Ministry of health Republic of Belarus
Establishment of education “Gomel state medical university”

Department of histology, cytology and embryology

MANUAL
for 1-st year students of faculty of foreign students on gynecology

Topic: 5:
HISTOPHYSIOLOGY OF THE ORAL ORGANS

Duration 4 hours

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Gomel 2022

THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

The digestive system of the person consists of the bodies making the digestive channel, and greater closely connected by it glands – a liver and a pancreas. The wall of hollow bodies of digestive system is formed by 4 membranes: mucous, sub mucous, muscular and adventitial, or serous

THE PURPOSE

Studying of a microscopic and ultramicroscopic structure and morphofunctional features of organs of a mouth and a teeth.

3. PROBLEMS

The student should know:

1. A general plan of a structure of a wall of organs of digestive system.
2. Embryonic sources of development of bodies of a forward department of a digestive path.
3. Features of a structure of organs of oral cavity (a lip, a cheek)
4. Structures of a tooth, their structure and structure.

The student should be able:

1. To define at a microscopic level structures of oral cavity.
2. To define parts of a tooth and tissues making them.
3. To identify structure of enamel, dentine and cementum of a tooth at microscopic and ultramicroscopic levels.
4. To explain interrelation structural and histochemical features of organs of oral cavitywith function carried out by them.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat questions from normal human anatomy about a structure of organs of oral cavity and teeth.

CONTROL QUESTIONS FROM RELATED SUBJECTS

1. Anatomy and topography of organs of oral cavity (lips, cheeks,).
2. Blood supply walls of a digestive canal.

CONTROL QUESTIONS ON THE THEME

1. Structural components and functions of digestive system.
2. Development of digestive system.
3. A general plan of a structure of a wall of the digestive channel.
4. Oral cavity. Structural components and features of mucosa.
5. A histologic structure of oral cavity organs. Lips, gums, cheeks, palatine.
6. Structure of tongue.
7. Development of a tooth. Structure of the tooth parts.
8. Blood supply of the teeth. Age changes.

THE PRACTICAL PART

1. A general plan of a structure of a gastro intestinal tract – to fill the scheme (Exercise № 1 in album).

2. Microscopy and a sketch in an album of a preparation « tongue of the rabbit » (Exercise № 2 in album).

3. The scheme of a structure of a tooth – to enter designations (Exercise № 5 in album).

4. To study sources of development of a tooth and to fill the scheme (Exercise № 6 in album).

5. Microscopy and a sketch in an album of preparations: « Development of a tooth. A stage of enamel body »; Development of a tooth a late stage » (the task №3, 4 in an album) (Exercise № 3, 4 in album)...

6. Studying diagrams

SLIDES

1. Tongue of a rabbit
2. Development of tooth, enamel organ stage.
3. Development of tooth, dentin and enamel production stage.

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1. Structural components and functions of digestive system.
2. Histogenesis of digestive system.
3. Layers and tissues of the wall of the alimentary canal.
4. Oral cavity. Structural components and features of the mucous membrane.
5. Histological structure of organs of the oral cavity. Lips, hard and soft palates, cheeks.
6. Tissue structure of tongue. Differences in structure of the mucous membrane dorsal and ventral surface of tongue. Papillae's of tongue.
7. Sources of tooth development. Dental bud. Enamel organ. Histogenesis of dentin and enamel.
8. Structure and functions of: a) enamel
   b) dentine
   c) cementum
   d) pulp
9. Blood supply and innervations of teeth. Age changing. Second dentition.

HISTOPHYSIOLOGY OF THE ORAL ORGANS

The wall of the oral cavity is made up partly of bone, and partly of muscle and connective tissue (lips, cheeks, soft palate, and floor of mouth). These structures are lined by mucosa. The oral cavity is lined by mucosa with nonkeratinized stratified squamous epithelium. Its superficial cells are nucleated and have scanty granules of keratin in their interior. In the lips, a transition from nonkeratinized to keratinized epithelium can be observed. The lips have an 'external' surface lined by skin, a transitional zone and an 'internal' surface lined by mucosa. A transitional zone is sometimes referred to as the *vermilion*, because of its pink color. This part meets the skin along a distinct edge. The 'external' surface of the lip is lined by true skin in which hair follicles and sebaceous glands can be seen.

The lamina propria of the oral cavity has papillae, similar to those in the dermis of the skin, and is continuous with a submucosa containing diffuse small salivary glands. The muscularis mucosae is absent. Submucosa is not always present. It is necessary for the cheeks and lips, but it is never present in hard palate and gingivae [1].

