basal and goblet cells
C Basal and ciliated cells
D Goblet and Clara cells
E Clara cells and ciliated cells

Wall of the trachea was damaged during intubation. What layers of the trachea wall are damaged in this case?
A *Mucosa, submucosa, fibro-cartilaginous, adventitial
B Mucosa, submucosa, muscular, adventitia
C Mucosa, fibro-cartilaginous, muscular, adventitia
D Mucosa, fibro-cartilaginous, adventitia
E Mucosa, submucosa, fibro-cartilaginous, serous

It is known that work in a mine causes inhalation of large amounts of coal dust. Inhaled coal dust can be detected in the following pulmonary cells:
A. * Alveolar macrophages
B. Respiratory epithelial cells
C. Secretory epithelial cells
D. Capillary endothelial cells
E. Pericapillary cells

Alveolar space of acinus was invaded by bacteria that interacted with the surfactant. This led to the activation of the cells that localized in the alveolar walls and on the surface. Name these cells:
A. * Alveolar macrophages
B. Alveolocytes type I
C. Endothelial cells
D. Clara cells
E. Alveolocytes type II

The auscultation of a patient with dry pleurisy has revealed sound of pleural friction. What epithelium type can cause such signs?
A. * Simple cuboidal epithelium
B. *Simple squamous epithelium
C. Transitional epithelium
D. Simple columnar epithelium
E. Pseudostratified

The cells that take place at the blood-air barrier were found at the alveoli microphotography. What are these cells?
A * Respiratory epithelial cells of the alveoli
B Secretory epithelial cells of the alveoli
C Alveolar macrophages
D Clara's cell
E Ciliated epithelial cells

The respiratory distress syndrome develops at the premature newborn. Lack of what air-blood barrier component is related with this disease?
A * Surfactant
B Endothelium of capillaries
C Endothelial basement membrane
D Basement membrane of alveolocyte
E Alveolocyte

There are cells with a domed apical part and microvilli on it at the respiratory epithelium. The synthetic apparatus of this cell is well developed. Apical part of this cell contains the secretory granules. Name this cell.
A * Clara's cell
B Goblet cell
C. Endocrine cell
D Basal
E Cambial

The structures in the form of open vesicles are represented on the microphotography. The inner surface of it is covered by a simple epithelium that consists of respiratory and secretory cells. What structure is this?
A * Alveolus
B Bronchioles
C Acinus
D Alveolar ducts
E Terminal bronchus

Lung of premature infant is presented on electronic photomicrography of biopsy material. Collapse of the alveolar wall caused by the deficiency of surfactant was revealed. Dysfunction of what cells of the alveolar wall caused it?
A *Alveolocytes type II
B Alveolocytes type I
C Alveolar macrophages
D Secretory cells
E Fibroblasts

Electronic microphotography of pulmonary alveoli's wall presents a big cell. Its cytoplasm has a lot of mitochondria, developed Golgi apparatus, osmiophil lamellated corpuscles. What is the main function of this cell?
A *It produces surfactant
B It is a component of blood-air barrier
C It warms the air
D It purifies the air
E It absorbs microorganisms

It is known that an important component of the air-blood barrier is alveolar surfactant complex, which prevents the falling of the alveoli during the expiratory. What cell is synthesizing the phospholipids surfactant membranes formation?
A * Epitheliocyte type II
B Respiratory cells
C Ciliated epithelial cells
D Alveolar macrophages
E Capillary endothelium

The structure that consist of surfactant, alveolocyte type I, basement membrane and the fenestrated endothelium of the capillaries was represented on the microphotography. Which barrier between blood and tissue was represented?
A *Air-blood
B Blood brain
C Blood thymic
D Filtration apparatus
E Blood testis

The bacteria penetrated into the alveolar space and affected the surfactant. This activated the cells localized in the walls of the alveoli and on their surface. What are these cells?
A Alveolar macrophages
B Alveolocyte type I
C Endothelial
D Clara's cells
E Alveolocyte type II

One was unable to induce the first breath in the newborn in the maternity ward. Analyzing the causes of death it was established that the airways are free, but lungs are not expanded. What is the cause of non expansion of the lungs in this case?
A *Lack of surfactant
B Constriction of the bronchi
C Rupture of the bronchi
D Pleural thickening
E Increase in size of the alveoli

The injury of the cells responsible for respiratory function was found in the microscopic lung preparation of human suffering from pneumonia. What cells are these?
A * Alveolocyte type I
B Alveolocyte type II
C Macrophages
D Clara's Cells
E Lymphocytes

A benign epithelial tumor of the visceral pleura was diagnosed in a 48-year-old man. What epithelium is a source of this tumor development?
A * Simple squamous
B Stratified nonkeratinized
C Pseudostratified ciliated
D Transitional
E Stratified keratinized

Processes of the alveolar epithelium differentiation impaired in a 8-year-old child during intensive formation of lung tissue under the influence of diseases. What consequences it will lead to?
A *Violation of large alveolocytes proliferation and production surfactant
B Violated production of surfactant
C Violation of refractory epithelial cells proliferation
D Violation of proliferation of ciliary cells proliferation
E -

X-ray examination of the patient with anthracosis revealed areas of darkening and in the sputum – the presence of dust particles. What cells of the alveoli capture dust particles?
A *Alveolar macrophages
B Respiratory epithelial cells
C Ciliated cells
D Brush cells
E -

Preterm infants often have pneumonia because the second type (secretory) alveolocytes do not perform their function. What is the role of the secretory alveolocytes?
A *Synthesis of surfactant membranes
B Phagocytosis
C Synthesis of enzymes that break down the surfactant
D Synthesis of hormones
E Respiratory function

Name cells that participate in the formation of the surfactant alveolar complex.
A *Second type alveolocytes
B First type alveolocytes
C Epithelial cells of the respiratory bronchioles
D Clara cells
E Ciliated cells

Areas of collapsed lung tissue as a result of insufficient surfactant system are possible during inflammatory lung diseases. Name the areas where surfactant covers the inner surface of the respiratory tract?
A *Alveolus
B Terminal bronchiole
C Lobular bronchus
D Segmental bronchus
E Lobar bronchus

It is known that preterm infants, who were born earlier than 34 weeks of development, die more often with symptoms of respiratory distress than babies born after 36 weeks of development. How can we explain this fact?
A *Insufficient amount of surfactant
B Formation of insufficient number of acini
C Impaired function of macrophages
D Hypoplasia of the vascular system of the lungs
E Violation of innervation

URINARY SYSTEM

Checking your primary level of the knowledge:

1. **Compounds and functions of the urinary system.**
2. **General structure of the kidney.**
3. **Cortex of the kidney structure.**
4. **Medulla of the kidney structure**
5. **Kidney lobes and lobules characteristic**
6. **Nephron general structure.**
7. **Tubes of nephron characteristic.**
8. **Types of nephrons**
9. **Renal (Malpighian) corpuscle**
10. **The filtration apparatus structure and function**
11. **Mesangium location and functions.**
12. **The proximal convoluted tubule structure and function**
13. **Proximal straight segment structure and functions**
14. **Henle loop structure and functions**
15. **The straight distal tubule structure and functions**
16. **The distal convoluted tubule structure and functions**
17. **Collecting tubules and collecting ducts structure and function**
18. **Three phases of urine production - description.**
19. **Juxtaglomerular apparatus structure**
20. **Juxtaglomerular apparatus functions**
21. **Interstitial tissue characteristic**
22. **Blood supply to the kidney**
23. **Excretory passages peculiarities.**
24. **Ureters structure**
25. **Urinary bladder structure**
26. **Urethra structure**

Standard answers for theoretical questions

1. Compounds and functions of the urinary system.

The urinary system is composed of the paired **kidneys** and **ureters** and the **bladder** and **urethra.** The urinary system produces and excretes **urine,** thereby clearing the blood of waste products. The kidneys also regulate the electrolyte levels in the extracellular fluid and synthesize renin and erythropoietin. The kidneys take part in hydroxylation of vitamin D, a steroid prohormone, to produce its active form.

2. General structure of the kidney.

The kidneys are highly vascular, large, reddish, bean-shaped organs enveloped by a thin **capsule** of connective tissue. Each kidney is divided into an outer reddish brown-colored **cortex** and an inner much lighter-colored **medulla**. Approximately 90-95% of the blood passing through the kidney is in the cortex; 5-10% is in the medulla.

3. Cortex of the kidney structure.

It has renal corpuscles with their tubules, extensive vascular supply and medullary rays. Each medullary ray contains straight collecting tubules and straight tubule components of the nephrons. Approximately 400 to 500 medullary rays project into the cortex from the medulla. The regions between medullary rays contain the renal corpuscles, the convoluted tubules of the nephrons, and the collecting tubules. These areas are referred to as **cortical labyrinths**.

4. Medulla of the kidney structure

It has straight tubules, collecting ducts, and a special capillary network (vasa recta).

The tubules in the medulla form a number of conical structures called **pyramids.**

Usually 8— 12 pyramids may occur in the human kidney. The bases of the pyramids face the cortex and the apices face the renal sinus. The caps of cortical tissue that lie over the pyramids extend around the lateral portion of the pyramids forming the **renal columns of Bertin.** The apical portion of each pyramid, which is known as the **papilla**, projects into a **minor calyx**, a cup-shaped structure that represents an extension of the renal pelvis. The tip of the papilla, also known as the **area cribrosa**, is perforated by the openings of the collecting ducts. The minor calyces are branches of the two or three **major calyces** that in turn are major divisions of the renal pelvis.

5. Kidney lobes and lobules characteristic

Each medullary pyramid and the associated cortical tissue at its base and sides (one half of each adjacent renal column) constitute a **lobe of the kidney**. Each human kidney contains 8 to 18 lobes. The lobes of the kidney are further subdivided into **lobules** consisting of a central medullary ray and surrounding cortical material. A lobule consists of a collecting duct and all the nephrons that it drains.

6. Nephron general structure.

The nephron is the basic functional and structural unit of the kidney. Each human kidney contains approximately 2 million nephrons. They are responsible for the production of urine and correspond to the secretory part of other glands.

The renal corpuscle represents the beginning of the nephron. It consists of the **glomerulus**, a tuft of capillaries, surrounded by a double-layered epithelial cup, the **renal or Bowman's capsule**. The glomerular capillaries are supplied by an **afferent arteriole** and are drained by an **efferent arteriole** that then branches, forming a new capillary network to supply the kidney tubules. This is then an arterial portal system.

Where the afferent and efferent arterioles penetrate and exit from the parietal layer of Bowman's capsule is called the **vascular pole.** Opposite this site is the **urinary pole** of the renal corpuscle, where the proximal convoluted tubule begins.

7. Tubes of nephron characteristic.

Continuing from Bowman's capsule, the remaining segments of the nephron, namely, the tubular parts are: **proximal thick segment**, consisting of the proximal convoluted tubule and the proximal straight tubule, **thin segment**, which constitutes the thin limb of the loop of Henle, **distal thick segment**, consisting of the distal straight segment and the distal convoluted tubule. The distal convoluted tubule connects to the **collecting tubule**. The nephron plus collecting tubule is called **uriniferous tubule**.

8. Types of nephrons

Cortical or subcapsular nephrons have their renal corpuscles located in the outer part of the cortex.
Juxtamedullary nephrons have their renal corpuscles in proximity to the base of a medullary pyramid.
Intermediate nephrons have their renal corpuscles in the midregion of the cortex.

9. Renal (Malpighian) corpuscle

The renal corpuscle consists of the glomerular capillary tuft and the surrounding visceral and parietal epithelial layers of **Bowman's capsule**. The **outer layer** of Bowman's capsule, called the **parietal layer**, is a simple squamous epithelium.

The **inner layer** of Bowman's capsule, called the **visceral layer**, constitute podocytes cells. The space between the visceral and parietal layers of Bowman's capsule is called the **urinary** or **Bowman's space**. The renal corpuscle contains group of cells called **mesangial cells**. The renal corpuscle contains the filtration apparatus of the kidney.

10. The filtration apparatus structure and function

The filtration apparatus consists of endothelium of the glomerular capillaries with numerous fenestrations, three layered basal lamina (**the glomerular basement membrane (GBM))** and visceral layer of Bowman's capsule. Endothelium of the glomerular capillaries possesses numerous fenestrations. These fenestrations are larger (70 to 90 nm in diameter), more numerous, and more irregular in outline than fenestrations in other capillaries. The **basal lamina** is between the podocytes and the glomerular endothelial cells. Podocytes constitute the visceral layer of Bowman's capsule. They extend processes around the glomerular capillaries. Each process, in turn, has numerous secondary processes called **pedicels** or **foot processes.** The elongated spaces between the interdigitating foot processes, called **filtration slits**. The filtration slit membrane is thin membrane, spans the slits. The GBM restricts the movement of particles, usually proteins such as, albumin or hemoglobin.

11. Mesangium location and functions.

The renal corpuscle contains an additional group of cells called **mesangial cells**. These cells and their extracellular matrix constitute the **mesangium**. Some mesangial cells are located outside of the corpuscles along the vascular pole where they are also designated as **lacis** cells and form part of what is called the **juxtaglomerular apparatus**.

Mesangial cells are **phagocytic**; they can remove trapped residues and aggregated proteins from the GBM. Mesangial cells and their matrix provide structural support for the podocytes where the epithelial basement membrane is absent or incomplete.

Mesangial cells synthesize and secrete platelet-derived growth factor, which play a central role in response to glomerular injury. The mesangial cells may function in regulating glomerular distension in response to increased blood pressure.

12. The proximal convoluted tubule structure and function

The proximal convoluted tubule receives the primary filtrate from the urinary space of Bowman's capsule. The proximal convoluted tubule is lined by a single layer of **irregularly shaped** (cuboidal to columnar) epithelial cells that have microvilli forming a prominent **brush border.** The microvilli of proximal convoluted tubule cells are covered with a well-developed glycocalyx, which function is glucose reabsorption. These cells exhibit the following structures: apical canaliculi, vesicles, and vacuoles, which function in protein absorption, prominent interdigitations along their lateral borders, which interlock adjacent cells with one another and **basal striations**, consisting of numerous mitochondria compartmentalized in the basal region by extensive infoldings of the basal plasma membrane, which supply energy for the **active transport of** Na^+ out of the tubule.

13. **Proximal straight segment structure and functions**

It is lined by a simple **cuboidal** epithelium that has a prominent **brush border** and is similar to that lining the proximal convoluted tubule. Its function is to resorb, exchange, and secrete in a manner similar to that of the proximal convoluted tubule.

14. **Henle loop structure and functions**

The limb of the Henle loop is composed of a descending segment, a loop, and an ascending segment, all of which are lined by simple **squamous** epithelial cells possessing a few short microvilli.

The **thin descending limb** of the loop of Henle is highly permeable to water. Because the interstitial fluid in the medulla is hyperosmotic, water diffuses out of this nephron segment. The **thin ascending limb** of the loop of Henle allows passive diffusion of NaCl into the interstitium. Further, the thin ascending limb is largely impermeable to water, so that at this site, as the salt concentration increases in the interstitium, the interstitium becomes hyper osmotic and the fluid in the lumen of the nephron becomes hyposmotic.

15. The straight distal tubule structure and functions

It is lined by **cuboidal** epithelial cells that possess only a few microvilli, an apical nucleus, and mitochondria compartmentalized within extensive basal plasma membrane infoldings. It transports ions from the tubular lumen to the interstitium. The ascending thick limb returns to the renal corpuscle of origin, where it is in close association with the afferent and efferent glomerular arterioles. In this region, the wall of the tubule is modified, forming the **macula densa,** which is part of the juxtaglomerular (JG) apparatus.

16. The distal convoluted tubule structure and functions

The distal convoluted tubule is similar histologically to the straight distal tubule. It is much shorter, has a wider lumen than the proximal convoluted tubule, and **lacks a brush border.** The distal convoluted tubule **resorbs** Na^+ from the filtrate and actively transports it into the renal interstitium; this process is stimulated by **aldosterone. Antidiuretic hormone** can act on the terminal portion of the distal convoluted tubule to increase the permeability of the tubule to water, thereby producing more concentrated urine.

17. Collecting tubules and collecting ducts structure and function

Both the collecting tubules and ducts are composed of a simple epithelium. The arched and cortical collecting tubules have flattened cells, somewhat squamous to cuboidal in shape. The medullary collecting ducts have cuboidal cells, with a transition to columnar cells as the ducts increase in size.

