КАЗАНСКИЙ (ПРИВОЛЖСКИЙ) ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ
ИНСТИТУТ ФУНДАМЕНТАЛЬНОЙ МЕДИЦИНЫ И БИОЛОГИИ
Кафедра морфологии и общей патологии

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Handbook

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Практикум предназначен для англоговорящих студентов первого курса медицинских специальностей для работы на практических занятиях по дисциплине «Гистология, цитология, эмбриология». В настоящем учебном издании рассматривается раздел общей гистологии «Ткани». В него включены авторские микрофотографии гистологических препаратов, выполненные на кафедре морфологии и общей патологии ИФМиБ КФУ, а также детальное описание морфологического строения тканей. Все описания составлены в соответствии с международной номенклатурой и детально раскрывают морфологическое строение тканей, обеспечивая необходимую базу для прохождения соответствующего модуля.

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1. EPITHELIAL TISSUE

1.1. Simple squamous epithelium (mesothelium)

This is a section of a lung (Fig. 1 A), which covered by pleura. The pleura is a serous membrane consisting of mesothelium and underlying loose connective tissue.

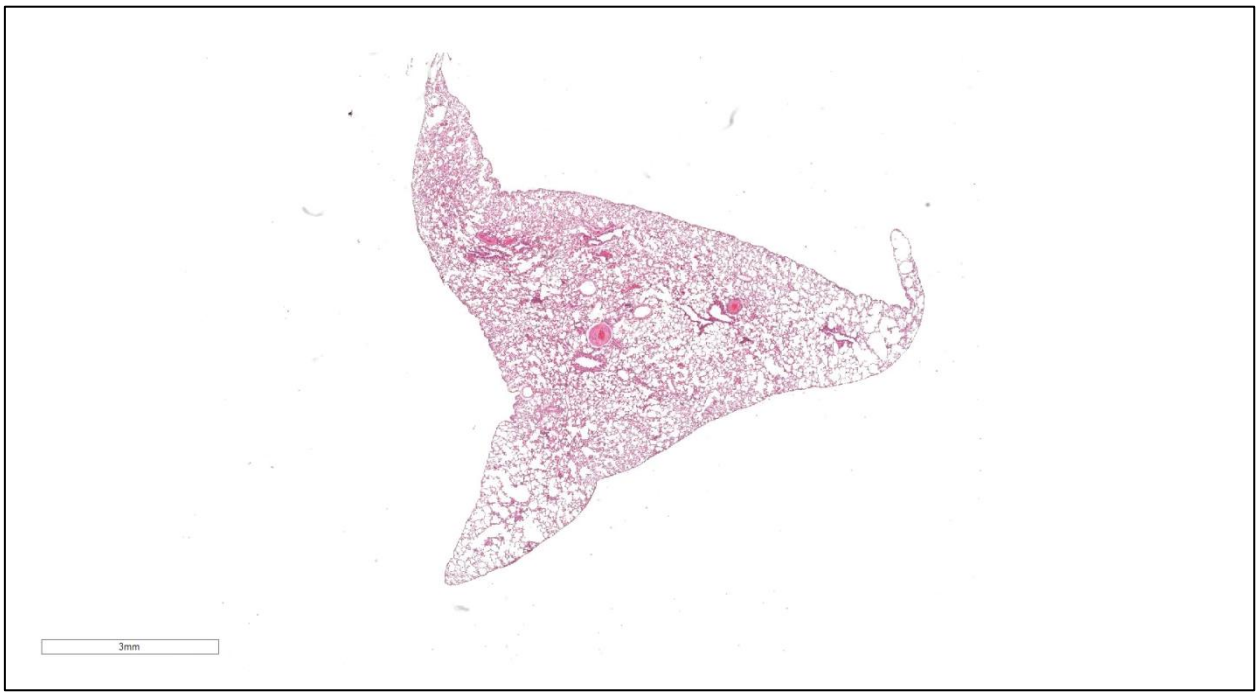

Fig. 1 A. Pleura, lung. Hematoxylin and eosin staining

At high magnification the mesothelium is composed of one layer of flattened epithelial cells (Fig. 1B) lying on the basement membrane. Epithelial cells are tightly attached to each other, there is no extracellular matrix between them.