Muscularis externa is represented by the skeleton muscle. Sometimes muscularis externa is replies of the bone.

The roof of the mouth is composed of the hard and soft palates, both covered with the same type of stratified squamous epithelium. In the hard palate, the mucous membrane rests on bony tissue. The soft palate has a core of skeletal muscle and numerous mucous glands in its submucosa.

The tongue is a mass of striated muscle covered by a mucosa on the dorsal surface and a mucosa with submucosa on the ventral. The muscle fibers cross one another in 3 planes. This arrangement of muscle fibers is found only in the tongue and allows for easy histological identification of this tissue as lingual muscle.

Numerous mucous and serous salivary glands locate between the muscle fibers. The dorsal surface is covered by a great number of small eminences called papillae, creating mucosa.. The three main types *are filiform, fungiform,* and *circumvallate papillae.* A fourth type located at the edges of the tongue are the *foliate papillae.* Taste buds are located hi the facing walls of the neighboring papillae.

The filiform papillae are the most numerous and smallest. They consist of a connective tissue core covered by stratified squamous epithelium. Their epithelium, which does not contain taste buds, is frequently partially keratinized and can to form white patch. [1, 2].

TEETH

Each tooth is composed of a portion that projects above the gingiva (or gum) – the crown – and one or more **roots** below the gingiva that hold the teeth in bony sockets called **alveoli,** one for each tooth. The greater part of the tooth is formed by a bone-like material called *dentine.* The crown is covered by the extremely hard **enamel,** while roots are covered by **cementum.** These 2 coverings meet at the **neck** (or cervix) of the tooth. The **periodontal ligament** is a collagenous, fibrous struclure inserted in the cementum that serves to fix the tooth firmly in its bony socket (alveolus).

Within the dentine there is the pulp *cavity* which contains a loose connective tissue, blood vessels, and nerves which constitute the pulp. The blood vessels and nerves enter the pulp canal through the *apical foramen* which is located at the apex of the root [3].

Dentin is a calcified tissue similar to bone but harder. It is composed mainly of collagen fibrils (type I), glycosaminoglycans, and calcium salts (70% of dry weight) in the form of crystals of **hydroxyapatite.** The organic matrix of dentin is secreted by odontoblasts, cells that line the internal surface of the tooth, separating it from the pulp cavity.

The odontoblast is a polarized, slender cell, producing organic matrix only at the dentinal surface. The cytoplasm of each of these cells contains a nucleus at its base, a large Golgi complex, many free ribosomes and rough endoplasmic reticulum, and secretion granules containing procollagen. Odontoblasts have slender, branched cytoplasmic extensions that penetrate perpendicularly through the width of the dentin – the **odontoblast processes** (Tomes fibers). These processes gradually become longer as the dentin becomes thicker, running in small canals called **dentinal tubules** that are extensively branched near the junction between dentin and enamel. The space between the process of the cell and the tubule is full of tissue fluid. The matrix produced by odontoblasts is initially unmineralized and is called **predentin.** Mineralization of developing dentin begins when membrane-limited vesicles – **matrix vesicles** – appear. They contain fine crystals of hydroxyapatite that grow and serve as nucleation sites for further mineral deposition on the surrounding collagen fibrils.

Like bone, dentine is laid down in layers. The layers may be separated by less mineralized tissue that forms the *incremental lines of Von Ebner.* The ground substance of dentine is more dense immediately around the dentinal tubules, and forms the *peritubular dentine.*

In contrast to bone, dentin persists as a mineralized tissue for a long time after destruction of the odontoblasts. It is thus possible to maintain teeth whose pulp and odontoblasts have been destroyed by infection. In adult teeth, destruction of the covering enamel by erosion due to use or dental caries usually triggers a reaction in the dentin that causes it to resume the synthesis of its components [1 – 3].

Enamel

Enamel is the hardest component of the human body. It consists of about 95% calcium salts (mainly hydroxyapatite), 0.5% organic material, and water as the remainder. Enamel is a cell-free extracellular tissue. Enamel consists of elongated columns of hydroxyapatite crystals called **enamel rods** (prisms) that are bound together by **interred enamel.** Interred enamel differs from rod enamel onlv in the orientation of the hydroxyapatite crystals that form both structures. Each rod extends through the entire thickness of the enamel layer. The organic enamel matrix is not composed of collagen fibrils but consists of at least 2 heterogeneous classes of proteins called amelogenins and **enamelins.** The roles of these proteins in the organization of the mineral component of enamel are under intensive investigation.

During development, enamel is laid down in the form of layers. They are separated by lines running more or less parallel to the surface of the enamel. These lines are called the *incremental lines* or the *lines of Retzius.*

Enamel is an extracellular product of the cells called ameloblasts. They are cells of ectodermal origin [1 – 4].