Cytologically, two distinct types of cells are present in the collecting system:

Light cells (principal cells) have basal infoldings, true infoldings rather than processes that implicate with those of adjacent cells. They possess a single cilium and have relatively few short microvilli. These cells possess an abundance of antidiuretic hormone – regulated water channels, which are responsible for water permeability of the collecting ducts.

Dark cells (intercalated cells) occur in considerably smaller numbers. They have many mitochondria. Numerous vesicles are present in the apical cytoplasm. The intercalated cells are involved in the secretion of H^+ or bicarbonate.

The collecting tubules are responsible for the final concentration of the urine.

18. Three phases of urine production - description.

First phase of urine production is called **filtration**. Bowman's capsule is the initial portion of the nephron where blood flowing through the glomerular capillaries undergoes a filtration process to produce the initial urine filtrate. Filtration apparatus restricts the movement of albumin and hemoglobin.

Second phase of urine production is called **reabsorption.** This phase takes place in the tubular portion of the nephron. Amount of urine is decreasing from 180 to 1-2 L per day.

Tubular reabsorption is the process of reclaiming water and other substances from the tubular fluid (glomerular filtrate which passes from the Bowman's capsule to the renal tubule) and returning them to the blood. The proximal tubule reabsorbs amino acids, sugars, and proteins. Normally all glucose in the tubular fluid is reabsorbed and there is none in the urine. Proteins and large peptides are reabsorbed by endocytosis

in the proximal tubule. Reabsorption of fluid and other substances is driven by active transport of Na^+ into the lateral intercellular space and into the peritubular capillary network.

Final third phase of urine formation is called **secretory phase**. It occurs in the collecting tubules. **Tubular secretion** is the process in which renal tubule extracts chemicals from the capillary's blood and secretes them into the tubular fluid. This process serves two main purposes: **waste removal** (urea, uric acid, bile acids, ammonia, and creatinine are secreted into the renal tubule) and maintaining the **acid-base balance** (tubular secretion of hydrogen and bicarbonate irons serves to regulate the pH of the body's fluids). H^+ ions are secreted in the cortical and medullary collecting tubules. The collecting tubules are responsible for the final concentration of the urine.

19. Juxtaglomerular apparatus structure

The juxtaglomerular apparatus includes the macula densa, the juxtaglomerular cells, and the extraglomerular mesangial cells.

The juxtaglomerular cells are **modified smooth muscle cells** that exhibit some characteristics of protein secreting cells. They are located primarily in the wall of the **afferent arteriole,** but a few may also be present in the efferent arteriole. They synthesize **renin** and store it in secretory granules.

Macula densa cells are tall, narrow, closely packed epithelial cells of the **distal straight tubule.** They have elongated, closely packed nuclei that appear as a dense spot (macula densa) by light microscopy. They may **monitor the osmolarity and volume** of the fluid in the distal tubule and transmit this information to juxtaglomerular cells via the gap junctions between the two cell types.

Extraglomerular mesangial cells are also known as **lacis cells.** They lie between the afferent and efferent glomerular arterioles.

20. Juxtaglomerular apparatus functions

Renin catalyzes the hydrolysis of circulating angiotensinogen to produce **angiotensin I.** Angiotensin I is converted to the active **angiotensin II** by an enzyme in the lung. Angiotensin II stimulates the release of the hormone **aldosterone** from the zona glomerulosa of the adrenal gland. Aldosterone, in turn, increases distal tubular resorption of sodium and concomitant resorption of water, thereby raising blood volume and pressure. Angiotensin II is also a potent vasoconstrictor that has a regulatory role in the control of renal and systemic vascular resistance. Renin secretion stimulates by decrease in NaCl (sodium chloride) concentration.

The cells of the macula densa monitor the NaCl concentration in the afferent arteriole and regulate the release of renin by the juxtaglomerular cells. The cells of the macula densa monitor the Na concentration in the tubular fluid and regulate both the glomerular filtration rate and the release of renin from the juxtaglomerular cells.

The specific function of extraglomerular mesangial cells has been associated with the secretion of erythropoietin. The juxtaglomerular apparatus functions as a sensor of blood volume and tubular fluid composition.

21. Interstitial tissue characteristic

The connective tissue of the kidney parenchyma, called **interstitial tissue**, surrounds the nephrons, ducts, and blood and lymphatic vessels. In the cortex, it consists primarily of two types of interstitial cells: **fibroblasts** and occasional **macrophages**. These cells synthesize and secrete the collagen and glycosaminoglycans of the extracellular matrix of the interstitium.

In the medulla, the principal interstitial **cells resemble myofibroblasts**. They are oriented to the long axes of the tubular structures and may have a role in compressing these structures. The cells contain prominent bundles of actin filaments, abundant rough endoplasmic reticulum (rER), a well developed Golgi complex, and lysosomes. Prominent lipid droplets in the cytoplasm appear to increase and decrease in relation to the diuretic state. These cells manufacture **medullipin I,** a vasodepressor hormone that is converted to **medullipin II** in the liver. Medullipin II is a vasodilator that acts to reduce blood pressure. Prostaglandins and prostacyclin that reduces blood pressure are synthesized in the interstitium.

22. Blood supply to the kidney

Branches of the renal artery enter each kidney at the hilum and give rise to interlobar arteries. **Interlobar arteries** travel between the renal pyramids and divide into several **arcuate arteries,** which run along the corticomedullary junction parallel to the kidney’s surface. **Interlobular arteries** are smaller vessels that arise from the arcuate arteries. They enter the cortical tissue and travel outward between adjacent medullary rays. They give rise to **afferent (glomerular) arterioles.** Afferent arterioles supply the glomerular capillaries. **Efferent arterioles** arise from the glomerular capillaries. They leave the glomerulus and give rise to second network of capillaries, the **peritubular capillaries**.

The arrangement of these capillaries differs according to whether they originate from cortical or juxtamedullary glomeruli.

Efferent arterioles from cortical glomeruli lead into a peritubular capillary network that surrounds the local uriniferous tubules.

Efferent arterioles from juxtamedullary glomeruli give rise to **vasa recta** involved in the countercurrent exchange system. These long, thin vessels (**arteriolae rectae**) follow a straight path into the medulla and renal papilla, where they form capillaries and then loop back and increase in diameter toward the corticomedullary boundary (**venulae rectae**).They are closely associated with the Henle loops, to which they supply nutrients and oxygen.

Generally, venous flow in the kidney follows a reverse course to arterial flow, with the veins running in parallel with the corresponding arteries. Thus, **peritubular cortical capillaries** drain into **interlobular veins**, which in turn drain into arcuate veins, interlobar veins, and the renal vein.

The **medullary vascular network** drains into **arcuate veins** and so forth.

Peritubular capillaries near the kidney surface and **capillaries of the capsule** drain into **stellate veins** (so called for their pattern of distribution when viewed from the kidney surface), which drain into **interlobular veins**, and so forth.

23. Excretory passages peculiarities.

The urine that excreted at the tip of the papilla flows sequentially to the minor calyx of that papilla than to a major calyx and to the renal pelvis than through the ureter to the urinary bladder and finally from the urinary bladder to the urethra, where it is voided.

All excretory passages except the urethra have the same general structure, namely, a mucosa, a muscularis, and an adventitia (or in some regions serosa). **Transitional epithelium** lines all of the excretory passages. The epithelium begins in the minor calyces as two cell layers and increases to an apparent four to five layers in the ureter and as many as six or more layers in the empty bladder. Transitional epithelium is essentially impermeable to salts and water. The apical surface of the cell is very irregular, with deep clefts penetrating into the apical region. Modified areas of plasma membrane called plaques are seen on the luminal surface of the cells. In the minor and major calyces present a few inner longitudinal and outer circular smooth muscle fibers. In the renal pelvis, ureters and urethra there are usually two layers of smooth muscle beneath the lamina propria: longitudinal inner layer and circular outer layer.

The smooth muscle of the urinary passages is mixed with connective tissue, so that it forms parallel bundles rather than pure muscular sheets. Peristaltic contractions of the smooth muscle move the urine from the minor calyces through the ureter to the bladder.

The smooth muscle of the bladder wall is less regularly arranged than that of the tubular portions of the excretory passages, and thus, there is more random mixing of muscle and collagen bundles. Contraction of the smooth muscle of the bladder muscle compresses the whole viscus and forces the urine into the urethra.

24. Ureters structure

The ureters conduct urine from the renal pelvis to the bladder and follow an oblique path through the wall of the bladder. Contraction of the smooth muscle of the bladder wall also compresses the openings of the ureters into the bladder. This is important in protecting the kidney from the spread of infection from the bladder and urethra. The terminal portion of the ureters is a thick outer layer of longitudinal muscle.

25. **Urinary bladder structure**

It contains three openings, two for the ureters **(ureteric orifices)** and one for the urethra **(internal urethral orifice)**. The triangular region defined by these three openings, the **trigone**, is relatively smooth and constant in thickness, whereas the rest of the bladder wall is thick and folded when the bladder is empty and thin and smooth when the bladder is distended. The smooth muscle of the bladder wall forms the **detrusor muscle**. Toward the opening of the urethra, the muscle fibers form the involuntary **internal urethral sphincter**, a ringlike arrangement of muscle around the opening of the urethra. The smooth muscle is arranged in three layers: an inner longitudinal layer, a middle circular layer, and an outer longitudinal layer.

26. **Urethra structure**

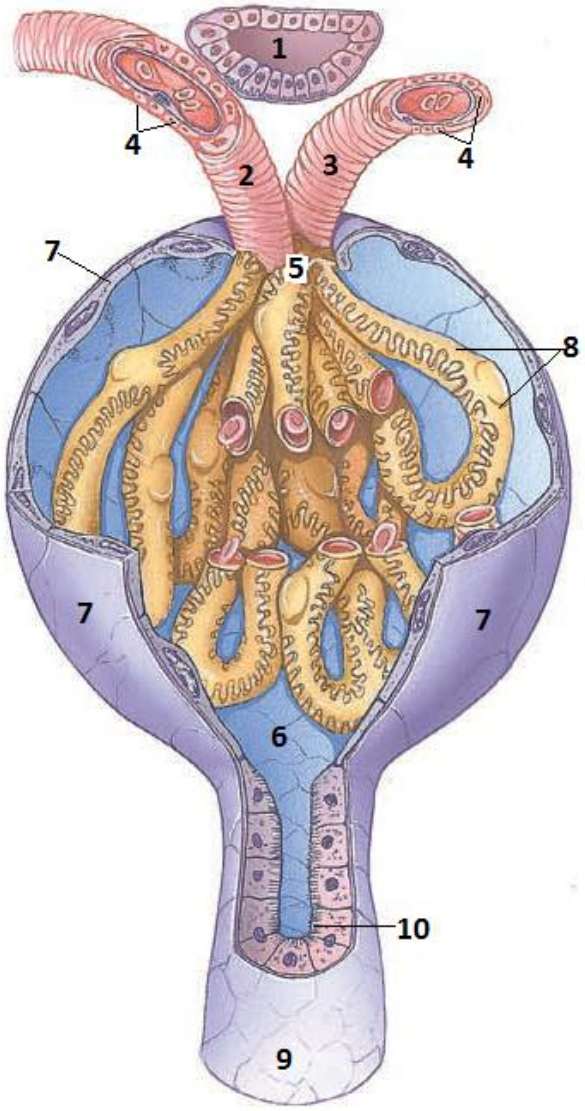
The urethra conveys urine from the bladder outside the body. In males, the urethra also carries semen during ejaculation. It is surrounded at some point by an **external sphincter** of **skeletal muscle,** which permits its voluntary closure. It contains mucus-secreting **glands of Littre** in the lamina propria.

In the male, the urethra is about 20 cm long and serves as the terminal duct of both the urinary and genital systems. It has three distinct segments:

Prostatic urethra extends for 3-4 cm from the neck of the bladder through the prostate gland and it is lined by **transitional epithelium**

Membranous urethra extends for about 1 cm from the apex of the prostate gland through the body wall and it is lined by **pseudostratified columnar epithelium.**
Penile (cavernous or spongy) urethra extends for about 15cm through the length of the penis to open the body surface at the glans penis. Proximal portion and middle portion of it is lined by stratified columnar epithelium and the distal end of the cavernous urethra is lined by **stratified squamous epithelium.**
The female urethra is much shorter (4–5 cm long) than the male urethra. It is lined primarily by **stratified squamous epithelium,** although patches of pseudostratified columnar epithelium are present.

PRACTICAL QUESTIONS



1. In this diagram of a renal corpuscle identify the structure labeled 1.

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2. Identify the structure labeled 2.

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3. Identify the structure labeled 3.

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4. Identify the structure labeled 4.

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5. Identify the structure labeled 5.

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6. Identify the structure labeled 6.

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7. Identify the structure labeled 7.

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8. Identify the structure labeled 8.

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9. Identify the structure labeled 9.

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10. Identify the structure labeled 10.

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11. What parts of the filtration apparatus do you know?

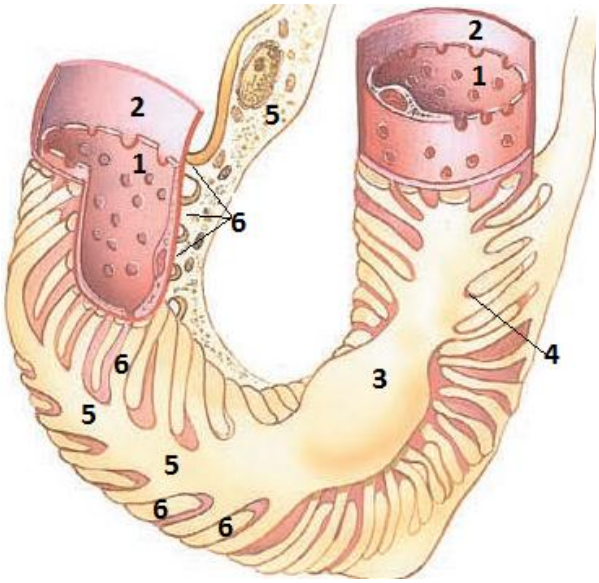
_____
_____
_____
_____
_____

12. What is the function of the filtration apparatus?

_____
_____
_____

13. What parts of the juxtaglomerular apparatus do you know?

_____
_____
_____



14. In this diagram of a podocyte identify the structure labeled 1.

_____

15. Identify the structure labeled 2.

_____

16. Identify the structure labeled 3.

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17. Identify the structure labeled 4.

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18. Identify the structure labeled 5.

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19. Identify the structure labeled 6.

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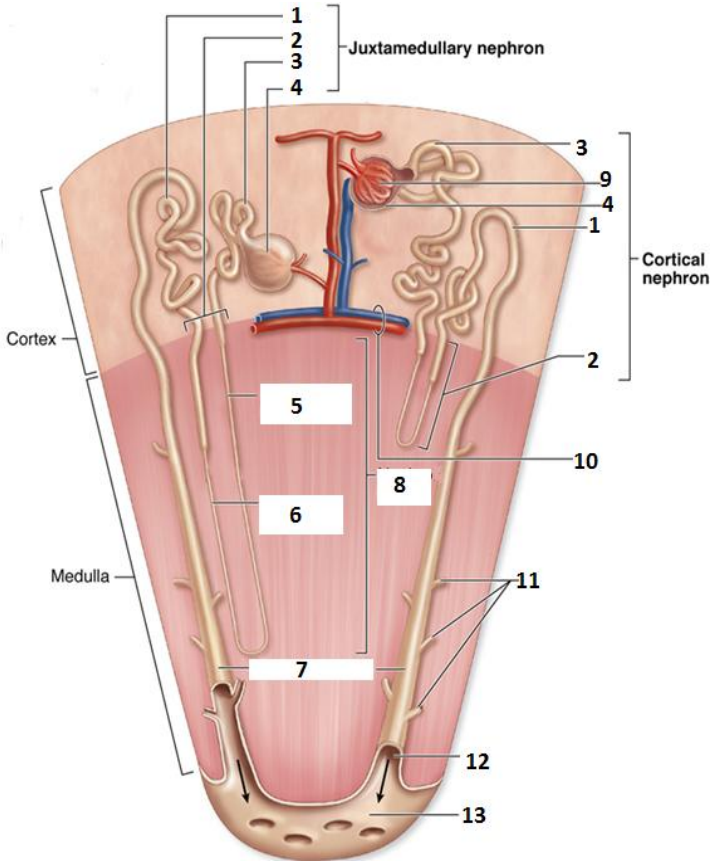
20. In this diagram below showing the relationship of two nephrons and their collecting tubules identify the structure labeled 1.

