PREFACE

The second volume of textbook systematically presents the material on alimentary, respiratory, urinary and genital systems according to the current curriculum for medical universities.

In addition to providing general anatomical information, each section of the textbook includes material on the development, variations, and anomalies of organs and systems. The textbook also emphasizes clinical applications of the presented information. We paid particular attention to the substantiation of general principles in the study of anatomy: the correlation between the structure and function, the integrity of the organism, and the unity of the organism with its external environment. Each unit ends with practice questions, which allow students to self-evaluate their progress.

In preparing this textbook, we have been guided by the pedagogical expertise of many Ukrainian scientists-anatomists who became the coauthors of this work (Bobryk I. I., Kyiv; Voloshyn M. A., Zaporizhzhia; Holovatskyi A. S., Uzhhorod; Iliin I. I., Odesa; Kiriakulov H. S., Donetsk; Koveshnikov V. H., Luhansk; Kozlov V. O., Dnipro; Luzin V. I., Luhansk; Lupyr V. M., Kharkiv; Pykaliuk V. S., Simferopol; Romenskyi O. Yu., Vinnytsia; Sikora V. Z., Sumy; Fedoniuk Ya. I., Ternopil; Cherkasov V. H., Kyiv. All coauthors followed a uniform representational style depicting a modern scientific state of the subject in a given unit of the textbook.

In the textbook, we used new anatomical terminology, approved by FCAT (Saõ Paulo, 1997). Ukrainian equivalents of the terms are presented in accordance with the book "International Anatomical Nomenclature" edited by Professor I. I. Bobryk and Professor V. H. Koveshnikov (Kyiv, 2001).

Illustrations were borrowed from the manuals and textbooks accompanied by the authors' additions and revisions. The majority of the drawings made from the specimens are original.

The organization of the material on human anatomy into units corresponds to the curriculum of the credit/module-based educational system.

I wish to acknowledge and express my appreciation to N. H. Mykula, N. P. Mishenko, V. V. Mavrich, and O. S. Bolhova for their help in preparing this textbook for publication. Apart from this I'm truly greatful to Mrs. Larysa Sankova and Ms. Eugenie Bekova, who made the English translation of the book.

Comments, suggestions, and critique aimed to improve this textbook are welcomed by the authors and will be taken into consideration in further editions.

Professor V. H. Koveshnikov

SHORTENINGS KEY

a.	– arteria	– artery
aa.	– arterie	– arteries
art.	– articulation	– joint
artt.	– articulations	– joints
for.	– foramen	– opening
forr.	– foramina	– openings
lam.	– lamina	– plate
lamm.	– laminae	– plates
lig.	– ligamentum	– ligament
ligg.	– ligamenta	– ligaments
m.	– musculus	– muscle
mm.	– musculi	– muscles
n.	– nervus	– nerve
nn.	– nervi	– nerves
r.	– ramus	– branch
rr.	– rami	– branches
sul.	– sulcus	– sulcus
sull.	– sulci	– sulci
sut.	– sutura	– sutura
sutt.	– suturae	– suturae
v.	– vena	– vein
vv.	– venae	– veins

SPLANCHNOLOGY

GENERAL INFORMATION

Splanchnology is a branch of anatomy, which studies the structure of the internal organs. *Internal organs,* **splanchna** (Greek) or **viscera** (Latin), are the organs located mainly in body cavities (thoracic or abdominal) and in the areas of head and neck. Internal organs form alimentary, respiratory, urinary and genital systems (the heart will be discussed in "Angiology" section). The internal organs are responsible for important functions of the organism: homeostasis maintenance, metabolism, water and gases turnover, excretion of metabolic products and reproduction. The internal organs are traditionally referred to vegetable existence organs **(vegetabilis)** unlike animal existence organs **(soma)** which in turn are responsible for movements of the whole organism or its separate parts and environmental communication.

The main gross structural pattern for the hollow organs is a tube. The digestive tube has two openings: inlet and outlet; the respiratory system and the genitourinary apparatus have only one opening. The tubular organs communicate with parenchymal internal organs.

