The digestive system consists of the alimentary canal (oral cavity, mouth, esophagus, stomach, small and large intestines, rectum, and anus) and its principal associated glands (salivary glands, liver, and pancreas).

Embryonic sources of alimentary canal tissues development

The stratified epithelium of the anterior (oral cavity, pharynx and esophagus) and posterior parts (rectum) of the alimentary пищевого canal is of the ectodermal origin. The organs of these both region contain skeletal muscles which are developed from myotomes of mesoderma somites. The middle part of the alimentary canal lines with the simple columnar epithelium of the entodermal origin and the smooth muscle, which develops from mesenchyme.

The connective tissue of the alimentary canal organs has the mesenchymal origin.

General structure of the digestive tract (alimentary canal)

The digestive tract is a hollow tube composed of 4 principal layers: the mucosa, the submucosa, the muscularis externa, and the serosa.

The mucosa (mucous membrane) is composed of: 1) epithelium; 2) lamina propria; 3) muscularis mucosae.

The main functions of the epithelium lining of the digestive tract are the following:

1) to provide a selectively permeable barrier between the content of the tract and the tissues of the body;

2) to facilitate the transpórt and digestion of food;

3) to promote the absorption of the products of this digestion;

4) to produce hormones that affect the activity of the digestive system;

5) epithelial cells produce mucus that is involved вовлекается in digestion or absorption of food.

The lamina propria is loose connective tissue rich in blood and lymph vessels and smooth muscle cells, sometimes containing also glands and lymphoid tissue.

The muscularis mucosae, usually consisting of an inner circular and an outer longitudinal layer of smooth muscle cells separates the mucosa from the submucosa. In some regions of alimentary canal (oral cavity) it is absent.

The muscularis mucosae promotes the movement of the mucosa indepéndently of other movements of the digestive tract and increases its contact with the food. The contractions of the muscularis externa propél and mix the food in the digestive tract. Nerve plexuses coordinate this muscular contraction.

The submucosa is composed of loose connective tissue with many blood and lymph vessels and a submucosal (also called Meissner's) nerve plexus, which innervates secretory cells and myocytes of the mucosa. The submucosa also contain glands and lymphoid tissue.

In most part of the alimentary canal the muscularis externa consists of smooth muscle. Only in the upper part of the esophagus this layer contains striated muscle fibres.

The muscularis externa is divided into 2 sublayers: the internal sublayer where the muscles orientation is generally circular and the external sublayer where the muscles orientation is generally longitudinal. The muscularis externa contains the myenteric plexus also called Auerbach's nerve plexuses of vegetative nervous system, which are located between the muscle sublayers. They innervate and control contraction of the muscularis externa. The contractions of the muscularis externa propél and mix the food in the digestive tract.

The serosa is a thin layer, covering the alimentary canal from outside. It is composed of loose connective tissue and simple squamous epithelium called mesothelium. The serosa is the visceral peritoneum that covers most parts of the gastrointestinal tract. In some places where a mesothelium absent (e.g., upper part of the oesophagus) the muscularis externa is covered by an adventitia which made up only of loose connective tissue.

Lymphatic tissue of digestive tract

The abundant lymphatic tissue presenting in the lamina propria and in the submucosal layer in association with the epithelium protects the organism against bacterial invasion and other antigenic substances that could potentially enter through the mucosa from the lumen of the alimentary canal. The lymphatic tissue is represented by diffuse lymphatic tissue consisting of numerous lymphocytes and plasma cells, lymphatic nodules, eosinophils and macrophages.

The diffuse lymphatic tissue and the lymphatic nodules are referred to as gut-associated lymphatic tissue (GALT). In the distal small intestine, the ileum, extensive aggregates of nodules, called Peyer's patches, occupy much of the lamina propria and submucosa. Large aggregations of lymphatic nodules are also present in the appendix and tonsils.

GALT serves as an immunologic barrier throughout the length of the gastrointestinal tract. In cooperation with the overlying epithelial cells, the lymphocytes and other antigen-presenting cells process the antigens and migrate to lymphatic nodules in the lamina propria where they undergo activation leading to antibody secretion by newly differentiated plasma cells. Plasma cells produce antibodies mainly immunoglobulin A (IgA). Immunoglobulins A secrete into a lumen of gastrointestinal tract trough epithelial cell. In the lumen, IgA binds to antigens, toxins, and microorganisms to prevents the attachment and invasion of viruses and bacteria to the mucosa.