_____



_____

21. Identify the structure labeled 2.

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22. Identify the structure labeled 3.

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23. Identify the structure labeled 4.

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24. Identify the structure labeled 5.

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25. Identify the structure labeled 6.

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26. Identify the structure labeled 7.

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27. Identify the structure labeled 8.

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28. Identify the structure labeled 9.

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29. Identify the structure labeled 10.

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30. Identify the structure labeled 11.

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31. Identify the structure labeled 12.

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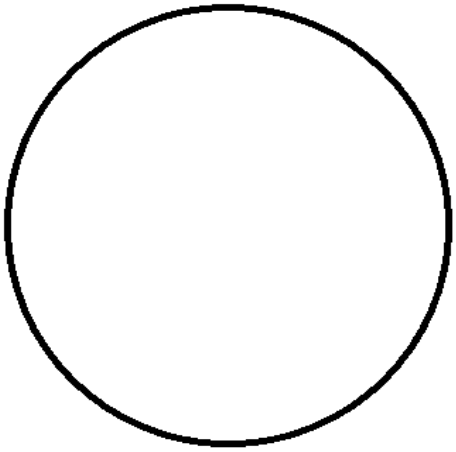
32. Identify the structure labeled 13.

_____

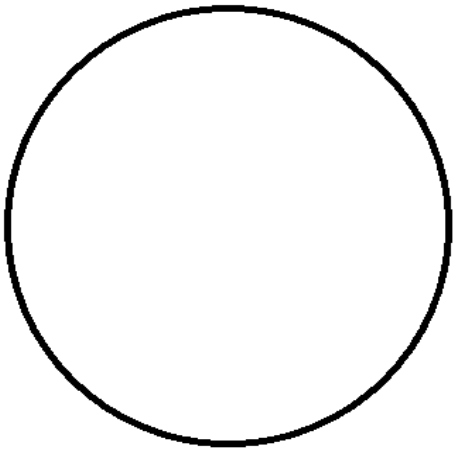


SLIDE 1

Kidney.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

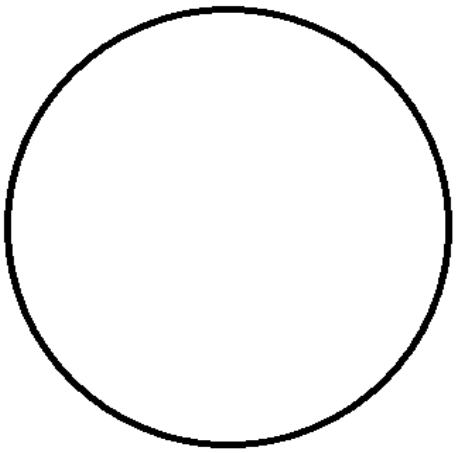
1. Connective tissue capsule
2. Cortex
    a) Renal corpuscle
    b) Proximal and distal part of the nephron
    c) Medullary rays
    d) Stellate venulae
3. Arcuate vessels
4. Medulla
    e) Straight tubules (descending and ascending portion of the loop of Henle, collecting tubules)



SLIDE 2
Ureter.
Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Transitional epithelium
2. Lamina propria of the mucosa
3. Submucosa
4. Muscularis
    a) Longitudinal layer
    b) Circular layer
5. Adventitia



SLIDE 3
Urinary bladder. Stained with hematoxylin and eosin.
SLIDE'S DESIGNATIONS

1. Transitional epithelium
2. Lamina propria of the mucosa
3. Submucosa
4. Muscularis
    a) Inner longitudinal layer
    b) Circular layer
    c) Outer longitudinal layer
5. Serosa

An important part of the renal filtration barrier is a three-layer basement membrane, which has a special mesh structure of its middle layer. Where is situated this basement membrane?
A * In the renal corpuscles
B In the capillaries of the peritubular capillary net
C In the proximal tubules
D In the thin tubules
E In the distal tubules

Electron microscopy of kidneys revealed tubules, which are lined by cuboidal epithelium. There are light and dark cells in the epithelium. Light cells have a few organelles. The cytoplasm forms folds. These cells provide the reabsorption of water from primary urine into the blood. Dark cells in structure and function resemble parietal cells of the stomach. What tubules are presented on the electronogram?
A *Collecting renal tubules
B Proximal tubules
C Distal tubules
D Ascending tubules loop of Henle
E Descending tubules loop of Henle

The blood cells and fibrinogen was detected in the urine of 35-year-old woman with kidney disease. It was probably associated with the renal filter function. What is the structural composition of this filter?
A * Endothelium of glomerular capillaries, three-layered basement membrane, podocytes
B Three-layer basement membrane
C Endothelium of capillaries, basement membrane
D Podocytes, basement membrane
E Endothelium, podocytes

A histological specimen of kidney shows a structure consisting of a glomerulus of fenestrated capillaries and a bilayer epithelial capsule. Specify this structure:
A *Renal corpuscle
B Proximal tubule
C Distal tubule
D Henle's loop
E Receiving tube

The leached erythrocytes were detected in the patient urine. What part of the nephron was damaged?
A * Renal corpuscle membrane
B Proximal tubule
C Loop of Henle
D Distal tubule
E Composite renal tube

Biopsy material of the kidney is examined by the method of electron microphotography. The fenestrated endothelium with basement membrane is revealed on the microphotography. There are dendritic epithelial cells from the outer side of the basement membrane. What formation of the kidney is represented on the microphotography?
A * Filtrating barrier
B Renal corpuscle
C Proximal part of nephron
D Distal part of nephron
E Loop of nephron

The presence of albumin (albuminuria) and glucose (glucosuria) in the secondary urine is observed in a patient with suspected glomerulonephritis for two weeks. What part of the kidney function is disordered?
A * Proximal tubules
B Distal tubules
C Thin tubule
D Collecting tubules
E Juxtaglomerular apparatus

The injury of the distal nephron part epithelium was made at the experimental model on the rats. What functional processes in the kidney will be weakened?
A * Reabsorption of water and electrolytes
B Reabsorption of glucose
C Reabsorption of sodium and glucose
D Reabsorption of protein
E Filtration

Residues of proteins and glucose are detected in the analysis of urine of the 27-year-old patient. What part of the nephron is affected?
A *Proximal tubule
B Ascending tubule loop of Henle
C Descending tubule loop of Henle
D Distal tubule
E Nephron

30 g of glucose was found in the patient urine in case of normal its amount in the blood. What structural and functional mechanism of kidney was damaged?
A * Process of reabsorption in the proximal part of the nephron
B Process of filtration
C Process of reabsorption in the distal part of the nephron
D Process of reabsorption in the thin tubules
E Process of reabsorption in the distal part as a result of ADH insufficiency

The structures covered by cuboidal epithelium with the brush border and deep plasmolemma folds in the basal part ware determined at the cortex of the kidney. A large mitochondria number is situated between the plasmolemma folds. What part of nephron is described?
A * Proximal tubule
B Straight distal tubule
C Tortuous distal tubule
D Loop of Henle
E Renal corpuscles

The damage of the first four branches of somits to the right happened in the process of embryogenesis. What organ will have the impaired development?
A *Development of pronephros
B Development of liver
C Development of pancreas
D Development of right adrenal gland
E Development of spleen

The podocytes can be damaged as result of kidney disease. What functional changes will develop as result of it?
A * Filtration of protein will increase
B Filtration of protein will decrease
C Secretion of renin will increase
D Secretion of renin will decrease
E Secretion of prostaglandins will increase

The large epithelial cell with large and small processes was represented in the electron microphotography of the kidney fragment. The large and small processes are attached to the basement membrane of capillaries. What cell is this?
A * Podocytes
B Juxtavascular cell
C Smooth myocyte
D Endotheliocyte
E Mesangial cell

The blood cells don't appear in the urine in normal condition. What nephron structure prevent their appearance in the urine?
A * Basement membrane of glomerular capillaries
B Juxtavascular cell
C Mesangial cell
D Outer layer of the glomerulus capsule epithelium
E Loop of Henle epithelium

The subacid urine reaction was revealed at the patient. What kidney cells provide such urine reaction?
A * Secretory cells of collecting tubules
B Juxtaglomerular cells of cortical nephrons
C Juxtavascular cells of cortical nephrons
D Macula densa cells
E Interstitial cells of stroma

The nephrons, which are situated on the border between the cortex and medulla and have the same diameter and extension afferent and efferent arterioles, were revealed on the kidney preparation. What function of kidney will be disordered in case of these nephrons injury?
A * Blood shunting at intensification of blood supply
B Synthesis of renin
C Synthesis of prostaglandins
D Synthesis of erythropoietin
E Sodium receptor activity

The cuboidal shaped cells, the apical surface of which contains brush border and basal surface has basal striations with mitochondria arranging between invaginations of cytolemma are determined in electron micrographs of one part of the nephron. Name the part of the nephron.
A *Proximal tubule
B Collecting renal tubules
C Distal tubule
D Thin tubule
E Glomerulus of the nephron

A threat of development of ascending infection of the urinary tract appeared in the patient after exogenous intoxication as a result of the loss of acid urine reaction. What cells of kidneys were damaged in this case?
A *Dark cells of collecting tubules
B Light cells of collecting tubules
C Epithelial cells of proximal tubules
D Squamous cells of loop of Henle
E Epithelial cells of distal tubules

The patient's analysis of urine shows a significant amount of protein. What part of the nephron has disordered processes of urine formation?
A *Proximal convoluted tubule
B Collecting tubules
C Distal convoluted tubules
D Thin tubule
E distal straight tubule

0,1 – 0,25 mm renal corpuscles surrounded by two leaflets, which limits wide, compared to the norm, slit cavity having a shape of a bowel were revealed in the preparation kidneys removed during surgery. Which structure would manifest these changes?
A *Capsule of the renal corpuscle
B Renal corpuscle
C Vascullar glomerulus
D Afferent arteriole
E Efferent arteriole

Constant hypercalcemia, hypercalciuria and hypophosphatemia were found in a 38-year-old patient with nephrolithiasis. The disease was complicated by bilateral aggravation of chronic pyelonephritis. On the background of progressive chronic renal failure the patient was died. Histological examination discovered lime deposits in the convoluted tubule of kidneys and in lungs. Determine ultrasrtuctures in which calcium is deposited.
A *Mitochondria
B Ribosomes
C Endoplasmic reticulum
D Golgi apparatus
E Nucleus

Fenestrated endothelium, three-layered basement membrane, on the outer surface of which located branched epithelial cells with filtration slits between the branches are determined in the kidney's biopsy material during electron microscopic study. Name this formation.
A *Filtration barrier
B Nephron
C Juxtaglomerular apparatus
D Mesangium
E Medullary rays

Histological specimen of a kidney demonstrates cells closely adjoined to the renal corpuscle in the distal convoluted tubule. Their basement membrane is extremely thin and has no folds. These cells sense the changes in sodium content of urine and influence renin secretion occurring in juxtaglomerular cells. Name these cells:
A. Macula densa cells
B. Juxtaglomerular cells
C. Mesangial cells
D. Podocytes
E. Glomerular capillary endothelial cells

A histological specimen of a kidney shows a part of the distal tubule going between the afferent and efferent arteriole. The cells constructing the tubule wall have dense nuclei; basal membrane is absent. Such structural formation is called:
A *Macula densa
B Juxtaglomerular cells
C Mesangial cells
D Juxtavascular cells
E -

The stable increase in blood pressure was made in the experiment by the constriction of the renal artery. The function of what kidney cells can results this effect?
A * Juxtaglomerular cells
B Podocytes
C Endothelial
D Interstitial cells
E Macula densa cells

The cells are tightly adjacent to the renal corpuscles were revealed at the histological preparation of kidney distal convoluted tubule. Their basement membrane is very thin and do not form the folds. These cells feel the changes of sodium content in the urine and affect the renin secretion by the juxtaglomerular cells. What are these cells?
A * Macula densa cells
B Juxtaglomerular cells
C Mesangial cells
D Podocytes
E Endothelium glomerular capillaries

The electronic microphotography of kidney fragment has exposed an afferent glomerular arteriole, which has giant cells under its endothelium, containing secretory granules. Name the type of these cells:
A *Juxtaglomerular
B Mesangial
C Smooth muscular
D Juxtavascular
E Interstitial

Examination of a 43 y.o. anephric patient revealed anemia symptoms. What is the cause of these symptoms?
A *Reduced synthesis of erythropoietin
B Enhanced destruction of erythrocytes
C Iron deficit
D Vitamin B 12 deficit
E Folic acid deficit

Considerable increase of systematic arterial pressure was observed a month after surgical constriction of rabbit's renal artery. What of the following regulation mechanisms caused the animals' pressure change?
A *Angiotensin-II
B Vasopressin
C Adrenaline
D Noradrenaline
E Serotonin

The cells with large secretory granules in the cytoplasm were found at the kidney electron microphotography in the wall of afferent and efferent arteries. Identify the structural formation of the kidney, which consists of these cells.
A * Juxtaglomerular apparatus
B Renal corpuscle
C Proximal part of nephron
D Distal part of nephron
E Loop of nephron

The low specific gravity of the secondary urine (1002) was found out in the sick person. What is the most distant part of nephron where concentration of secondary urine takes place?
A *In the collecting duct
B In the nephron's glomerulus
C In proximal tubule of nephron
D In ascending part of loop of Henle
E In distal tubule of nephron

A patient has a decreased vasopressin synthesis that causes polyuria and as a result of it evident organism dehydratation. What is the mechanism of polyuria development?
A *Reduced tubular reabsorption of water
B Reduced tubular reabsorption of Na ions
C Reduced tubular reabsorption of protein
D Reduced glucose reabsorption
E Acceleration of glomerular filtration

Anemia was developed at a 50-year-old patient with chronic nephritis. What is the reason of anemia development at this patient?
A * Reduced production of erythropoietin
B Absence of cancer
C Lack of vitamin B12
D Disorders of porphyrin synthesis
E Immunological injury of the cells - precursors of erythropoiesis

The patient with kidney disease has increased blood pressure. What structures of kidneys cause these symptoms?
A *Juxtaglomerular cells
B Cells of proximal tubules
C Cells of distal tubules
D Cells of the macula densa
E Cells of the loop of Henle

Very often high blood pressure is one of the symptoms of kidney damage. What cells responsible for the implementation of these symptoms?
A *Juxtaglomerular cells
B Juxtavascular cells
C Cells of the macula densa
D Interstitial cells
E Fibroblasts

Hypertension with elevated renin in the blood was revealed in a 40-year-old patient. What cells of kidneys produce this hormone?
A *Juxtaglomerular cells
B Cells of the macula densa
C Juxtavascular cells
D Mesangial cells
E Interstitial cells

MALE REPRODUCTIVE SYSTEM

Checking your primary level of the knowledge:

1. **Components and functions of male reproductive system.**
2. **General structure and functions of testis.**
3. **Interstitial cells of Leydig structure and function.**
4. **Structure of the seminiferous tubule and tunica propria.**
5. **Sertoli cells structure.**
6. **Sertoli cells functions.**
7. **Three phases of spermatogenesis.**
8. **Spermatogenic cells peculiarities.**
9. **Spermatocytes peculiarities.**
10. **Spermatids peculiarities.**
11. **Four phases of Spermiogenesis.**
12. **Intratesticular ducts –tubuli recti and rete testis peculiarities.**
13. **Excurrent duct system. Efferent ductules characteristic.**
14. **Excurrent duct system. Ductus epididymis structure and function.**
15. **Excurrent duct system. Ductus deferens structure and function.**
16. **Excurrent duct system. Ejaculatory duct structure and function.**
17. **Accessory sex glands. Seminal vesicles structure and function.**
18. **Accessory sex glands. Prostate gland structure and function.**
19. **Accessory sex glands. Bulbourethral glands structure and function.**
20. **Semen peculiarities.**
21. **Penis structure and function.**

Standard answers for theoretical questions

1. Components and functions of male reproductive system.

The male reproductive system consists of the **testes, genital ducts,** accessory genital glands (**seminal vesicles, prostate gland,** and **bulbourethral glands**), and the **penis.**

The male reproductive system produces **spermatozoa** (sperm), **testosterone,** and **seminal fluid.** Seminal fluid transports and nourishes the sperm as they pass through the excretory ducts. The penis delivers sperm to the exterior and also serves as the conduit for excretion of urine from the body.