The structure of tubular organs' wall. The wall of the internal organs is also subject to a specific pattern and comprises mucosa, sub-mucosa, muscular layer and outer tunica, either serosa or adventitia. The structure of the tube may vary depending on functional features of separate segments yet the four-layer arrangement remains unchanged.

Mucosa, **tunica mucosa.** The mucosa is the inner layer, which faces the tube lumen. It is pink-colored, wet and normally covered with mucus, which protects mucosa against damage.

The mucosa consists of three layers as follows:

- *the epithelium of mucous membrane,* **epithelium mucosae;**
- *the lamina propria mucosae* (Lat. Id.), a layer of loose connective tissue;
- *the muscularis mucosae,* **lamina muscularis mucosae,** a layer of smooth muscular tissue.

Epithelium of mucous membrane varies depending on function of the tube segment and may be stratified squamous non-keratinized, simple (columnar, prismatic, cuboidal and squamous) and transitional.

Epithelium separates the internal environment from the external, provides protection, and takes part in processes of absorption, excretion, and secretion of substances.

Lamina propria mucosae is a layer of loose connective tissue containing numerous blood and lymphatic vessels, which give the capillaries that reach epithelium and perform trophic and absorption functions.

Apart from this, the lamina propria provides protection and serves as scaffold for epithelium. Protection is provided by means of lymphoid tissue composed of

single lymphocytes, lymphocytic clusters and plasmatic cells producing secretory immunoglobulin[1].

The muscularis mucosae is a thin layer of smooth muscle fibers, which contracts to change the relief of mucosa. With the plate tonus increase, numerous wrinkles appear on the mucosa surface and smooth out after relaxation.

The submucosa, **tela submucosa,** is formed of loose connective tissue, which fixes mucosa to the muscular layer. Submucosa contains nerves, larger blood and lymphatic vessels, nerve plexuses, ganglia and separate autonomic neurons, glands and lymphoid nodules. At the places where submucosa is developed quite well the mucosa forms folds and areas. In some places, submucosa is scarce and mucosa adheres directly to muscular layer. Such places feature smooth mucosa free from folds.

The glands of mucosa, **glandulae,** are the organs composed of glandular epithelium, which produces secretion extruded into a tube lumen of the hollow viscera (external or exocrine secretion). The mucosa features larger or smaller quantity of various glands that produce mucus and digestive juices. The glands develop from epithelial cells, which grow and incorporate into mucosa or submucosa yet keeping connection with the site of origin via ducts.

The glands in mucosa are classified into unicellular glands (goblet cells) located between epithelial cells and multicelluar glands of various sizes and shapes with secretory portion lying under basement membrane. The glands produce mucous secretion. Multicellular glands have ducts, which open on the surface of mucous membrane.

The glands, which have ducts, are referred to as exocrine glands. The ductless glands are referred to as endocrine because they secrete the products into bloodstream.

Depending on secretory portion structure the glands are classified into tubular, acinar and tubuloacinar. They also may be **simple** and **compound.**

Simple glands have shape of tubule, vesicle, or sac.

Compound glands appear as system of branched tubules and alveoles with well visible ducts.

The compound glands are larger and reach submucosa. The largest exocrine glands are the liver, the pancreas, the major salivary glands; they develop the same as lesser but in the development process reach large size and leave the tube limits.

Lymphoid tissue. The mucosa and submucosa contain a lot of lymphoid tissue represented with lymphoid nodules, clusters and tonsils. Their structure is based on reticular tissue framework with lymphocytes and macrophages placed between the tissue loops. Generally lymphoid nodules look like rounded clusters of lymphoid tissue lacking connective tissue capsule.

The nodules are distinguishable as either solitary ones 1.5–2.0 mm of size or aggregated ones growing up to several centimeters. The tonsils (palatine, lingual, pharyngeal, etc.) have the similar structure but are much larger.