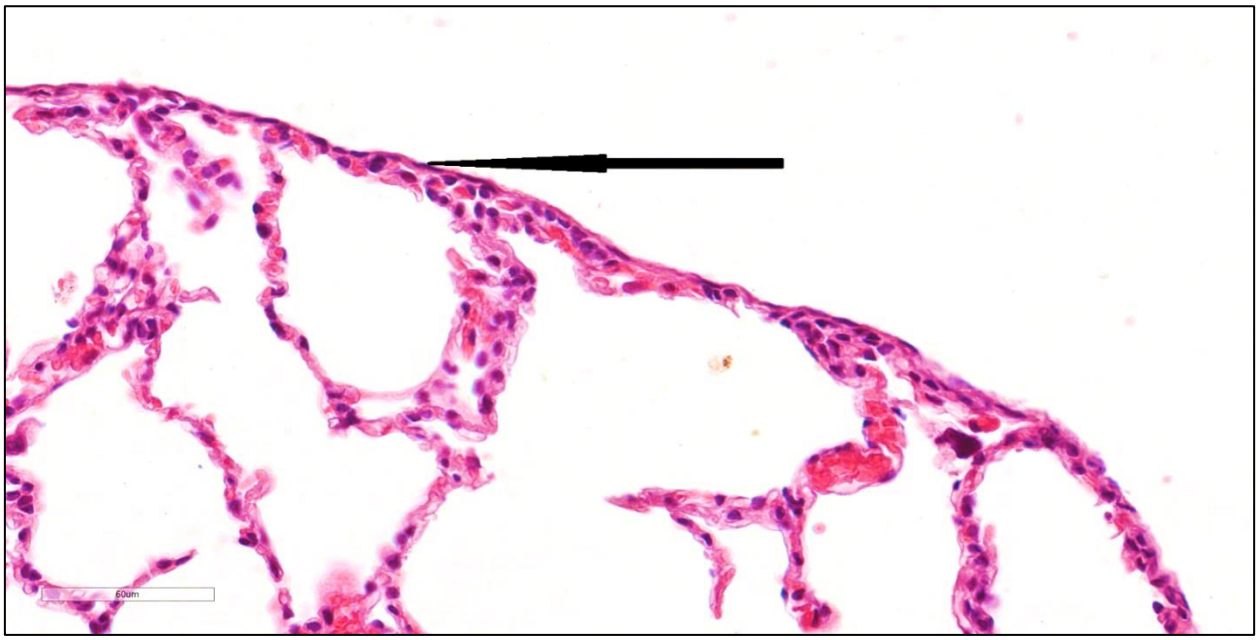

Fig. 1 B. Pleura, lung. The arrow indicates the mesothelium (simple squamous epithelium). Hematoxylin and eosin staining

1.2. Simple cuboidal epithelium (kidney tubules)

This is a longitudinal section of kidney. (Fig. 2 A).