2. General structure and functions of testis.

Testes develop in the abdominal cavity and later descend into the scrotum, where they are suspended at the ends of the **spermatic cords.** They are the sites of **spermatogenesis** and production of the male **sex hormones,** primarily **testosterone.**

Androgens, especially testosterone, are steroid hormones secreted by the interstitial cells in the testes. They influence embryonic development, sexual maturation, and reproductive function.

The **tunica vaginalis** is a **serous sac** derived from the peritoneum that partially covers the anterior and lateral surfaces of each testis.

Tunica albuginea is the thick, fibrous connective tissue capsule of the testis**.** It is lined by a highly vascular layer of loose connective tissue, the **tunica vasculosa.** It is thickened posteriorly to form the **mediastinum testis,** from which incomplete connective tissue septa arise to divide the organ into approximately 250 compartments (lobuli testis).

Each lobule contains 1-4 **convoluted seminiferous tubules**, which produce the sperm, and a connective tissue stroma in which the **interstitial** or **Leydig cells** are contained. Each tubule within the lobule forms a convoluted loop. The ends of the loop in the vicinity of the mediastinum are called the **tubuli recti** or straight tubule and are continuous with the **rete testis** anastomosing channel system within the mediastinum.

3. Interstitial cells of Leydig structure and function.

Interstitial cells of Leydig are round to polygonal acidophilic cells in the interstitial regions between seminiferous tubules. They possess a large central nucleus, numerous mitochondria with tubulovesicular cristae, a well-developed Golgi complex, and many lipid droplets. The lipid droplets contain cholesterol esters, precursors of testosterone. Like other steroid-secreting cells, Leydig cells have an elaborate smooth endoplasmic reticulum (sER), a feature that accounts for their eosinophilia. The enzymes necessary for the synthesis of testosterone from cholesterol are associated with the sER. Lipofuscin pigment is also frequently

present in these cells as well as distinctive, rod-shaped cytoplasmic crystals, the **crystals of Reinke.** They are richly supplied with capillaries and lymphatic vessels. Leydig cells differentiate and secrete **testosterone** during early fetal life. Secretion of testosterone is required during embryonic development, sexual maturation, and reproductive function. Secretion is stimulated by luteinizing hormone.

4. Structure of the seminiferous tubule and tunica propria

Each **seminiferous tubule** is approximately 50 cm long (range, 30 to 80 cm) and 150 to 250 μm in diameter. The seminiferous tubules consist of a seminiferous epithelium surrounded by a tunica propria. The **seminiferous epithelium** is a complex stratified epithelium composed of two basic populations of cells: **spermatogenic cells**, which regularly replicate and differentiate into mature sperm and **Sertoli cells**, also known as supporting or sustentacular cells.

The **tunica propria** also called the lamina propria, is a multilayered connective tissue.

It consists of three layers: basal layer, myoid layer and fibrous layer.

Basal layer (inner non cellular layer) consists of collagen fibers net, which is separated from seminiferous epithelium by basal lamina.

Myoid layer (inner cellular layer) includes three to five layers of **myoid** cells. Rhythmic contractions of the myoid cells create peristaltic waves that help move spermatozoa and testicular fluid through the seminiferous tubules to the excurrent duct system.

Fibrous layer contains two parts. The internal part of this layer, which is in proximity to the myoid layer, consists of basal membrane and collagen fibers net and the external part contains cells of the fibroblastic lineage.

Blood vessels and extensive lymphatic vasculature as well as Leydig cells are present external to the fibrous layer.

5. Sertoli cells structure

The **Sdertoli cells** are tall, columnar cells with complex apical and lateral processes that surround the adjacent spermatogenic cells and fill the spaces between them. They rest on the thick, multilayered basal lamina of the seminiferous epithelium.

Sertoli cells have a pale, oval nucleus that displays frequent invaginations and possess a large nucleolus. They have a well-developed smooth endoplasmic reticulum, some rough endoplasmic reticulum, an abundance of mitochondria and lysosomes, varying numbers of microtubules, lipid droplets, vesicles, glycogen granules, filaments and an extensive Golgi complex. Receptors for follicle-stimulating hormone (FSH) are present on their plasma membranes.

The Sertoli cells give structural organization to the tubules as they extend through the full thickness of the seminiferous epithelium. They form **zonulae occludentes** (tight junctions) with adjacent Sertoli cells near their bases, thus dividing the lumen of the seminiferous tubule into a **basal** and a **luminal compartment.** Spermatogonia and early primary spermatocytes are restricted to the basal compartment, i.e., between the Sertoli-Sertoli junctions and the basal lamina. More mature spermatocytes and spermatids are restricted to the luminal side of the Sertoli-Sertoli junctions.

6. Sertoli cells functions.

Sertoli cells support, protect, and nourish the spermatogenic cells. They phagocytose excess cytoplasm discarded by maturing spermatids. Sertoli cells phagocytized and break down any spermatogenic cells that fail to differentiate completely. They secrete a fructose-rich fluid into the lumen that nourishes and facilitates the transport of spermatozoa through the seminiferous tubules to the genital ducts. They synthesize **androgen-binding protein (ABP)** under the influence of FSH. **ABP** assists in maintaining the necessary concentration of testosterone in the seminiferous tubule so that spermatogenesis can progress. They secrete **inhibin,** a hormone that inhibits the synthesis and release of FSH by the anterior pituitary. They synthesize and release **antimüllerian hormone,** which determines maleness. Sertoli cells tight junctions are responsible for the **blood-testis barrier,** which protects developing sperm cells from autoimmune reactions. Most importantly, the barrier isolates the genetically and, therefore, antigenically different haploid germ cells (secondary spermatocytes, spermatids, and sperm) from the immune system of the adult male. Antigens produced by or specific to the sperm are prevented from reaching the systemic circulation.

7. Three phases of spermatogenesis.

Spermatogenesis is the entire process of spermatozoon formation. It is divided into three phases:

(1) Spermatocytogenesis—differentiation of spermatogonia into primary spermatocytes

(2) Meiosis—reduction division to reduce the diploid chromosomal complement of primary spermatocytes to form haploid spermatids

(3) Spermiogenesis—transformation of spermatids into spermatozoa

Spermatogenesis does **not** occur simultaneously or synchronously in all seminiferous tubules, but rather in wavelike sequences of maturation, referred to as **cycles of the seminiferous epithelium.** During spermatogenesis, daughter cells remain connected to each other via **intercellular bridges.** The resultant **syncytium** may be responsible for the **synchronous development** of germ cells along **any one** seminiferous tubule.

8. Spermatogenic cells peculiarities.

Spermatogonia are **diploid** germ cells adjacent to the basal lamina of the seminiferous epithelium. At puberty, testosterone influences them to enter the cell cycle. Pale type A spermatogonia possess a pale-staining nucleus, spherical mitochondria, a small Golgi complex, and abundant, free ribosomes. They are **mitotically active** (starting at puberty) and give rise either to more cells of the same type (to maintain the supply) or to type B spermatogonia. Dark type A spermatogonia represent mitotically **inactive** (reserve) cells (in the G0 phase of the cell cycle), with dark nuclei; they have the potential to resume mitosis and produce pale type A cells. Type B spermatogonia undergo mitosis and give rise to primary spermatocytes.

9. Spermatocytes peculiarities

Primary spermatocytes are large **diploid** cells with 4cDNA content (the normal chromosomal number (2*n*) and double the amount of DNA (4*d*). They undergo the **first meiotic division** (reductional division) to form secondary spermatocytes.

Secondary spermatocytes are **haploid** cells with 2cDNA (chromosome number (1n) represented by 22 autosomes and an X or a Y chromosome and diploid amount of DNA (2d)), that quickly undergo the **second meiotic division** (equatorial division), without an intervening S phase, to form spermatids.

10. Spermatids peculiarities

Spermatids are small **haploid** cells that results from the second meiotic division is haploid in DNA content **(1d)** and chromosome number **(1n)** represented by 22 autosomes and an X or Y chromosome. They are located near the lumen of the seminiferous tubule. Their nuclei often display regions of condensed chromatin. They possess a pair of centrioles, mitochondria, free ribosomes, sER, and a well developed Golgi complex.

11. Four phases of spermiogenesis

Spermiogenesis is a unique process of **cytodifferentiation** whereby **spermatids** shed much of their cytoplasm and **transform into spermatozoa,** which are released into the lumen of the seminiferous tubule. Spermiogenesis is divided into four phases.

The **Golgi phase** is characterized by the formation of an **acrosomal granule,** enclosed within an **acrosomal vesicle,** which becomes attached to the anterior end of the nuclear envelope of a spermatid. In this phase, centrioles migrate away from the nucleus to form the **flagellar axoneme** (the assembly of the nine peripheral microtubule doublets and two central microtubules) of the sperm tail.

The **cap phase** is characterized by expansion of the acrosomal vesicle over much of the nucleus, forming the **acrosomal cap.**

During **acrosomal phase** the **nucleus** becomes condensed, flattened, and located in the head region. The **spermatid** elongates; this process is aided by a temporary cylinder of microtubules called the **manchette.**

Centrioles migrate back toward the nucleus to assist in forming the **connecting piece** or neck region associated with the tail.

As the plasma membrane moves posteriorly to cover the growing **flagellum**, the manchette disappears, and the mitochondria form a tight, helically wrapped sheath around the coarse fibers in the neck region and its immediate posterior extension. This region is the **middle piece** of the tail of the sperm. Distal to the middle piece, a **fibrous sheath** consisting of two longitudinal columns and numerous connecting ribs surrounds the nine longitudinal fibers of the **principal piece** and extends nearly to the end of the flagellum. This short segment of the tail distal to the fibrous sheath is called the **end piece**.

The acrosomal phase, ends as the spermatid is oriented with its acrosome pointing toward the base of the seminiferous tubule.

Maturation phase is characterized by loss of excess cytoplasm and intercellular bridges connecting spermatids into a syncytium. The Sertoli cells phagocytose this excess cytoplasm, also termed the **residual body**. Maturation phase ends when the **nonmotile** spermatids are released (tail first)into the lumen of the seminiferous tubule. Spermatozoa remain immotile until they leave the epididymis. They become **capacitated** (capable of fertilizing) in the female reproductive system. Structure of mature sperm you can read in the embryology chapter.

12. Intratesticular ducts –tubuli recti and rete testis peculiarities.

At the end of each seminiferous tubule there is an abrupt transition to the **tubuli recti** or **straight tubules**. The wall of the tubuli recti as same as other genital ducts consists of three layers: mucosa,

muscularis and adventitia. An initial segment of tubuli recti lined only by Sertoli cells. Near their termination, the straight tubules narrow, and their lining changes to a simple columnar epithelium.

The straight tubules empty into the **rete testis**, a complex series of interconnecting channels within the highly vascular connective tissue of the mediastinum. A simple cuboidal epithelium lines the channels of the rete testis. There are some macrophages in the rete testis, which phagocytose defective sperm cells. Muscular layer consists of smooth muscle cells circularly oriented. Adventitial layer contains loose connective tissue.

13. Excurrent duct system. Efferent ductules characteristic.

In man, approximately 20 **efferent ductules** (ductuli efferentes) connect the channels of the rete testis at the superior end of the mediastinum to the proximal portion of the ductus epididymis. They are highly coiled and form 6-10 conical masses.

They are lined by a simple columnar epithelium composed of alternating clusters of nonciliated secretory cuboidal cells and ciliated columnar cells. Interspersed among the columnar cells are a few basal cells and intraepithelial lymphocytes. They possess a thin circular layer of **smooth muscle** beneath the basal lamina of the epithelium. Interspersed among the muscle cells are elastic fibers. Transport of the sperm in the efferent ductules is affected largely by both ciliary action and contraction of this fibromuscular layer. Most of the fluid secreted in the seminiferous tubules is reabsorbed in the efferent ductules.

14. Excurrent duct system. Ductus epididymis structure and function

The epididymis lies along the posterior surface of testis. It consists of the **ductus epididymis** and its associated vascularized connective tissue, smooth muscle, and a fibrous connective tissue tunic. The ductus epididymis is a highly coiled tube. It is divided a head (caput), a body (corpus), and a tail (cauda). Sperm mature during their passage through the epididymis acquiring motility and the ability to fertilize an oocyte. This maturation, like their earlier differentiation, is androgen dependent. During this process, changes occur in the sperm plasma membrane, including the addition to the glycocalyx of glycoproteins secreted by the epididymal epithelial cells. The ductus epididymis is lined with a pseudostratified columnar epithelium. It contains principal cells (tall) and basal cells(short). **Principal cells** are varying from about 80 μm in height in the head of the epididymis to about 40 μm in height in the tail. Numerous long, modified microvilli called **stereocilia** extend from the luminal surface of the principal cells. These cells possess a large Golgi complex, rER, lysosomes, and many apical pinocytotic and coated vesicles; the latter suggest that these cells function in **fluid resorption.** Most of the fluid that is not reabsorbed by the efferent ductules is reabsorbed in the proximal portion of the epididymis. Principal cells secrete **glycerophosphocholine,** which inhibits **capacitation** (the process whereby a sperm becomes capable of fertilizing an oocyte). Thus, capacitation occurs only after the sperm enters the female genital tract.

Basal cells are small, round cells resting on the basal lamina. They serve as the stem cells of the duct epithelium.

In addition, **migrating lymphocytes** called **halo cells** are often found within the epithelium. The epithelial cells phagocytose sperm that degenerate in the duct.

In the head of the epididymis and most of the body, the smooth muscle coat consists of a thin layer of circular smooth muscle. In the tail, inner and outer longitudinal layers are added. These three layers are then continuous with the three smooth muscle layers of the ductus deferens, the next component of the excurrent duct system. Adventitia consists of loose connective tissue.

15. Excurrent duct system. Ductus deferens structure and function

The ductus deferens is a direct continuation of the epididymis and is involved in transporting spermatozoa from the epididymis to the ejaculatory ducts. The distal end of the ductus deferens enlarges to form the ampulla. It is joined there by the duct of the seminal vesicle continues through the prostate gland to the urethra as ejaculatory duct.

The wall of the vas deferens consists of three main layers: an inner mucosal, middle muscular and outer connective tissue layer. Muscular layer is thick with inner and outer layers of longitudinal smooth muscle, which are separated from one another by a middle circular layer. The vas deferens consists of an inner epithelial lining with supportive lamina propria. The epithelium lining the vas deferens is pseudostratified columnar epithelium and is very similar to the epithelium seen in the epididymis. This inner layer is comprised of longitudinal folds, which allows the vas deferens to expand during ejaculation.

16. Excurrent duct system. Ejaculatory duct structure and function

The ejaculatory duct is the straight continuation of the ductus deferens beyond where it receives the duct of the seminal vesicle. It lacks a muscular wall. It enters the prostate gland and terminates in a slit on the **colliculus seminalis** located in the prostatic urethra.

17. Accessory sex glands. Seminal vesicles structure and function

The seminal vesicles are paired, elongate tubular glands. The wall of the seminal vesicles contains a mucosa, a thin layer of smooth muscle, and an adventitia. The mucosa is the extensively folded and that increase the secretory surface area. It is lined by the pseudostratified columnar epithelium which contains tall, nonciliated columnar cells and short, round cells that rest on the basal lamina. The short cells appear identical to those of the rest of the excurrent duct system. They are the stem cells from which the columnar cells are derived. The columnar cells have the morphology of protein-secreting cells, with a well-developed rER and large secretory vacuoles in the apical cytoplasm. It contains many **yellow lipochrome pigment granules** and secretory granules, a large Golgi complex and many mitochondria. The **lamina propria** consists of **fibroelastic** connective tissue surrounded by an inner circular and outer longitudinal layer of smooth muscle. The **adventitia** is composed of **fibroelastic** connective tissue.