[1] – Details are provided in histology course

Functions of lymphoid tissue. Lymphoid tissue belongs to immune system and provides immunobiological protection against foreign antigenic information (microorganisms, bacteria, viruses, foreign cells and proteins). Together with plasmatic cells, lymphocytes create a defense barrier against microbes and other antigens penetrating through epithelium. The most significant aggregations of follicles reside in the walls of alimentary and respiratory systems because these tubes are open to ambient.

Muscular layer, **tunica muscularis**. This tunica is mainly composed of non-striated (smooth) muscular tissue and most often forms two layers – the external *longitudinal* **(stratum longitudinale)** and internal *circular* **(stratum circulare)**. At the beginning and the end of the tubular organs there are striated muscles, which provide voluntary contractions and regulate the tube orifice diameter.

Smooth muscular fibers form distinct layers and provide involuntary, slow, waveform unidirectional contractions. Such contractions are called *peristalsis.* In some pathologies *antiperistalsis* may appear (e.g. in vomiting) when contraction waves move in opposite direction.

The circular layer in certain places thickens to form sphincters, which prevent tube contents from backflow.

External tunica. The external tunica may be represented with either serosa or adventitia.

Serosa, **tunica serosa,** consists of connective tissue and a single layer of cells – mesothelium. The surface of serosa is smooth, shining and moistened with serous fluid. These properties provide frictionless movements of viscera.

There are three types of serous tunics: peritoneum, pleura and pericardium facing the serous cavities. Inflammation of these tunics (peritonitis, pleurisy or pericarditis respectively) belongs to severe processes, which require intensive treatment. The inflammatory processes may result in adhesions, which restrict the organ motility and cause chronic painful sensations.

The external tunic, **tunica adventitia,** covers the organs in the areas devoid of serous coating[1].

Adventitia is formed of loose connective tissue, which adheres to neighboring tissues; the organs covered with adventitia are less movable than serosa-covered organs. The adventitia contains the vessels and nerves, which supply the organs.

Parenchymal organs. Parenchymal organs are liver, pancreas, salivary glands, lungs, kidneys, genitals and some other. The parenchymal organs consist of parenchyma and stroma. The term **parenchyma**[2] is of Greek origin. As far back as in III century B.C., Erasistratus used this word to determine the glandular portions of liver, kidneys and lungs. Nowadays this tem stands for specific functional portion of glandular organs, which performs the chief function of the organ given.

[1] – **adventicus** (Latin) – outside, external
[2] – **parenchyma (eo)** (Greek) – pulp

Stroma[1] **(stroma)** is a connective tissue base (soft framework) which serves as scaffold. The connective tissue layers of stroma contain nerves, blood and lymph vessels. These layers divide the parenchyma into more or less isolated areas – lobes, segments or lobules, which contain morpho-functional units of the organs.

Morpho-functional unit of the organ is the smallest portion of the organ, which retains its structural and functional features. Knowledge of arrangement features of such units is of great significance for understanding of pathologies development.

How topography of the internal organs is studied?

Position (topography) of the viscera in anatomy and clinical disciplines is considered from three main positions – holotopy, syntopy and skeletotopy[2].

Holotopy refers to three-dimensional relation of the organ to a certain body area, its surface projection. Most often the term is applied to abdominal organs related to the body surface regions (Fig. l).

Syntopy stands for relative positioning of viscera, blood vessels and nerves.

Skeletotopy stands for relative positioning of the organ and skeletal bones (as a rule vertebral column and ribs).