These tall, columnar cells possess numerous mitochondria in the region below the nucleus, well-developed rough endoptasmic reticulum and Golgi complex above the nucleus. Each ameloblast has an apical extension, containing numerous secretory granules. These granules contain the proteins amelogenins and **enamelins,** that make up the enamel matrix. Ameloblasts disappear after formation of the enamel.

Although the enamel of an erupted tooth is devoid of cells, it is not a static tissue. Erupted enamel is under the influence of the salivary glands through their production of saliva without which the enamel is subject to decay.

Cementum: This tissue covers the dentin of the root and is similar in composition to bone, although haversian systems and blood vessels are absent. It is thicker in the apical region of the roots. In this area there are cells with the appearance of ostcocytes, the cementocytes. Like osteocytes, they are encased in lacunae that communicate through canaliculi. This cementum is called *cellular cementum.* In other regions, the cementum contains no cells; this is the *noncellular cementum.* It is more old.

Like bony tissue, cementum is labile and reacts by resorption or production of new tissue according to the stresses to which it is subjected. When the periodontal ligament is destroyed, cementum undergoes necrosis and may be resorbed. Continuous production of cementum compensates for the normal growth that teeth undergo. This process maintains a close contact between the roots of the teeth and their sockets [5, 6].

The primary function of cementum is to provide for the attachment of collagen fibers of the periodontal ligament. Those collagen fibers that extend from the periodontal ligament into the cementum are called *Sharpey's fibers.*

Pulp

Tooth pulp consists of a loose connective tissue. Its main components are odontoblasts at its perimeter, fibroblasts, thin collagen fibrils, and a ground substance containing glycosaminoglycans.

Pulp is a highly innervated and vascularized tissue. Blood vessels and myelinated nerve fibers enter the apical foramen and divide into numerous branches. Some nerve fibers lose their myelin sheaths and extend for a short distance into the dentinal tubules. These sensory fibers are sensitive to pain.

The periodontal ligament is composed of a special type of dense connective tissue. Its fibers penetrate the cementum of the tooth and bind it to the bony walls of its socket – permitting, however, limited movements of the tooth.

Collagen of the periodontal ligament has characteristics that resemble those of immature tissue. It has a high rate of the renewal. Protein or vitamin C deficiency to cause atrophy of this ligament. As a consequence, teeth become loose in their sockets and in extreme cases may fall out. This relative plasticity of the periodontal ligament is important because it allows orthodontic intervention, which can produce extensive changes in the disposition of teeth in the mouth [1 – 3].

Development of Teeth

At about 6 weeks of gestation, oral epithelium (it is the ectoderm) proliferates and bulges into the underlying mesenchyme. A horseshoe-shaped band known as the **dental lamina** is formed in each jaw. A little later, 10 regions of intensified mitotic activity are noted in each dental lamina. These ectodermal outgrowths form caps over clumps of mesenchyme, and each will develop into a deciduous tooth. The intervening ectodermal cells later degenerate and disappear. The ectodermal component of a tooth bud forms the **enamel organ** responsible for the secretion of **enamel.** The mesenchymal component, which is derived from the neural crest, forms the **dental papilla. Odontoblasts** (cells that secrete dentin) and other structures of the dental pulp will differentiate from the papilla. Other mesenchyme (it is derived from mesoderma) condenses around the enamel organ, forming **dental sac,** and will eventually differentiate into **cementoblasts** (cells that form cementum) and the **periodontal ligament.**

The enamel organ continues to enlarge and assumes a bell shape at about 8 weeks of gestation. The **outer** (external) **enamel epithelium,** which is continuous with the dental lamina, is indented by numerous capillary vessels. Cells immediately adjacent to the dental papilla assume a columnar shape and form the **inner** (internal) **enamel epithelium.** These cells differentiate into **ameloblasts** (cells **that** will secrete enamel). Other epithelial cells between the outer and inner layers form the **stellate reticulum** and the **stratum intermedium;** the functions of these layers are nutrition of the ameloblasts.

Ameloblast differentiation is induced by the cells of the dental papilla. Before ameloblasts begin to secrete enamel, they cause a superficial layer of cells of the dental papilla to elongate and differentiate into odontoblasts. Odontoblasts begin to secrete predentin, which in **turn** stimulates the secretion of enamel by ameloblasts.

A. Formation of Dentin: Odontoblasts secrete procollagen, which becomes organized into the collagen fibrils of **predentin.** These cells also mediate the mineralization of collagen fibrils, leading to the formation of dentin. The cell bodies of odontoblasts retreat into the pulp cavity as dentin accumulates, but their processes remain in **dentinal tubules** that span the entire thickness of the dentin.