The secretion of the seminal vesicles is a whitish yellow, viscous material. It contains **fructose**, which is the principal metabolic substrate for sperm. **Prostaglandins** are synthesized in large amounts in the seminal vesicles. Contraction of the smooth muscle coat of the seminal vesicles during ejaculation discharges their secretion into the ejaculatory ducts and helps to flush sperm out of the urethra. The secretory function and morphology of the seminal vesicles are under the control of testosterone.

18. Accessory sex glands. Prostate gland structure and function

The **prostate** is the largest **accessory sex gland** of the male reproductive system. Its size and shape are commonly compared to those of a walnut. The prostate gland surrounds the urethra as it exits the urinary bladder. The hallmark histological feature of the prostate is the fibromuscular stroma in which there are clusters of smooth muscles mixed with elastic fibers. Surrounded by this mixture of tissue are 30 to 50 discrete **branched tubuloalveolar glands** that empty their contents via excretory ducts into the prostatic urethra, which are responsible for the production of approximately 27% of seminal fluid. These glands are arranged in three concentric layers (**mucosal, submucosal** and a peripheral layer containing the main prostatic glands) around the urethra. The glands of the mucosal layer secrete directly into the urethra; the other two layers have ducts that open into the prostatic sinuses located on either side of the urethral crest on the posterior wall of the urethra.

The gland is covered by a **fibroelastic capsule** that contains smooth muscle. Septa from the capsule penetrate the gland and divide it into lobes. The epithelium of the prostate gland is **simple columnar** or **pseudostratified columnar** and lines the individual glands that constitute the prostate. It is composed of tall columnar cells that contain abundant rER, a well-developed Golgi complex, numerous lysosomes, and many secretory granules and basal cells. The alveoli of the prostatic glands, especially those in older men, often contain **prostatic concretions (corpora amylacea)** of varied shape and size, composed of glycoprotein, which may become calcified. Posterior to the concavity of the prostatic urethra, the ejaculatory ducts and the prostatic utricle can also be appreciated within the stroma of the gland.

The main function of the prostate gland is to secrete a clear, whitish slightly alkaline (pH 7.29) fluid that contributes to the formation of seminal fluid. It contains proteolytic enzymes, citric acid, acid phosphatase, prostate-specific antigen, fibrinolysin, and lipids. The prostatic secretion serves to liquefy the coagulated semen after it is deposited in the female genital tract. Its synthesis and release are regulated by testosterone. The alveolar secretion from the prostate gland is pumped into the prostatic urethra during ejaculation by contraction of the fibromuscular tissue of the prostate.

19. Accessory sex glands. Bulbourethral glands structure and function

The paired bulbourethral glands are pea-sized structures located in the urogenital diaphragm. They are compound tubuloalveolar glands that structurally resemble mucus secretory glands. They are lined by simple columnar epithelium. They are surrounded by a fibroelastic capsule containing smooth and skeletal muscle. The clear, mucus-like glandular secretion of these glands contains considerable amounts of galactose and galactosamine, galacturonic acid and sialic acid. Erotic stimulation causes release of the secretion into the lumen of the membranous urethra. Secretion of these glands constitutes the major portion of the preseminal fluid and probably serves as a lubricant of the penile urethra.

20. Semen peculiarities.

Semen contains fluids and sperm from the testis and secretory products from the epididymis, vas deferens, pros seminal vesicles, and bulbourethral glands.

The volume of the average ejaculate of semen is 3 mL. This normally contains up to 100 million sperm mL, of which it is estimated that 20% are morphologic abnormal and nearly 25% are immotile.

21. Penis structure and function.

The penis is the termination of both the urinary system and the reproductive excurrent duct system in the male. The urethra, which originates at the bladder and extends through the penis, carries both semen and

urine to the exterior. The **penis** consists principally of two dorsal masses of erectile tissue, the **corpora cavernosa**, and a ventral mass of erectile tissue, the corpus spongiosum, in which the spongy part of the urethra is embedded. The **tunica albuginea** is a thick, fibroelastic connective sheath that surrounds the paired corpora cavernosa and the corpus spongiosum, and forms a capsule around each one. The arrangement of dense collagen bundles permits extension of the penis during erection. Erection of the penis involves the filling of the vascular sinuses of the corpora cavernosa and spongiosum.

Corpora cavernosa

Corpora cavernosa are **paired** masses of erectile tissue that contain **irregular vascular spaces** lined by a continuous layer of endothelial cells. These spaces are separated from each other by trabeculae of connective tissue and smooth muscle. The vascular spaces decrease in size toward the periphery of the corpora cavernosa. During erection, the vascular spaces become engorged with blood as a result of **parasympathetic impulses,** which constrict arterio-venous shunts and dilate the helicine arteries, thus increasing flow to the vascular spaces of the two corpora cavernosa and the single corpus spongiosum.

Corpus spongiosum

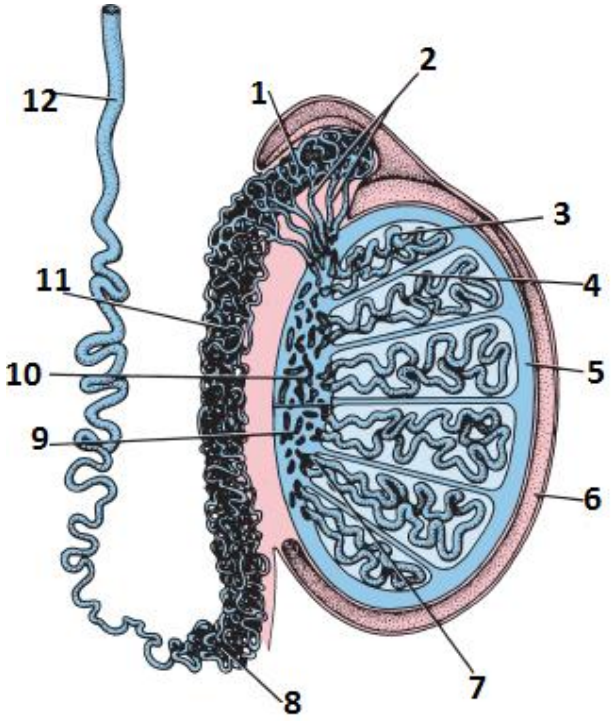
The corpus spongiosum is a single mass of **erectile tissue** that contains vascular spaces of uniform size. It possesses **trabeculae** that contain more elastic fibers and less smooth muscle than those of the corpora cavernosa.

Glans penis

The glans penis is the dilated distal end of the corpus spongiosum. It contains dense connective tissue and longitudinal muscle fibers .It is covered by retractable skin, the **prepuce,** which is lined by stratified squamous lightly keratinized epithelium. **Glands of Littre** are mucus-secreting glands present throughout the length of the penile urethra.

The skin of the penis is thin and loosely attached to the underlying loose connective tissue except at the glans, where it is very thin and tightly attached. There is a thin layer of smooth muscle that is continuous with the dartos layer of the scrotum.

PRACTICAL QUESTIONS



1. In this diagram of a sagittal section of human testis identify the structure labeled 1.

_____

2. Identify the structure labeled 2.

_____

3. Identify the structure labeled 3.

_____

4. Identify the structure labeled 4.

_____

5. Identify the structure labeled 5.

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6. Identify the structure labeled 6.

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7. Identify the structure labeled 7.

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8. Identify the structure labeled 8.

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9. Identify the structure labeled 9.

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10. Identify the structure labeled 10.

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11. Identify the structure labeled 11.

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12. Identify the structure labeled 12.

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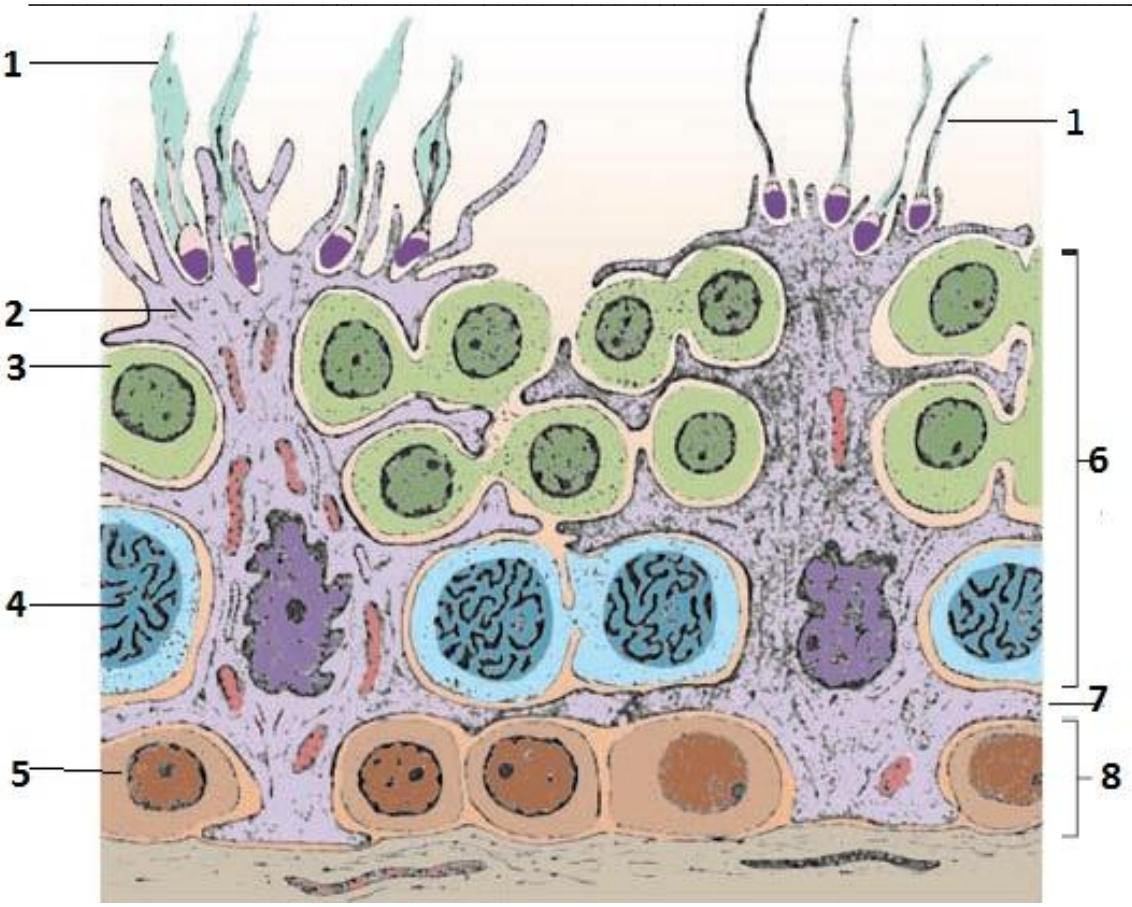
13. What characteristic of Sertoli cells do you know?



14. In the above diagram of seminiferous germanous epithelium identify the structure labeled 1.

15. Identify the structure labeled 2.

16. Identify the structure labeled 3.

17. Identify the structure labeled 4.

18. Identify the structure labeled 5.

19. Identify the structure labeled 6.

20. Identify the structure labeled 7.

21. Identify the structure labeled 8.

22. What is the structural feature that best distinguishes the ductus deferens from the other genital ducts?

_____
_____
_____
_____
_____

23. What peculiarities of interstitial cells of Leydig do you know?

_____
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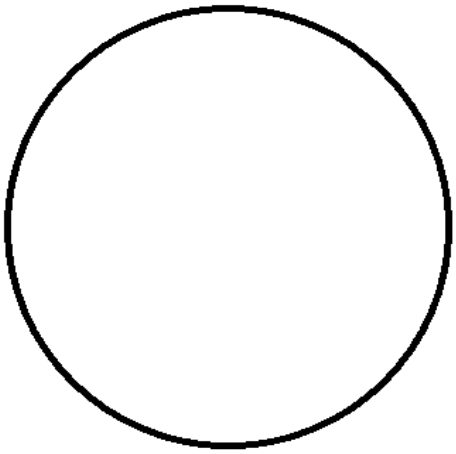
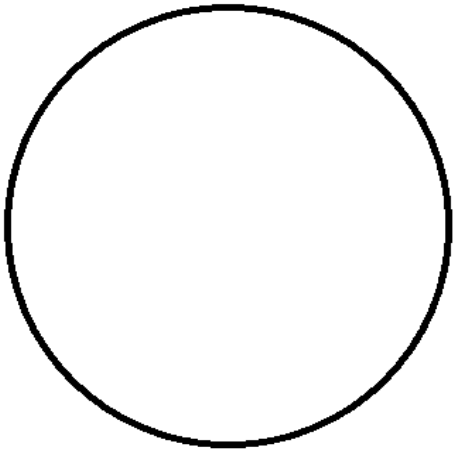


SLIDE 1

Testis with epididymis. Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. Tunica albuginia
2. Testis
    a) Convoluted seminiferous tubules
    b) Seminiferous epithelium
    c) Interstitial tissue of the testis
3. Efferent ductules
4. Ductus epididymis



SLIDE 2

Prostate. Stained with hematoxylin and eosin.

SLIDE'S DESIGNATIONS

1. End piece of the gland
2. Excretory duct
3. Clusters of smooth muscle cells
4. Urethra
    a) Transitional epithelium
    b) Lamina propria of the mucosa
    c) Muscularis layer

TESTS OF THE "KROK-1" DATABASE. MALE REPRODUCTIVE SYSTEM.

The changes in the nucleus and cytoplasm of spermatids are observed during the one of the spermatogenesis phases that leads to the formation of mature gametes. What is the phase of gametogenesis?
A * Formation
B Maturation
C Growth
D Reproduction
E Proliferation

A disorder of the tests epithelium was developed as result of the scrotum mechanical trauma. What epithelium was damaged?
A * Simple cuboidal
B Ciliated
C Simple columnar
D Stratified
E Transitional

The organ that is covered by albuginea and serous membranes from outside was represented in the histological section. Organ stroma consists from loose connective tissue that contains the Leydig cells. The parenchyma is represented by the tubules covering with spermatogenic epithelium from the inner surface. What organ is this?
A * Testes
B Epididymis
C Prostate
D Mammary gland
E Ovaries

Destroyed wall of convoluted tubules is marked at man after the testis mechanical trauma. What will it lead to?
A * Aspermatogenesis
B Polyspermia
C Increasing of testosterone synthesis
D Monospermia
E Reduction of testosterone synthesis

The insufficient number of germ cells was found in the seminal fluid of a 25-year-old patient during the study. Which cells of male gonads provide a sufficient number of sperm for fertilization?
A *Spermatogonia
B Sustentacular cells
C Supporting cells
D Sertoli Cells
E Leydig cells

The couple complains of inability to have children. Injury of testes spermatogenic epithelium that leads to the absence of sperm in the semen and infertility was found after the man examination. What part of the testis was injured?
A * Seminiferous tubuli (Ductuli seminiferi contorti)
B Rete testis
C Tubuli recti (Ductuli seminiferi recti)
D Ductuli efferentes testis
E Ductus epididymis

The cells of male sex glands begin to produce the male sex hormone testosterone that causes the appearance of secondary sex characteristics during the puberty. What cells of male gonads produce this hormone?
A * Leydig cells
B Sustentacular cells
C Sertoli Cells
D Supporting cells
E Spermatozoa

The production of sperm was disordered as result of orchitis at 43-year-old men. What part of the testis was injured?
A * Seminiferous tubuli (Ductuli seminiferi contorti)
B Rete testis
C Tubuli recti (Ductuli seminiferi recti)
D Ductuli efferentes testis
E Ductus epididymis

What factors contribute to divergence of development of the reproductive system?
A. *Sex chromosomes and hormone inhibin
B. Sex chromosomes
C. Inhibin
D. Somatic chromosomes
E. Testosterone

Large sized, rounded or polygonal shape cells with acidophilic cytoplasm containing numerous lipid granules are found in a histological specimen of the testis between the seminiferous tubules. What is produced by these cells?
A. Testosterone
B Inhibin
C Progesteron
D Estrogen
E -

Olygosperm (insufficient number of sperm) was revealed in an ejaculate of the liquidator of an accident at the nuclear power plant during microscopy examination. What structures of the reproductive system, in which spermatogenesis occurs, were damaged?
A *Primary spermatocytes
B Tubuli recti
C Rete testis
D Efferent ductules
E Ductus epididymis