For description of organ related to the ribs, the topographic lines are used in addition to the number of the respective rib:

- *the anterior median line,* **linea mediana anterior,** which runs vertically along the midline of the sternum;
- *the sternal line,* **linea sternalis,** which runs along the sternal edge;
- *the parasternal line,* **linea parasternalis,** which lies between the sternal and midclavicular lines;
- *the midclavicular line,* **linea mediоclavicularis,** which runs vertically crossing the middle of the clavicle;
- *the anterior, posterior* and *midaxillary lines,* **lineae axillares anterior, posterior et media,** which run vertically through the respective areas of the axillary fossa;
- *the scapular line,* **linea scapularis,** which runs along the medial border of the bladebone (the scapula);

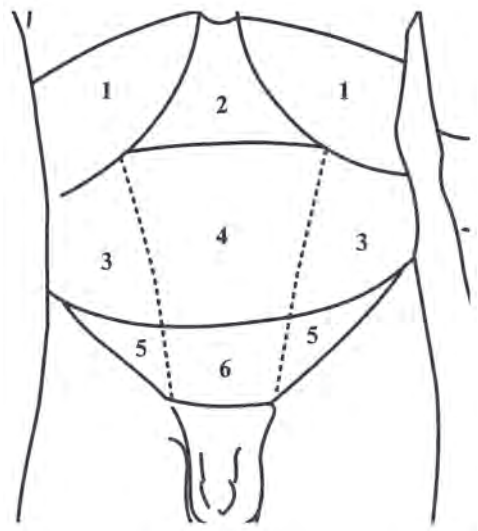

Fig. 1. Regiones abdominales: 1 – regio hypochondriaca; 2 – regio epigastrica; 3 – regio lateralis; 4 – regio umbilicalis; 5 – regio inguinalis; 6 – regio pubica.

[1] – **stroma** (Greek) – base

[2] – **topos** (Greek) – place, **holos** (Greek) – whole, entire; **sin** (Greek) – together; **skeletus** (Greek) – skeleton

- *the paravertebral line,* **linea paravertebralis,** which runs along the transverse processes of vertebrae;
- *the posterior median line,* **linea mediana posterior,** which runs along the apices of the vertebral spinous processes.

Topography and exterior of the internal organs are considered with due regard for body structure, body constitution, age and sex.

Practice questions:

1. What is the subject of splanchnology?
2. Classification of the organs by structure.
3. Discuss the structure of hollow organs.
4. Characterize the mucosa of the hollow organs.
5. Describe structure of the submucosa and muscular layer.
6. What the tubular organs are covered with from outside?
7. Discuss the structure of parenchymal organs.
8. How the topography of the internal organs is studied?
9. Name the lines used for description of the organs' skeletal relations.

THE ALIMENTARY SYSTEM, SYSTEMA DIGESTORIUM

Alimentary system comprises the organs (Fig. 2), which provide mechanical and chemical processing of the food ingested. Alimentary system also provides absorption