Oral Cavity

The wall of the oral cavity is made up partly of bone (Jaws (dʒo:s) , hard palate, and partly of muscle and connective tissue (lips, cheeks, soft palate and floor of mouth). These structures are lined by mucosa presenting by 2 sublayers – epithelium and lamina propria. Epithelium of oral cavity organs is stratified nonkeratinized squamous.

In the lips the nonkeratinized epithelium is transited into the keratinized epithelium. The lips have 3 regions: 1) an external surface (thin skin) lining by stratified keratinized squamous epithelium; 2) an intermediate zone

(mucocutaneous junction) lining by stratified parakeratinized squamous epithelium and 3) an internal surface (labial mucosa) lining by stratified keratinized squamous epithelium. An intermediate zone of the lips has pink color because there are many blood vessels in lamina propria of this lips part. Parakeratinized epithelium is similar to keratinized epithelium except that the superficial cells do not lose their nuclei which are pyknotic (highly condensed) and remain until the cell is exfoliated from epithelial surface.

The lamina propria of the oral cavity mucosa is continuous with a submucosa containing diffuse small salivary glands.

Submucosa is not always present in oral cavity organs. It is present in the cheeks and lips, but it is never present in hard palate and gingivae.

Muscularis externa of oral cavity organs is represented by the skeletal muscle tissue.

The roof of the mouth is composed of the hard and soft palates. In the hard palate, the mucous membrane rests on bony tissue. The soft palate has a skeletal muscle and numerous mucous glands in its submucosa.

Tongue

The tongue is essential to human speech as well as its role in digestion and swallowing.

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. Variable amounts of adipose tissue are found among the muscle fiber groups. Numerous mucous and serous salivary glands locate between the muscle fibers.

The dorsal surface is covered by a great number of small eminences of mucosa called lingual papillae. There are four types of papillae. They are filiform, fungiform, circumvallate and foliate.

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. Keratinized epithelium can form white

patch on the dorsal surface of the tonge. This epithelium does not contain taste buds. Filiform papillae serve only a mechanical role and are distributed over на the entire anterior dorsal surface of the tongue.

Fungiform papillae are mushroom shaped projections located on the dorsal surface of the tongue. 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 moat likes invagination lined with stratified squamous epithelium that contains numerous taste buds. Ducts of lingual salivary (von Ebner's) glands empty their serous secretion into the base of the moats. This secretion flushes material from the moat to enable the taste buds to respond rapidly to changing stimuli.

Foliate papillae consist of parallel ridges separated by deep mucosal clefts. They situate on the lateral edge of the tongue. The foliate papillae are characteristic for the children. In younger individuals, they are easily found on the posterior lateral surface of the tongue and contain many taste buds in the epithelium of the facing walls of neighboring papillae. In aged individuals, the foliate papillae may not be recognized. Small serous glands empty into the clefts between foliate papillae.

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. There is alveolus for each tooth. The greater part of the tooth is formed by a bone-like material called dentine. The crown is covered by the hard enamel, while roots are covered by cementum. These 2 coverings meet at the neck (or cervix) of the tooth.

Dentin forms all parts of tooth. It lies deep to the enamel in the crown and cementum in the root. Within the dentine there is the pulp cavity which contains a loose connective tissue, blood vessels, and nerves. The blood vessels and

nerves enter the pulp canal through the apical foramen which is located at the apex of the root.

The periodontal ligament is a collagenous, fibrous structure inserted in the cementum. The periodontal ligament fixes the tooth in its bony socket (alveolus).

Dentin

Dentin is a calcified tissue similar to bone but it's 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 cells called odontoblasts. They are cells laying on border with the pulp cavity.

The odontoblast is a polarized, slender cell, having well developed synthetic apparatus. The cytoplasm of each of these cells contains a nucleus at its base. Odontoblasts have slender, branched cytoplasmic extensions called the odontoblast processes (Tomes fibers). Tomes fibers are situated in the small canals called dentinal tubules of dentin. 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. Predentin situates near the junction of dentin with the pulp cavity.