Large, tetraploid cells which are located in recesses of the supporting cells are visible in a histological specimen of the seminiferous tubule. They come into the prophase of the first meiotic division. What cells are these?
A *Primary spermatocytes
B Secondary spermatocytes
C Spermatogonia type A
D Spermatogonia type B
E Spermatids

An increased level of testosterone was found in the blood during examination of the patient with endocrine pathology. What cells in the male body are responsible for the production of this hormone?
A *Glandular cells of testis
B Sustentacular cells of testis
C Spermatogenic cells
D Cells of the prostate gland
E Cells of the seminal vesicles

Groups of large irregular rounded shape cells with light nucleus and acidophilic cytoplasm are determined in a histological specimen of the testis in loose connective tissue between the seminiferous tubules. Determine the function of these cells.
A *Testosterone production
B Trophic function
C Estrogens production
D Barrier function
E Supporting function

Epithelial cells have axoneme in one of the part of the excurrent ducts of the mucosa. Specify the part of the excurrent duct system.
A *Rete testis and efferent ductules
B Rete testis
C Efferent ductules and ductus epididymis
D Ductus epididymis and ductus deferens
E Ductus deferens and ejaculatory duct

Cells at different stages of spermatogenesis were determined in the biopsy of the testis in the wall of seminiferous tubules. What is a name of these cells after the growth phase?
A *Primary spermatocyte
B Spermatogonia type A
C Sperm
D Secondary spermatocyte
E Spermatozoon

Cystic formation of the pelvis has been removed after surgery. Histological examination determined that it originates from the right seminal vesicles. What kind of epithelium covers the cavity of seminal vesicles?
A *Simple columnar
B Simple squamous
C Simple cuboidal
D Stratified cuboidal
E Stratified squamous

Cells with large nuclei, increased glycogen content and high activity of alkaline phosphatase are found in the wall of yolk sac. These cells migrate through the vessels into sex cushions. What cells of the male reproductive system will be differentiate from them?
A *Spermatogenic cells
B Leydig cells
C Fibroblasts
D Blood cells
E Supporting cells

The cells of male sexual glands begin to produce male sex hormone testosterone which induces development of secondary sexual signs during pubescence. What cells of male sexual glands produce this hormone?
A Leydig cells
B Sustentacular cells
C Sertoli cells
D Supporting cells
E Spermatozoa

One can see tubules in cross section of the histological preparation. The wall of these tubules consists of mucosa, tunica muscularis and tunica adventitia. The epithelium of the mucosa is represented by high columnar cells with stereocilia and low stem cells. What organ of the male reproductive system was studied?
A *Ductus epididymis
B Testis
C Prostate gland
D Ejaculatory duct
E Urethra

Muscular-glandular organ, which has a lobular structure, is represented in a histological specimen. Separate glands located in the lobules. The excretory ducts of these glands open into the canal, located in the center of this organ. The wall of this canal is lined by transitional epithelium. The stroma of this organ consists of connective tissue and muscle tissue. Smooth muscle cells are located around glands forming longitudinal and circular layers. Reduction of these cells facilitates the removal of the glands secrete. Name the organ.

A. *Prostate gland
B. Testis
C. Seminal vesicles
D. Epididymis
E. Mammary gland

The mucosal epithelium is pseudostratified in a histological specimen of a part of excurrent duct system. Columnar cells with stereocilia on the apical surface interspersed with intercalated cells. There are tunica muscularis and tunica adventitia. What part of the excurrent duct system is represented?

A *Ductus epididymis
B Tubuli recti
C Seminiferous tubules
D Ductus deferens
E Ejaculatory duct

FEMALE REPRODUCTIVE SYSTEM

Checking your primary level of the knowledge:

1. **Components and functions of female reproductive system.**
2. **Functions of the ovaries.**
3. **General structure of the ovaries.**
4. **Follicle development.**
5. **Hormonal regulation of follicles development.**
6. **Ovulation characteristic.**
7. **Fertilization peculiarities.**
8. **Corpus luteum characteristic.**
9. **Corpus albicans.**
10. **Follicular atresia.**
11. **Oviduct (Fallopian tubes) structure and function.**
12. **Oviduct transport**
13. **Uterus general plan of structure.**
14. **Uterus endometrium structure**
15. **Uterus myometrium structure**
16. **Uterus perimetrium structure**
17. **Cervix structure**
18. **Menstrual cycle phases.**
19. **The proliferative phase characteristic**
20. **The secretory phase characteristic.**
21. **The menstrual phase characteristic**
22. **Vagina structure**
23. **External genitalia characteristic**
24. **Mammary glands structure**
25. **The morphology of the secretory portion of the mammary gland during the menstrual cycle.**
26. **The morphology of the secretory portion of the mammary gland during pregnancy.**
27. **Characteristic of merocrine and apocrine secretion involved in milk production.**
28. **Peculiarities of the colostrum.**

Standard answers for theoretical questions

1. Components and functions of female reproductive system.

The female reproductive system consists of the paired **ovaries** and **oviducts;** the **uterus, vagina,** and **external genitalia;** and the paired **mammary glands.** It undergoes marked changes at the onset of puberty, which is initiated by **menarche.** It exhibits monthly menstrual cycles and menses from puberty until the end of the reproductive years, which terminate at **menopause.**

The female reproductive system (or female genital system) serves multiple functions: it is responsible for producing the eggs necessary for reproduction, facilitating the occurrence of reproduction, and also for producing the female sex hormones that maintain the reproductive cycle and that play a direct or indirect role elsewhere in the body.

2. Functions of the ovaries.

Production of gametes and production of steroid hormones are the two major functions of the ovary. Two major groups of steroid hormones are secreted by the ovaries. They are the estrogens and the progestogens. **Estrogens** promote growth and maturation of internal and external sex organs and are responsible for the typical female characteristics. **Progestogens** prepare the internal sex organs, mainly the uterus, for pregnancy by promoting secretory changes in the endometrium. Both hormones play an important role in the menstrual cycle by preparing the uterus for implantation of a fertilized ovum.

3. General structure of the ovaries.

The ovaries are paired, almond-shaped, pinkish-white structures. Ovaries are covered by a simple cuboidal epithelium called the **germinal epithelium.** Deep to the germinal epithelium, the ovaries possess a capsule, the **tunica albuginea that** is composed of a dense, irregular collagenous connective tissue. Each ovary is attached to the mesovarium. Each ovary is subdivided into a **cortex** and a **medulla,** which are not sharply delineated.

The **ovarian medulla** located in the central portion of the ovary contains large blood vessels, lymphatic vessels, and nerve fibers in a loose connective tissue stroma. It also possesses a small number of **estrogen**-secreting **interstitial cells** and a few **androgen**-secreting **hilus cells.**

The **ovarian cortex** found in the peripheral portion of the ovary surrounding the medulla consists of **ovarian follicles** in various stages of development and a connective tissue **stroma** containing cells that respond in unique ways to hormonal stimuli. Scattered smooth muscle fibers are present in the stroma around the follicles.

4. Follicle development

Three basic types of ovarian follicles can be identified, based on developmental state: primordial follicles**,** growing follicles (primary and secondary (or antral) follicles) and mature or Graafian follicles.

The **primordial follicle** is the earliest stage of follicular development. Primordial follicles first appear in the ovaries during the third month of fetal development. Early growth of the primordial follicles is independent of gonadotropin stimulation. The primordial follicles are found in the stroma of the cortex just beneath the tunica albuginea. A single layer of squamous **follicular cells** surrounds the oocyte. Follicular cells are attached to one another by **desmosomes.** They are separated from the surrounding stroma by a basal lamina.

The **primary follicle** is the first stage of the growing follicle. Initially, the oocyte enlarges and the surrounding flattened follicular cells proliferate and become cuboidal. As the oocyte grows, a homogeneous, acidophilic layer called the **zona pellucid** appears between the oocyte and the adjacent follicular cells.

Follicular cells undergo stratification to form the granulosa layer (stratum granulosum) of the primary follicle. The follicle cells are now identified as **granulosa cells**. Connective tissue cells form the theca layers of the primary follicle. The **theca interna** is the inner, highly vascularized layer of cuboidal secretory cells. Cells of the theca interna possess a large number of luteinizing hormone (LH) receptors. In response to LH stimulation, they synthesize and secrete the androgens that are the precursors of estrogen. The **theca externa** is the outer layer of connective tissue cells. The oocytes exhibit specialized secretory vesicles known as **cortical granules**. They are located just beneath the plasma membrane.

In the **secondary follicle** begins to form a single fluid-containing cavity called the **antrum**. The follicle is now identified as a secondary or antral follicle. Liquor folliculi includes **estrogen.** The granulosa cells form the cumulus oophorus that projects into the antrum.

The **mature follicle**, also known as a **Graafian follicle**, has a diameter of 10 mm or more. The stratum granulosum appears to become thinner as the antrum increases in size. The oocyte and cumulus cells are gradually loosened from the rest of the granulosa cells in preparation for ovulation. The cumulus cells immediately surrounding the oocyte now form a single layer of cells of the corona radiata. These cells and loosely attached cumulus cells remain with the oocyte at ovulation. During this period of follicle maturation, the thecal layers become more prominent. Lipid droplets appear in the cytoplasm of the theca interna cells, feature associated with steroid-producing cells.

5. Hormonal regulation of follicles development

In humans, LH stimulates the cells of the theca interna to secrete androgens, which serve as estrogen precursors. Some androgens are transported to the granulose cells. In response to FSH, the granulose cells catalyze the conversion of androgens to estrogens, which in turn stimulate the granulose cells to proliferate and thereby increase the size of the follicle. A surge in the release of FSH or LH is induced in the adenohypophysis approximately 24 hours before ovulation. In response to the LH surge, LH receptors on granulose cells are down regulated (desensitized), and granulose cells no longer produce estrogens in response to LH. The granulose and thecal cells after ovulation undergo luteinization and produce progesterone.

6. Ovulation characteristic

Ovulation is the process by which an oocyte is released from the Graafian follicle.

A combination of hormonal changes and enzymatic effects is responsible for the actual release of the secondary oocyte at the middle of the menstrual cycle. The factors include increasing in the volume and pressure of the follicular fluid, enzymatic proteolysis of the follicular wall by activated plasminogen and contraction of the smooth muscle fibers in the theca externa layer.

Just before ovulation, blood flow stops in a small area of the ovarian surface which known as the **stigma**. Last one becomes elevated and then ruptures. The oocyte is forcefully expelled from the ruptured follicle. At the time of ovulation, the fimbriae of the uterine tube become closely apposed to the surface of the ovary, and the cumulus mass containing oocyte is then gently swept by the fimbriae into the abdominal ostium of the uterine tube.

7. Fertilization peculiarities.

Fertilization normally occurs in the ampulla of the oviduct. Several spermatozoa may penetrate the zona pellucida, but only one spermatozoon completes the fertilization process.

8. Corpus luteum characteristic

At ovulation, the follicular wall, composed of the remaining granulosa and thecal cells, is transformed into the **corpus luteum** (yellow body) or **luteal gland**. At first, bleeding from the capillaries in the theca interna into the follicular lumen leads to the formation of the **corpus hemorrhagicum** with a central clot. Connective tissue from the stroma then invades the former follicular cavity. These luteal cells become filled with lipid droplets which give them a yellow appearance. As the corpus luteum begins its formation, blood and lymphatic vessels from the theca interna rapidly grow into the granulosa layer. This highly vascularized structure located in the cortex of the ovary secretes progesterone. If fertilization and implantation do occur, the corpus luteum increases in size to form the **corpus luteum of pregnancy**. It remains active 12 weeks. If fertilization and implantation do not occur, the corpus luteum remains active only for 14 days; in this case it is called the **corpus luteum of menstruation**.

9. Corpus albicans.

The corpus luteum degenerates and undergoes a slow involution after pregnancy or menstruation. **Corpus albicans** formation is due to the hypoxic conditions present in the corpus luteum as fibroblasts manufacture an overabundance of collagen. The cells become loaded with lipid, decrease in size, and undergo autolysis. A white scar, the corpus albicans, is formed as intercellular hyaline material accumulates among the degenerating cells of the former corpus luteum. The corpus albicans sinks deeper into the ovarian cortex as it slowly disappears over a period of several months.

10. Follicular atresia.

Very few of the ovarian follicles that begin their differentiation in the embryonic ovary are destined to complete their maturation. Most of the follicles degenerate and disappear through a process called **follicular atresia**. Atresia is mediated by apoptosis of granulosa cells. The oocyte undergoes typical changes associated with degeneration and autolysis. Atretic follicles are follicles (in various stages of maturation) that are undergoing degeneration.

In atresia of primordial and small, growing follicles, the immature oocyte becomes smaller and degenerates; similar changes occur in the granulosa cells. Atretic follicles shrink and eventually disappear from the stroma of the ovary as a result of repeated apoptosis and phagocytosis by granulosa cells. As the cells are reabsorbed and disappear, the surrounding stromal cells migrate into the space previously occupied by the follicle, leaving no trace of its existence.

In atresia of large, growing follicles, the degeneration of the mature oocyte is delayed and appears to occur secondary to degenerative changes in the follicular wall.

The oocyte undergoes typical changes associated with degeneration and autolysis, and the remnants are phagocytized by invading macrophages. The zona pellucida, which is resistant to the autolytic changes occurring in the cells associated with it, becomes folded and collapses as it is slowly broken down within the cavity of the follicle. The basement membrane between the follicle cells from the theca interna may separate from the follicle cells and increase in thickness, forming a wavy hyaline layer called the **glassy membrane**.

As atretic follicles continue to degenerate, a scar with hyaline streaks develops in the center of the cell mass, giving it the appearance of a small corpus albicans. This structure eventually disappears as the ovarian stroma invades the degenerating follicle.

11. Oviduct (Fallopian tubes) structure and function.

The oviducts are paired tubes that extend bilaterally from the uterus toward the ovaries. The oviducts, also commonly referred to as the uterine or Fallopian tubes, transmit the ova from the ovary to the uterus and provide the necessary environment for fertilization and for initial development of the conceptus to the morula stage.

The oviduct wall consists of three layers: mucosa, muscularis and serosa.

The **mucosa** is comprised of longitudinal folds, more pronounced at the infundibulum, and is lined by a single layer of tall, columnar epithelium. There are two types of columnar cells within the epithelium: ciliated and non-ciliated secretory cells. The **ciliated** cells are more predominant in the distal portion of the tubes and develop more cilia in the first half of the menstrual cycle. The wave like movement of the cilia aids in the movement of the ovum throughout the fallopian tubes. The longer **non-ciliated secretory** cells are more active during ovulation and unlike the ciliated cells, are more predominant in the proximal portion of the tubes. These cells secrete a fluid that is propelled with the ovum towards the uterus, by the cilia. The secretion provides a nutrient for the fertilized ovum and also aids in capacitation, a maturation step, of the spermatozoa. Post menopause, the epithelium decreases in height due to a reduction in the number of ciliated cells.

The **muscularis** is arranged into two layers: an inner relatively thick circular layer and an outer,thinner longitudinal layer. Innervation of these layers results in peristaltic contractions of the fallopian tubes, which assist in propulsion of the fertilized ovum.

The **serosa** or peritoneum consists of mesothelium and a thin layer of connective tissue.

12. Oviduct transport

The oviduct demonstrates active movements just before ovulation as the fimbriae become closely apposed to the ovary and localize over the region of the ovarian surface where rupture will occur. As the egg is released, the ciliated cells in the infundibulum sweep it toward the opening of the oviduct and, thus, prevent it from passing into the peritoneal cavity. The egg is transported along the oviduct by peristaltic contractions.

13. Uterus general plan of structure.

The human uterus is a hollow, pear-shaped organ. Its lumen is continuous with the oviducts and the vagina. The uterine wall is composed of three layers. From the lumen outward they are **endometrium**, the mucosa of the uterus, **myometrium**, the thick muscular layer and **perimetrium**, the external serous layer or visceral peritoneal covering of the uterus.

The myometrium and the endometrium both undergo cyclic changes each month to prepare the uterus for implantation of an embryo. These changes constitute the **menstrual cycle**. If an embryo implants, the cycle stops, and both layers undergo considerable growth and differentiation during pregnancy.