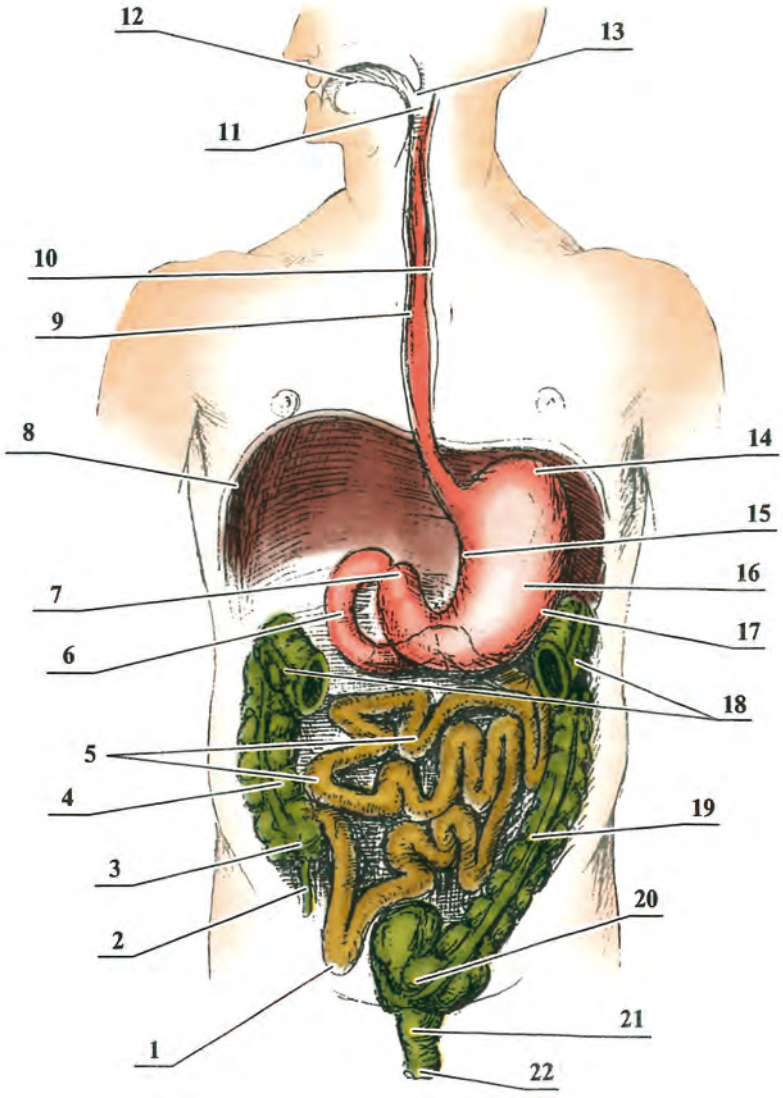

Fig. 2. Schematic representation of gastrointestinal tract. 1 – ileum; 2 – appendix vermiformis; 3 – caecum; 4 – colon ascendens; 5 – jejunum; 6 – duodenum; 7 – pylorus; 8 – m. phrenicus; 9 – oesophagus; 10 – pars descendens aortae; 11 – pars oralis pharyngis; 12- cavitas oris; 13 – fauces; 14 – fundus ventriculi; 15 – curvatura minor ventriculi; 16 – gaster; 17 – curvatura major ventriculi; 18 – colon transversum; 19 – colon descendens; 20 – colon sigmoideum; 21 – rectum; 22 – canalis analis.

of the nutrients (aminoacids, carbohydrates, lipids, minerals, and water) into blood and lymph and withdrawal of indigested and unabsorbed substances. The total length of the digestive tract is about 7–8 meters.

THE ORAL CAVITY, CAVITAS ORIS

The entire oral cavity is separated with gums and teeth into the oral vestibule and oral cavity proper (Fig. 3):

- *the oral vestibule,* **vestibulum oris,** communicates with exterior via oral fissure and is enclosed between the lips anteriorly, cheeks laterally and gums and teeth posteriorly. The oral vestibule communicates with the oral cavity proper via spaces between teeth and spaces behind the last molar teeth.
- *the oral cavity proper,* **cavitas oris propria,** is the deeper portion of the cavity, the teeth and gums form frontal and lateral bounds, the upper bound is formed by palate and the lower – by oral diaphragm. Posteriorly the oral cavity opens to pharynx via *fauces.*