B. Formation of Enamel: Ameloblasts are unusual epithelial cells because their histologic base, adjacent to the basal lamina, become their secretory surfaces.

Rough endoplasmic reticulum and an elaborate Golgi complex are **found** in the cytoplasm between the nucleus and the functional apex of these cells. Ameloblasts are responsible for the breakdown of the basal lamina that separates these cells from odontoblaslb and dentin. Short, conical extensions of ameloblasts **(Tomes processes)** are the sites of secretion of enamel matrix. The lateral surfaces of Tomes processes secrete the organic matrix of the **interrod enamel,** while the apical surface is responsible for deposition of the matrix of **enamel rods** (prisms). Hydroxyapatite crystals are formed on the organic matrix.

After enamel formation is completed, the enamel organ consists of a stratified squamous epithelium that is rapidly eroded when the tooth erupts into the oral cavity,

Root Development: After crown development is complete and just prior to its eruption, the cervical loop grows apically to envelop the dental papilla and forms **Hertwig's root sheath,** which is composed of the fused outer and inner enamel epithelia. The inner layer induces formation of odontoblasls that produce the dentin of the tooth root. When dentin has been formed, the root sheath breaks up, and newly formed dentin induces differentiation of **cementoblasts** from mesenchymal cells of the surrounding dental sac. Cementoblasts form the bonelike tissue (cementum) covering the roots of teeth [1 – 4].

Enamel is produced by cells of ectodermal origin,

Dentin – mesenchyme, which is derived from the neural crest.

Cementum and periodontal ligament – mesenchyme, which is derived from mesoderma

A little later and slower, but parallel with the formation of the deciduous tooth, the formation of the germ of permanent tooth begins [3].

REFERENCES

1. Singh, I. Textbook of Human Histology : with Colour Atlas and Practical Guide / I. Singh ; revised and edit. by N. Vasudeva, S. Mishra. – 8th edition. – New Delhi : Jaypee Brothers, 2016. – 300 p. – Mode of access: https://docs.google.com/file/d/0BxvjJ4mG_bfYV2ZjSTZzZ3VmVUU/edit?resourcekey=0-l0rcPJlIPE-C8jNx7fsOiA – Date of access: 25.01.2022.

2. Lowe, J. S. Stevens & Lowe's human histology [Electronic resource] / J. S. Lowe, P. G. Anderson, S. I. Anderson. – 5th ed. – China : Elsevier, 2020. – VIII, [I], 426 c. : color. ill. + Student Consult online. – Mode of access: https://www.sciencedirect.com/book/9780723435020/stevens-and-lowes-human-histology-fourth-edition – Date of access: 25.01.2022.

3. Кузнецова, Т. Г. Гистология, цитология и эмбриология : учеб.-метод. пособие для студентов 2 курса фак-та по подготовке специалистов для заруб. стран, обуч. на англ. языке = Histology, cytology and embryology in English for 2-nd year students of Faculty on preparation of experts for foreign countries, studying on speciality of “General Medicine» of medical higher educational institutions / Т.Г.Кузнецова, Е. К. Солодова ; пер. Т.Г.Кузнецова, – Гомель : ГомГМУ, 2016. – Ч. 2. – 64 с.

4. Солодова, Е. К. Тестовые задания по гистологии: учеб.-метод. пособие для студентов 1 курса факультета по подготовке специалистов для зарубежных стран медицинских вузов: в 2 ч. = Histology tests: teaching workbook for 1st year students of Faculty on preparation of experts for foreign countries of medical higher educational institutions: in 2 parts / Е. К. Солодова; ред. англ. текста А. Ф. Максименко. – Гомель: ГомГМУ, 2015. – Ч. 1. – 44 с. – Mode of access: https://elib.gsmu.by/handle/GomSMU/2466 – Date of access: 25.01.2022.

5. Солодова, Е. К. Тестовые задания по гистологии: учеб.-метод. пособие для студентов 2 курса факультета по подготовке специалистов для зарубежных стран медицинских вузов: в 2 ч. = Histology tests: teaching workbook for 1st year students of Faculty on preparation of experts for foreign countries of medical higher educational institutions: in 2 parts / Е. К. Солодова; ред. англ. текста А. Ф. Максименко. – Гомель: ГомГМУ, 2014. – Ч. 2. – 44 с. – Mode of access: https://elib.gsmu.by/handle/GomSMU/2467 – Date of access: 25.01.2022 [5 – 7].