14. Uterus endometrium structure

The **endometrium** proliferates and then degenerates during a menstrual cycle. The endometrium undergoes cyclic changes each month that prepare it for the implantation of the embryo. Changes in the secretory activity of the endometrium during the cycle are correlated with the maturation of the ovarian follicles. The discharge of tissue and blood from the vagina, which usually continues for a period of 3-5 days, is referred to as **menstruation** or **menstrual flow**.

The endometrium consists of two layers or zones that differ in structure and function. **Stratum functionale or functional layer** is the thick part of the endometrium, which is sloughed off at menstruation. **Stratum basale** or **basal layer** is retainer during menstruation.

The **stratum functionale** is the layer that proliferates and degenerates during the menstrual cycle. It is lined with a simple columnar epithelium with a mixture of secretory and ciliated cells. The surface epithelium invaginates into the underlying lamina propria, the endometrial stroma forming **uterine glands**. These glands are simple tubular. No submucosa separates the endometrium from the myometrium.

The endometrium contains a unique system of blood vessels. The main branch of the radial artery continues upward and becomes highly coiled. It is called the **spiral artery**. The vasculature of the endometrium also proliferates and degenerates in each menstrual cycle.

15. Uterus myometrium structure

The **myometrium** forms a structural and functional syncytium. It is continuous with the muscle layer of the oviduct and vagina. The smooth muscle fibers also extend into the ligaments connected to the uterus. The myometrium is the thickest layer of the uterine wall. It is composed of three indistinctly defined layers of smooth muscle. The **middle muscle layer** contains numerous large blood vessels (venous plexuses) and lymphatics and is called the **stratum vasculare**. It is the thickest layer and has smooth muscle bundles described as oriented circular or spiral pattern interlaced with each other.

The smooth muscle bundles in the **inner (subvascular)** and **outer layers (supravascular)** are described as predominantly oriented parallel to the long axis of the uterus.

16. Uterus perimetrium structure

The **perimetrium** consists of a mesothelium and a thin layer of loose connective tissue. Underneath the mesothelium is a layer of elastic tissue. The perimetrium covers the entire posterior surface of the uterus but only part of the anterior surface. The remaining part of the anterior surface consists of connective tissue or adventitia.

17. Cervix structure

The **cervical mucosa** measures about 2 to 3 mm in thickness and differs dramatically from the rest of the uterine endometrium in that it contains large, branched glands. The cervix does not participate in menstruation. During each menstrual cycle, however, the **cervical glands** undergo important functional changes that are related to the transport of spermatozoa within the cervical canal.

The cervix is covered by a **stratified squamous nonkeratinized epithelium.** It also lacks spiral arteries. The cervical wall is composed mainly of dense collagenous connective tissue interspersed with numerous elastic fibers and a few smooth muscle cells.

18. Menstrual cycle phases.

The **menstrual cycle** is convenient to describe the cycle as having three successive phases: **proliferative phase**, occurring concurrently with follicular maturation and influenced by ovarian estrogen secretion, **secretory phase,** coinciding with the functional activity of the corpus luteum and primarily influenced by progesterone secretion and **menstrual phase,** commencing as hormone production by the ovary declines with the degeneration of the corpus luteum.

It must be emphasized that the phases are part of a continuous process and that there is no abrupt change from one to the next.

19. The proliferative phase characteristic

The proliferative phase of the menstrual cycle is regulated by estrogens. At the end of the menstrual phase, the endometrium consists of a thin band of connective tissue, about 1 mm thick, containing the basal portions of the uterine glands and the lower portions of the spiral arteries. This layer is the **stratum basale**; the layer that was sloughed off was the **stratum functionale**. Under the influence of estrogens, the proliferative phase is initiated. Cells in the stratum basale proliferate rapidly, and the following changes can be seen:

Epithelial cells in the basal portion of the glands reconstitute the glands and migrate to cover the denuded endometrial surface.

Spiral arteries lengthen as the endometrium is reestablished; these arteries are only slightly coiled and do not extend into the upper third of the endometrium.

The proliferative phase continues for 1 day after ovulation, which occurs at about day 14 of a 28-day cycle. At the end of this phase, the endometrium has reached a thickness about 3 mm. The glands have narrow lumina and are relatively straight.

20. The secretory phase characteristic.

The **secretory phase** of the menstrual cycle is under the control of progesterone. Under the influence of progesterone, dramatic changes occur in the stratum functionale, beginning a day or two after ovulation. The endometrium becomes edematous and may eventually reach a thickness of 5-6 mm. The glands enlarge and become corkscrew shaped, and their lumina become sacculated as they fill with secretory products. The mucoid fluid being produced by the gland epithelium is rich in nutrients, particularly glycogen. Endometrium become edematic, vascularity increased and cells hypertrophic. The spiral arteries lengthen and become more coiled. They extend nearly to the surface of the endometrium. The sequential influence of estrogens and progesterone on the **stromal cells** makes them capable of undergoing transformation into **decidual cells**.

21. The menstrual phase characteristic

The menstrual phase results from a decline in the ovarian secretion of progesterone and estrogen. The corpus luteum remains active in hormone production for only about 10 days if fertilization does not occur. As the hormone levels rapidly decline, changes occur in the blood supply to the stratum functionale. Initially, periodic contraction of the walls of the spiral arteries, lasting for several hours, cause the stratum functionale to become ischemic, the glands stop secreting, and the endometrium shrinks in height as the stroma becomes less edematous. When spiral arteries close off, blood flows into the stratum basale but not into the stratum functionale. The desquamation continues until only the stratum basale remains. As noted, this is a cyclic process. In the absence of fertilization, a cessation of bleeding would accompany the growth and maturation of new ovarian follicles. The epithelial cells would rapidly proliferate and migrate to restore the surface epithelium as the proliferative phase of the next cycle begins. If fertilization and implantation occur, a gravid phase replaces the menstrual phase of the cycle.

22. Vagina structure

The vagina is a **fibromuscular canal** with a wall that is composed of three layers: an inner **mucosa,** a middle **muscularis,** and an external **adventitia.** It is circumscribed by a **skeletal muscle** sphincter at its external orifice. It lacks glands throughout its length and is lubricated by secretions from the cervix and by seepage of the extracellular fluid from the vascular supply of the lamina propria.

The **mucosa** of the vagina has numerous transverse folds or rugae and is lined with a thick, stratified squamous nonkeratinized epithelium and a fibroelastic connective tissue, the lamina propria. The epithelium undergoes cyclic changes during the menstrual cycle. Under the influence of estrogens, during the follicular phase, the epithelial cells synthesize and accumulate glycogen as they migrate toward the surface. **Glycogen** is used by the vaginal bacterial flora to produce **lactic acid,** an acid that lowers the pH during the follicular phase of the menstrual cycle and inhibits invasion by pathogens. The vaginal mucosa contains no glands. The vaginal surface is lubricated by mucus produced by the cervical glands.

The **lamina propria** exhibits two distinct regions. The outer region is a highly cellular loose connective tissue. The deeper region, adjacent to the muscular layer, is denser and may be considered a submucosa. Numerous elastic fibers are present here. Many lymphocytes and leukocytes are found in the lamina propria.
The **muscularis** is composed of irregularly arranged layers of **smooth muscle** (thin inner circular layer and a thicker outer longitudinal layer) interspersed with **elastic fibers.**
The **adventitia** is organized into an inner dense connective tissue layer, adjacent to the muscularis, and an outer loose connective tissue layer that blends with the adventitia of the surrounding structures.

23. External genitalia characteristic

The **labia majora** are fat-laden folds of skin; hair and secretions of sebaceous glands and sweat glands are present on their external surfaces.
The labia minora are folds of skin that possess a core of highly vascular connective tissue containing elastic fibers. They lack hair follicles, but their dermis contains numerous sebaceous glands, which open directly onto the epithelial surface.
The **vestibule** is the space between the two labia minora. **Glands of Bartholin** (mucus-secreting glands) and numerous smaller mucus-secreting glands around the urethra and clitoris (**minor vestibular glands**) open into this space.
The **clitoris** is composed of two small, cylindrical **erectile bodies,** which terminate in the prepuce-covered **glans clitoridis.** It contains many sensory nerve fibers and specialized nerve endings (e.g., Meissner corpuscles and pacinian corpuscles).

24. Mammary glands structure

The mammary glands or breasts are a distinguishing feature of mammals. Multiple glands develop along paired epidermal thickenings, called the **mammary ridges (milk lines).** In the female, the mammary glands undergo further development under hormonal influence. They are also influenced by changes in the ovarian hormone levels during each menstrual cycle. The actual initiation of milk secretion is induced by prolactin secreted by the adenohypophysis. The ejection of the milk from the breast is stimulated by oxytocin released from the neurohypophysis. With the change in the hormonal environment at menopause, the glandular component of the breast regresses or involutes and is replaced by fat and connective tissue.

Mammary glands are modified apocrine sweat glands that develop under the influence of sex hormones. The inactive adult mammary gland is composed of 15-20 irregular lobes of branched tubuloalveolar glands. The lobes, separated by fibrous bands of connective tissue, radiate from the **mammary papilla** or **nipple** and are further subdivided into numerous lobules. Abundant adipose tissue is present in the dense connective tissue of the interlobular spaces. The intralobular connective tissue is much less dense and contains little fat.

The epidermis of the adult **nipple** and **areola** is highly pigmented and somewhat wrinkled and has long dermal papillae invading into its deep surface. During pregnancy, the areola becomes larger, and the degree of pigmentation increases further. Deep to the areola and nipple, bundles of smooth muscle fibers are arranged radially and circumferentially in the dense connective tissue and longitudinally along the lactiferous ducts. These muscle fibers allow the nipple to become erect in response to various stimuli.
The areola contains sebaceous glands, sweat glands, and modified mammary glands. These glands, which are described as having a structure intermediate between sweat glands and true mammary glands, produce small elevations on the surface of the areola. Numerous sensory nerve endings are present in the nipple. The areola contains fewer sensory nerve endings.
The **tubuloalveolar glands**, derived from modified sweat glands in the epidermis, lie in the subcutaneous tissue. Each gland ends in a **lactiferous duct** that opens through a constricted orifice onto the nipple. Beneath the **areola**, the pigmented area surrounding the nipple, each duct has a dilated portion, the **lactiferous sinus**. Near their openings, the lactiferous ducts are lined with stratified squamous epithelium.

25. The morphology of the secretory portion of the mammary gland during the menstrual cycle.

In the **inactive gland**, the glandular component is sparse and consists chiefly of duct elements. During the menstrual cycle, the inactive breast undergoes slight cyclic changes. Early in the cycle, the ducts appear as cords with little or no lumen. Under estrogen stimulation, at about the time of ovulation, the secretory cells increase in height, lumina appear in the ducts as small amounts of secretions accumulate, and fluid accumulates in the connective tissue.

26. The morphology of the secretory portion of the mammary gland during pregnancy.

The mammary glands exhibit a number of changes in preparation for lactation. The changes in the glandular tissue are accompanied by decreases in the amount of connective tissue and adipose tissue. Plasma cells, lymphocytes, and eosinophils infiltrate the fibrous component of the connective tissue as the breast

develops. As the cells proliferate by mitotic division, the ducts branch and alveoli begin to develop. In the later stages of pregnancy, alveolar development becomes more prominent. The actual proliferation of the stromal cells declines and subsequent enlargement of the breast occurs through hypertrophy of the secretory cells and accumulation of secretory product in the alveoli.

27. Characteristic of merocrine and apocrine secretion involved in milk production.

The secreting cells contain large lipid droplets and secretory granules depending on the secretory state. The secretory cells produce two distinct products that are released by different mechanisms:

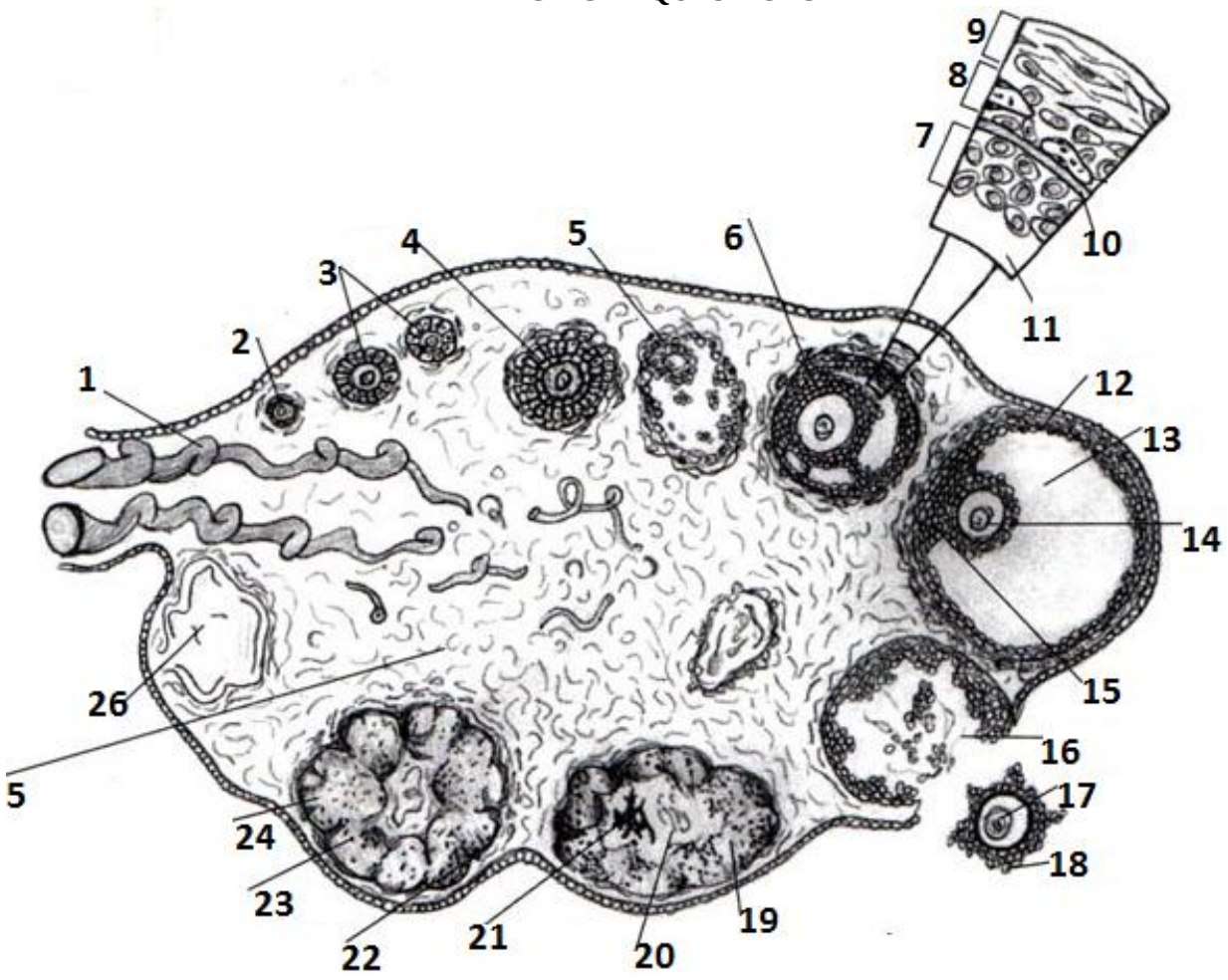
Merocrine secretion: The protein component of the milk is synthesized in the rER, packaged into membrane-limited secretory granules for transport in the Golgi apparatus, and released from the cell by fusion of the granule's limiting membrane with the plasma membrane.

Apocrine secretion: The fatty or lipid component of the milk arises as lipid droplets free in the cytoplasm. The lipid coalesces to form large droplets that pass to the apical region of the cell and project into the lumen of the acinus. The droplets are invested with an envelope of plasma membrane as they are released. A thin layer of cytoplasm is trapped between the plasma membrane and lipid droplet and is released with the lipid, but the cytoplasmic loss in this process is minimal.

28. Peculiarities of the colostrum.

The secretion released in the first few days after childbirth is known as **colostrum**. This premilk is an alkaline, yellowish secretion with a higher protein, vitamin A, sodium, and chloride content and a lower lipid, carbohydrate, and potassium content than milk. It contains considerable amounts of antibodies that provide the newborn with some degree of passive immunity. As these wandering cells decrease in number after parturition, the production of colostrum stops, and lipid-rich milk is produced.