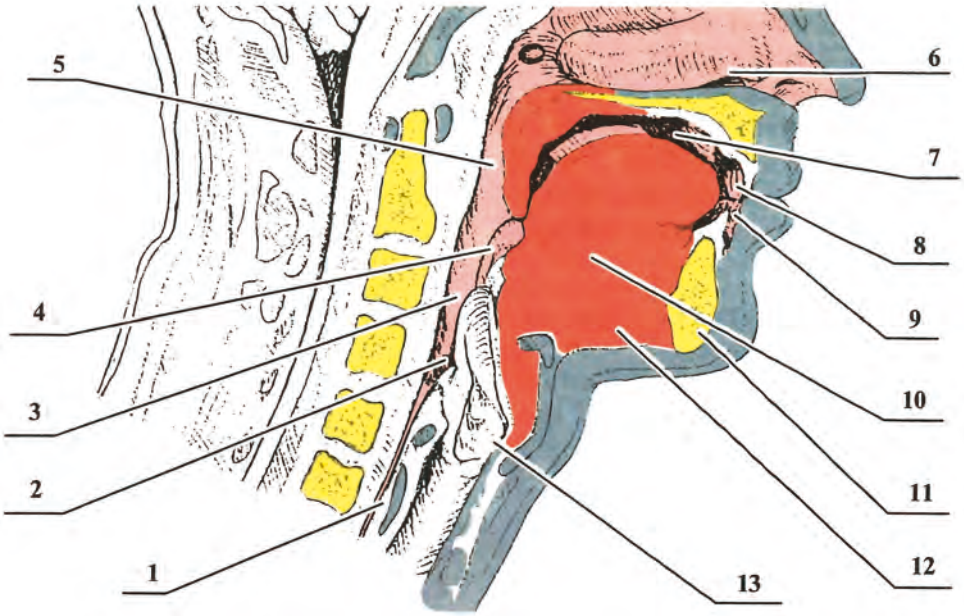

Fig. 3. Sagittal section of head. 1 – oesophagus; 2 – pars laryngea pharyngis; 3 – pars oralis pharyngis; 4 – fauces; 5 – pars nasalis pharyngis; 6 – cavitas nasi; 7 – cavitas oris propria; 8 – dentes; 9 – vestibulum oris; 10 – lingua; 11 – mandibula; 12 – diaphragma oris; 13 – larynx.

The lips, **labia oris,** are covered with skin from outside and with mucosa from inside passing onto the alveolar processes. In the depth of lips, there is a muscle – *the orbicularis oris*, to which the skin fixes. The opening between *the upper lip,* **labium superius,** and

the lower lip, **labium inferius,** is referred to as *oral fissure,* **rima oris,** closing to form *labial comissures,* **comissurae labiorum,** at each side. The mouth being open, the lips form the *angle of mouth,* **angulus oris.** The lips have the following structures:

- *the philtrum* (Lat. Id.), the eminence in the middle of the upper lip skin;
- *the tuberculum* (Lat. Id.), a tubercle placed midline on the red border of the upper lip;
- *the frenulum of upper lip,* **frenulum labii superioris,** the part of mucous membrane that lies midline in the oral vestibule; it runs upwards from the upper lip to the upper jaw gums;
- *the frenulum of the lower lip,* **frenulum labii inferioris,** situated midline in the oral vestibule; it runs downwards from the lower lip to the lower jaw gums;
- *the labial glands,* **glandulae labiales,** the goblet cells and multicellular glands embedded into the mucous membrane and submucosa of the lips.

The gums, **gingivae,** are the projections of oral mucosa, which cover the alveolar processes fixing to them.

The cheeks, **buccae,** are covered with skin from outside and with mucosa from inside; in the depth of layers, there is a muscle – *the buccinator,* **m. buccinator.** Apart from this, the cheeks contain the following structures:

- *the buccal glands,* **gll. buccales,** lying under the mucous membrane;
- *the papilla of parotid duct,* **papilla ductus parotideus,** the part of mucosa which covers the opening of parotid duct; it drains saliva into the oral cavity. The papilla is located at the level of the second upper molar tooth;
- *the buccal fat pad,* **corpus adiposum buccae,** lies under the skin between the masseter and the buccinator. The fat pad specifies the cheek shape; it is better developed in women and children.

THE PALATE, PALATUM

The palate forms the upper wall of the oral cavity and is divided into the hard palate and soft palate.

The hard palate, **palatum durum,** is based on the bone elements (bone palate), covered with mucous membrane (Fig. 4) which fixes to periosteum very firmly and directly passes onto the gums. The hard palate has the following structures:

- *the palatine raphe,* **raphe palati,** a pale line, passing midline along the mucosa;
- *the incisive papilla,* **papilla incisive,** lies in the anterior part of the palatine raphe;
- *the transverse palatine folds,* **plicae palatinae transversae,** look as 3–4 transverse ridges located in the anterior part. They are seen better in neonates;
- *the palatine glands,* **gll. palatinae,** lying in the depth of the mucosa.