Enamel

Enamel is the hardest component of the human body. It consists of about 96 to 98% calcium salts mainly hydroxyapatite, 1% organic material, and 3% water. Enamel is an acellular mineralized tissue that covers the crown of the tooth.

Enamel consists of elongated columns of calcium chydroxyapatite crystals called enamel rods. Each enamel rod spans охватывает the full thickness of the enamel layer from the dentinoenamel junction to the enamel surface. The rods keyhole shape with ballooned superior part called head, and inferior part called tail which is directed toward the root of the tooth. Striations on enamel rods called lines of Retzius are evidence of rhythmic growth of the enamel in the developing tooth.

Enamel is an extracellular product of the cells called ameloblasts. They are cells of ectodermal origination. Ameloblasts are tall, columnar cells with 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 that make up the enamel matrix.

Once formed enamel cannot be replaced, because cells ameloblasts disappear after formation of the enamel. Usually it takes place at about the time of tooth eruption through the gum.

Despite enamel hardness, it can be decalcified by acid-producing bacteria acting on food products trapped on the enamel surface. This is the basis of the initiation of caries.

Cementum

Cementum covers the dentin of the root and is similar to bone, although haversian systems and blood vessels are absent. Like bone, cementum is 65% mineral. It is thicker in the apical region of the roots. In this region, the cementum contains cells called the cementocytes. Like osteocytes, they are situated in lacunae that communicate through canaliculi. This cementum is called cellular cementum. In other regions, the cementum daesn't contain cells. This is the noncellular cementum. It is older.

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

Development of Teeth

At about 6 weeks of gestation, oral ectodermal epithelium proliferates and invaginates into the underlying mesenchyme. As a resalt of this 2 horseshoe shaped bands known as the dental lamina are formed in each jaw. Later, 10 regions of intensified mitotic activity appear in each dental lamina. These ectodermal

outgrowthes called tooth buds or early enamel organ responsible for the secretion of enamel later. Thus this stage of tooth development is called 1) bud stage.

Neural crest origin mesenchymal cells adjacent to the tooth bud begin to differentiate, forming the primordium of tooth pulp called dental papilla that protrudes into the tooth bud.

2) Cap stage. In this cap stage the tooth bud is transformed into cap shaped structure. The cells located in the concavity of the cap differentiate into tall, columnar cells forming the inner enamel epithelium. The condensed mesenchyme invaginates into the inner enamel epithelium, forming the dental papilla, which gives rise to the dentin and the pulp of tooth. At this stage, the forming tooth is surrounded by condensed mesenchyme, developing from mesoderm and called the dental sac. It gives rise to cementum of tooth and periodontal structures.

3) Bell stage. In bell stage, the enamel organ consists of an outer enamel epithelium, an inner enamel epithelium formed by ameloblasts, several condensed layers of cells that form the stratum intermedium, and the widely spaced stellate reticulum cells. The dental papilla is deeply invaginated within the enamel organ.

4) Dentin and enamel stage or crown stage. In dentin and enamel stage, the enamel organ is completely differentiated and loose the connection with oral epithelium. The formation of the two mineralized tissues of the dental crown - enamel and dentin begins.

Dentin is the first mineralized component of the tooth to be deposited. Dentin is produced by odontoblasts, wich differentiate from cells at the periphery of the dental papilla, lying on border with the enamel organ. Enamel matrix is then deposited by ameloblasts directly on their surfaces towards the forming dentin.

For dentin and enamel stage the surrounding tooth mesenchyme has developed into bony tissue.

5) Tooth eruption stage. In stage of tooth eruption, the apex of the tooth emerges through the surface of the oral epithelium. The odontoblastic layer lines the pulp cavity. Note of this stage the developed periodontal ligaments that fasten the root of the tooth to the surrounding bone.

Thus, the main sources of tooth development are ectoderm and mesenchyme.

Enamel is produced by cells of ectodermal origin – ameloblasts.

Dentin and tooth pulp is developed from mesenchyme, which is derived from the neural crest.

Cementum and periodontal ligament is developed from mesenchyme, which is derived from mesoderm.

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