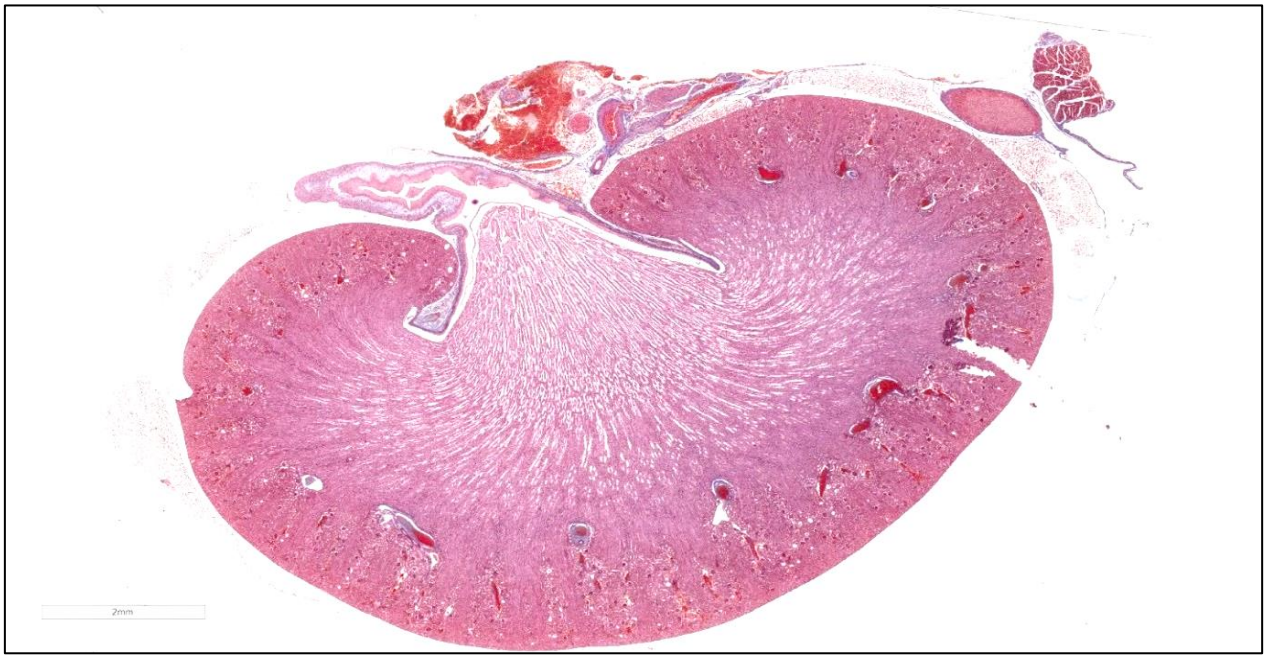

Fig. 1 A. Kidney. Mallory's trichrome staining

At high magnification, numerous tubules of the nephron are identified in the cortex of the kidney (Fig. 2B). The wall of the tubules is formed by simple cuboidal epithelium. Epithelial cells have cuboidal shape with a rounded nucleus and lie on the basement membrane. The apical surface of this cells facing the lumen of the tubules.

The specialization of the apical surface of the proximal convoluted tubules cells is the presence of microvillus which form a "brush border". They provide an increase in the surface area for reabsorbtion. The epithelium of the convoluted tubules of the nephron provides reabsorption of substances from primary urine into the blood.