The soft palate, **palatum molle,** is based on the palatine aponeurosis attaching with its anterior edge to the palatine bones. The aponeurosis is surrounded with muscles covered from outside with mucous membrane. The soft palate consists of the following structures:

- *the palatine veil,* **velum palatinum,** the posterior movable part of the soft palate;

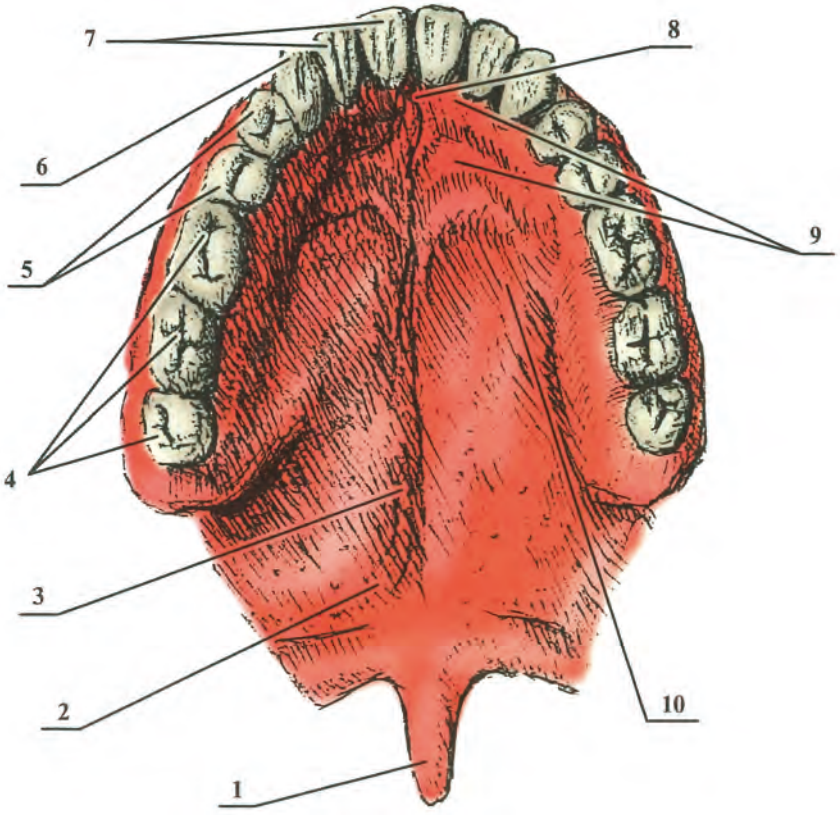

Fig. 4. Hard and soft palates. 1 – uvula palatina; 2 – palatum molle; 3 – raphe palati; 4 – dentes molares; 5 – dentes premolares; 6 – dens caninus; 7 – dentes incisivi; 8 – papilla incisiva; 9 – plicae palatinae transversae; 10 – palatum durum.

- *the uvula,* **uvula palatinae,** a narrow prosection on the free edge of the soft palate;
- *the palatoglossal arch* (the anterior pillar of fauces), **arcus palatoglossus,** the paired structure running down from the soft palate to the margins of tongue;
- *the palatopharyngeal arch,* **arcus palatopharyngeus,** also paired, runs down from the soft palate to the lateral wall of the pharynx, ending behind the latter;
- *the tonsillar sinus,* **fossa tonsillaris,** a depression between the arches, which contains *the palatine tonsil,* **tonsilla palatina**.

THE MUSCLES OF SOFT PALATE

The muscles of the soft palate are like the following:

- *the tensor veli palatini,* **m. tensor veli palatini,** arises from the spine of sphenoid bone and cartilaginous part of the auditory tube, runs vertically down, then loops around the pterygoid hamulus and assuming horizontal position interlaces as a fan-shaped bundle into the palatine aponeurosis. The muscle strains and extends the soft palate and opens the orifice of the auditory tube;

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