PRACTICAL QUESTIONS



1. In the above diagram of the ovary identify the structure labeled 1.

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2. Identify the structure labeled 2.

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3. Identify the structure labeled 3.

4. Identify the structure labeled 4.

5. Identify the structure labeled 5.

6. Identify the structure labeled 6.

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21. Identify the structure labeled 21.

22. Identify the structure labeled 22.

23. Identify the structure labeled 23.

24. Identify the structure labeled 24.

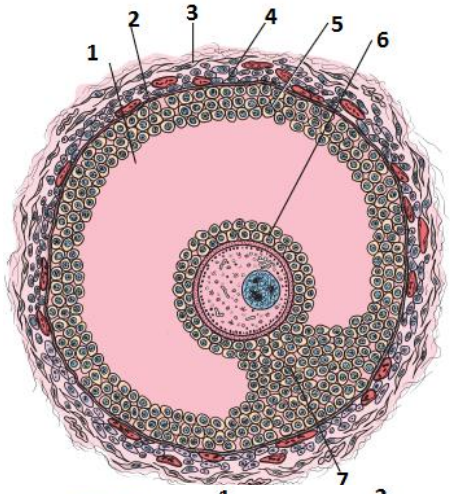
25. Identify the structure labeled 25.

26. Identify the structure labeled 26.

27. In the diagram below of mature (Graafian) follicle identify the structure labeled 1.

28. Identify the structure labeled 2.

29. Identify the structure labeled 3.



30. Identify the structure labeled 4.

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31. Identify the structure labeled 5.

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32. Identify the structure labeled 6.

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33. Identify the structure labeled 7.

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34. Identify the structure labeled 8.

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35. What hormone does cavity of the follicle include?

_____

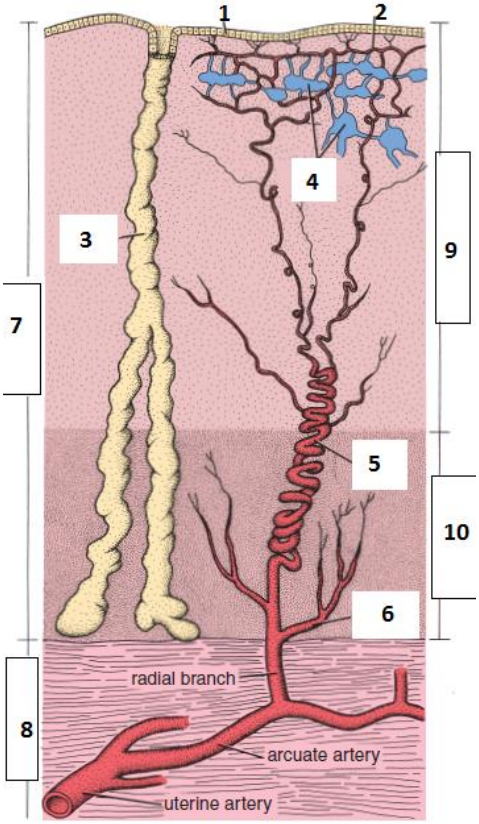
36. What happened to the follicular wall after ovulation?

_____

_____

_____

_____



37. In this diagram of the uterus identify the structure labeled 1.

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38. Identify the structure labeled 2.

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39. Identify the structure labeled 3.

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40. Identify the structure labeled 4.

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41. Identify the structure labeled 5.

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42. Identify the structure labeled 6

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43. Identify the structure labeled 7.

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44. Identify the structure labeled 8.

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45. Identify the structure labeled 9.

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46. Identify the structure labeled 10.

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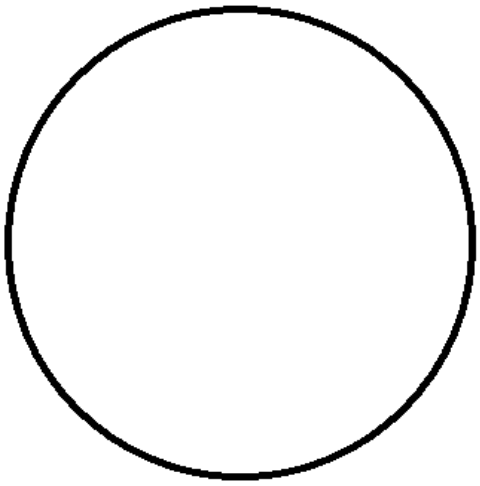
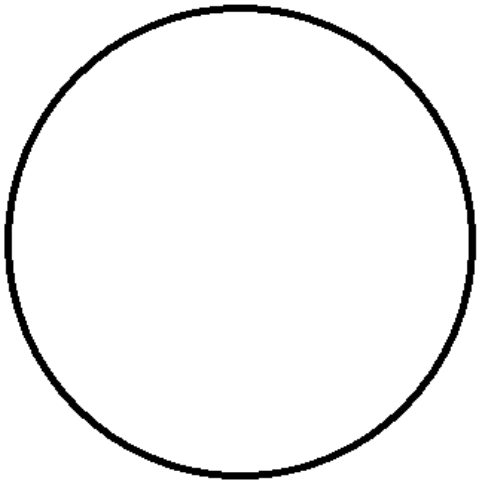


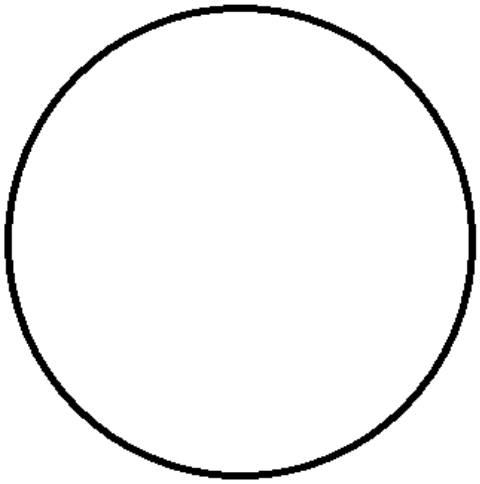
SLIDE 1
Ovary. Stained with hematoxylin and eosin.
SLIDE'S DESIGNATIONS

1. Serosa
2. Tunica albuginea
3. Primary follicles
4. Secondary follicles
5. Graafian follicles
    a) Zona pellucida
    b) Corona radiata
    c) Stratum granulosum
    d) Antrum of the follicle
    e) Connective tissue layer
6. Atretic follicles
7. Blood vessels



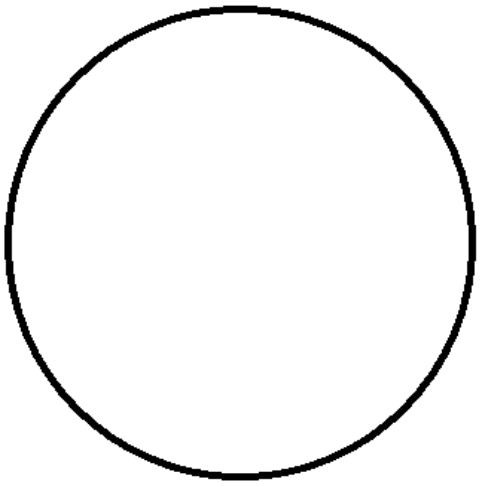
SLIDE 2
Fallopian tubes. Stained with hematoxylin and eosin.
SLIDE'S DESIGNATIONS

1. Fimbriae of the Fallopian tubes
    a) Ciliated cuboidal epithelium
    b) Lamina propria of the mucosa
    c) Blood vessels
2. Muscularis layer (longitudinal and circular layers)
3. Serosa



SLIDE 3
Uterus. Stained with hematoxylin and eosin.
SLIDE'S DESIGNATIONS

1. Mucosa (endometrium)
    a) Uterine glands
    b) Lamina propria of the mucosa
2. Muscularis layer
    c) Subvascular
    d) Stratum vasculare
    e) Supravascular
3. Serosa (perimetrium)



SLIDE 4
Mammary glands. Stained with hematoxylin and eosin.
SLIDE'S DESIGNATIONS

1. Adipose cells
2. Interlobular duct
3. Interlobular connective tissue septa
4. Lobules of the gland
5. Lactiferous duct
6. Secretory end piece
7. Blood vessels

TESTS OF THE "KROK-1" DATABASE. FEMALE REPRODUCTIVE SYSTEM.

The structures with a large cavity were defined at the histological slide of a female ovary. Primary oocyte is surrounded by a zona pellucida, corona radiata and situated at the cumulus oophorus. The wall is formed by a layer of follicular cells and theca. What structure of the ovary has the same morphological features?
A * Mature (tertiary) follicle
B Primordial follicle
C Primary follicle
D Yellow body
E Atretic body

The round-shaped structure that consists of large glandular cells containing pigment lutein was found at the histological slide of a female ovary. The small connective tissue scar is in the center of this structure. What structure is this?
A * Yellow body
B Matured follicle
C Atretic body
D Secondary follicle
E White body

Normal embryo implantation is possible only in case of corresponding changes of the endometrium of the uterus. Amount of what endometrial cells will increase in this case?
A * Decidual cells
B Fibroblasts
C Neurons
D Macrophages
E Myocytes

Oocyte surrounded with 1-2 layers of cuboidal follicular cells and scarlet covering around it have been detected in the ovary specimen colored with hematoxylin-eosin. Name this follicle:
A *Primary
B Primordial
C Secondary
D Mature
E Atretic

The endocrine function of ovary follicular cells was disordered as result of inflammation. Synthesis of what hormone will be suppressed?
A * Estrogen
B Progesterone
C Lutropin
D Follicle stimulating hormone
E Folistatin

The polygonal cells are rich in lipids and glycogen was revealed in the mucosa lamina propria in the endometrial biopsy of a healthy woman, taken in the secretory phase of the menstrual cycle. What are these cells?
A * Decidual cells
B Smooth myocytes
C Endothelial cells of the damaged vessels
D Myofibroblasts
E Fibroblasts

The corpse of the unknown woman was delivered for the forensic examination. The rounded structure with a diameter of 5 cm, containing a yellow pigment was revealed on the ovary section. Pathological changes in the ovary were not founded. What cells this formation is composed from?
A * Lutein
B Follicular
C Interstitial
D Muscle
E Fibroblasts

A cyst of the ovary was found at 50-year-old woman. From what structure was it developed?
A * From follicle
B From cortex stroma
C From atretic body
D From white body
E From interstitial cells

The bright pink irregularly shaped structures (hematoxylin-eosin staining) are occurring at the section of a normal ovary. What is the reason of these structures formation?
A * Atresia of the follicle
B Formation of the corpus luteum
C Ovulation
D Formation of the white body
E Necrosis of the follicle

An increased estrogens amount was found in the blood of a woman. What ovary cells take place at these hormones formation?
A * Interstitial and follicular cells of secondary follicles
B Oocytes
C Follicular cells of primary follicles
D Follicular cells of primordial follicles
E Follicular cells and oocytes

Changes in the structure of the endometrium were found during microscopic examination of biopsy material of women suffering from infertility as a result of the action of hormone progesterone. Where is this hormone produced?
A. *Yellow body of the ovary
B. Ovarian follicles
C. Anterior pituitary
D. Posterior pituitary
E. Hypothalamus

Round shaped bodies containing luteal cells are revealed in the female ovary after ovulation. What is produced by these cells?
A *Progesterone
B Estrogen
C Lutropin
D Follitropin
E Testosterone

Primordial and primary follicles were found in the histological preparation of ovarian cortex. At what stage of oogenesis are they formed?
A *Small growth stage
B Large growth stage
C Maturation stage
D Reproductive stage
E Formation stage

Atretic bodies and developed yellow body can be observed along with follicles of various orders in an ovary specimen. What stage of ovarian and menstrual cycle is characterized by the described ovary condition?
A. Premenstrual
B. Menstrual
C. Postmenstrual
D. Regeneration
E. Follicle growth

Histological picture of the endometrium has the following features: thickening, edema, uterus glands are corkscrew shaped with enlarged lumen and produce large amount of mucus, mitosis in the cells are not observed, decidual cells are present in the stroma. What is the stage of the menstrual cycle?
A * Secretory (premenstrual)
B Menstrual
C Regenerative
D Proliferative
E Relative rest

There is prolongation of the large follicle growth phase at the patient with pituitary adenoma (the tumor of adenohypophysis). What is the length of the oocyte large growth phase in norm?
A * 12-14 days
B Several decades (from 10-13 to 40-50) after the birth
C After the birth until the puberty
D From 3 months of prenatal development to the birth
E 28 days

The hyperemia of the ovary, increased blood-follicular barrier permeability with next edema development, infiltration of the follicle wall by the segmented leukocytes is observed at the female. The follicle volume is large. The wall of it is very thin. What is the stage of the menstrual cycle?
A * Preovulatory stage
B Ovulation
C Menstrual stage
D Postmenstrual stage
E Relative rest stage

A diagnostic biopsy of the endometrium was made to the patient with infertility at the gynecologcal department. At the microscopic examination t was revealed that the mucosa is edematous, uterine glands are corkscrew shaped and filled with a thick secret. What hormone excess amount will lead to such changes in the endometrium?
A * Progesterone
B Estrogen
C Testosterone
D Somatotropin
E ACTH

A low concentration of estrogen and high level of progesterone was revealed in the blood of not pregnant 26-year-old women. At what stage of menstrual cycle the analysis was made?
A * Premenstrual phase (secretory)
B Menstrual phase
C Postmenstrual phase (proliferative)
D Phase of desquamation
E Proliferation phase of endometrium

The bleeding was stopped after the childbirth as a result of oxytocin action on the uterus wall. What component of the uterine wall takes the main part in it?
A * Middle layer of the myometrium
B Endometrium
C Inner layer of the myometrium
D Superficial layer of the myometrium
E Perimetrium

The bleeding was stopped after the childbirth as a result of oxytocin action on the uterus wall. What component of the uterine wall is reacting on the oxytocin action?
A * Myometrium
B Endometrium
C Perimetrium
D Parametrium
E Submucosa

It was found that the level of progesterone is approaching the lower limit of normal and the level of estrogens is approaching the upper limit of normal during analyzing the blood of women. At what stage of menstrual cycle was taken the blood test?
A. *In the phase of desquamation
B. In the early phase of proliferation
C. During ovulation
D. In the mid-phase of secretion
E. In the late phase of secretion

The patient was diagnosed with a collapse of the ovary during examination. Specify in which of the following phases of the menstrual cycle occurs the ovulation.
A. *Relative rest phase
B. Menstrual phase
C. Postmensrtual phase
D. Premenstrual phase
E. During the entire menstrual cycle

There are atrophy of the endometrium and myometrium of the uterus, atrophy of the follicles in the ovary, sclerotic changes of the blood vessels of these organs in women in the menopause. What factors cause these changes?
A *Insufficiency of lutropin
B Excess of follitropin
C Excess of lutropin
D Excess of lactotropin
E Excess of estrogens

It was found that the level of hormones progesterone and estrogen is approaching the lower limit of normal during analysis of the woman blood. At what stage of the cycle was taken a blood test?
A *Menstrual
B Postmenstrual phase (regenerative)
C Postmenstrual phase (proliferative)
D Relative rest phase
E Premenstrual

Human embryo consisting from two blastomeres was found. Name the place of its localization under the condition of its normal development.
A *Uterine tube
B Uterus
C Abdominal cavity
D Endometrium
E Ovary

The cessation of bleeding after birth relates with the influence of hormones on the structures of uterus. What structural component of the uterine wall is involved in this process?
A *The middle layer of the myometrium
B Endometrium
C The inner layer of the myometrium
D The superficial layer of the myometrium
E Perimetrium

The cessation of bleeding after birth relates with the action of oxytocin on the uterine wall. What layer of the uterus responds to the action of this hormone?
A *Myometrium
B Endometrium
C Perimetrium
D Parametrium
E Submucosa

Cyclic changes of epithelium were found in histological examination of smears from the vagina of 37-year-old women during the menstrual cycle. What kind of epithelium lines the vaginal wall?
A *Stratified squamous nonkeratinized
B Simple columnar glandular
C Pseudostratified ciliated epithelium
D Transitional epithelium
E Stratified cuboidal

Results of Credit 3.

Student _____ Group _____

Date	Mark	Signature