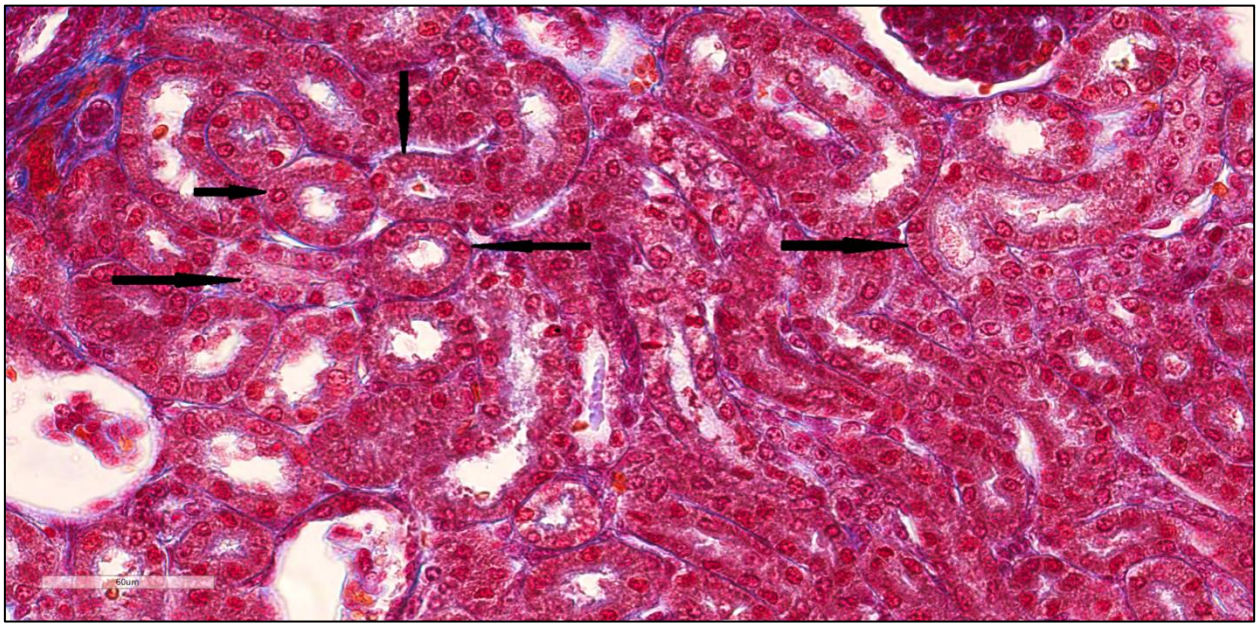

Fig. 2 B. Kidney. The arrows indicate the simple cuboidal epithelium. Mallory's trichrome staining

1.3. Simple columnar epithelium (stomach)

This is a longitudinal section of stomach. The mucosa of stomach is lined with simple columnar epithelium (Fig. 3 A).

Fig. 3 A. Stomach, pylorus. The arrows indicate epithelium of stomach. Hematoxylin and eosin staining

The epithelium is composed of cells, which have cylindrical shape and lie close to each other on the basement membrane (Fig. 3 B). The nuclei of these cells are arranged in one row.

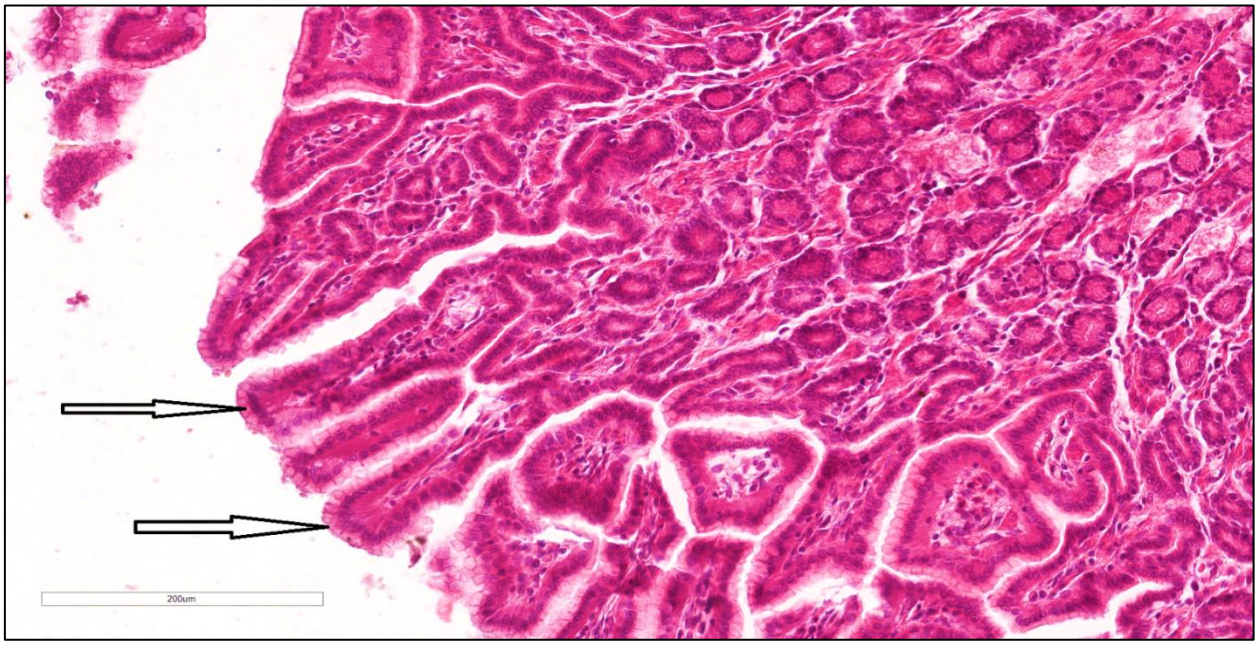

Fig. 3 B. Stomach, pylorus. The arrows indicate the simple columnar epithelium. Hematoxylin and eosin staining

Mucus is determined in the apical surface of the glandular epithelial cells. Mucus serves as protection from the mechanical action of coarse food particles and the chemical action of gastric juice.

1.4. Pseudostratified columnar (ciliated) epithelium (trachea)

This is a cross section of trachea. The mucosa of trachea is lined with pseudo-stratified columnar ciliated epithelium (Fig. 4 A).

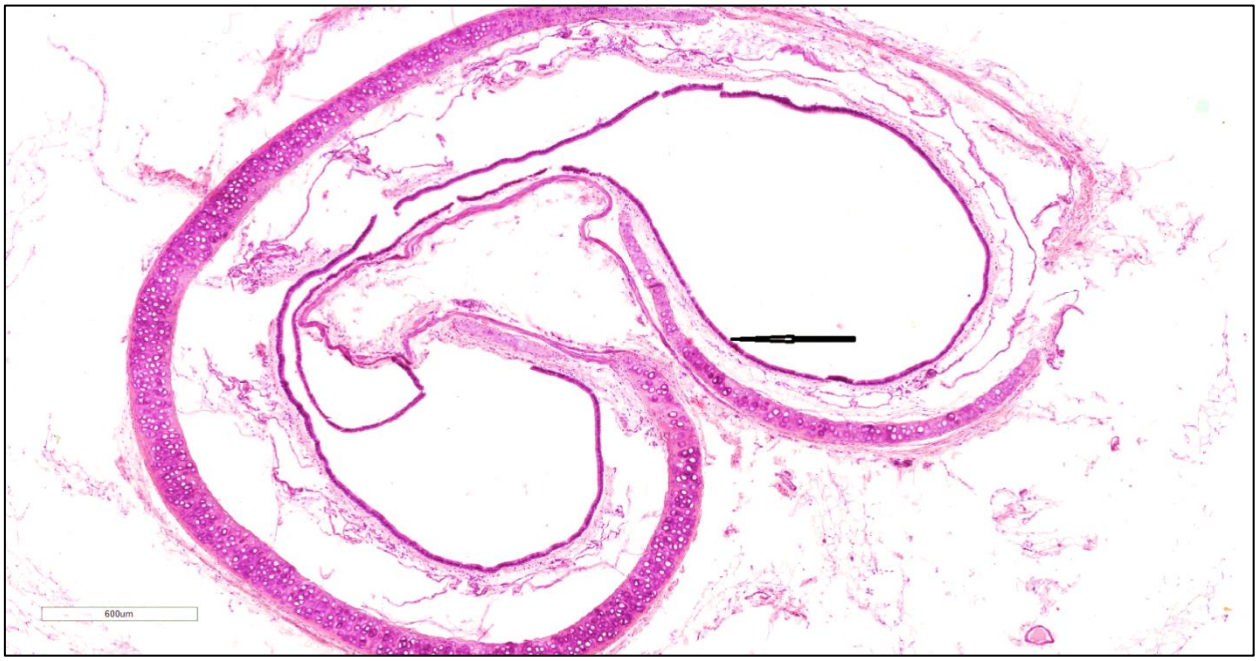

Fig. 4 A. Trachea. The arrow indicates the pseudostratified columnar ciliated epithelium. Hematoxylin and eosin staining

The epithelium is composed of cells, which lie on the basement membrane, have cylindrical shape and nuclei on the different rows (Fig. 4 B). The main cell type of this epithelium is ciliated cells, which have motile cilia on the apical surface.

Due to the flickering movement of the cilia, dust particles and excess mucus are removed from the airways.

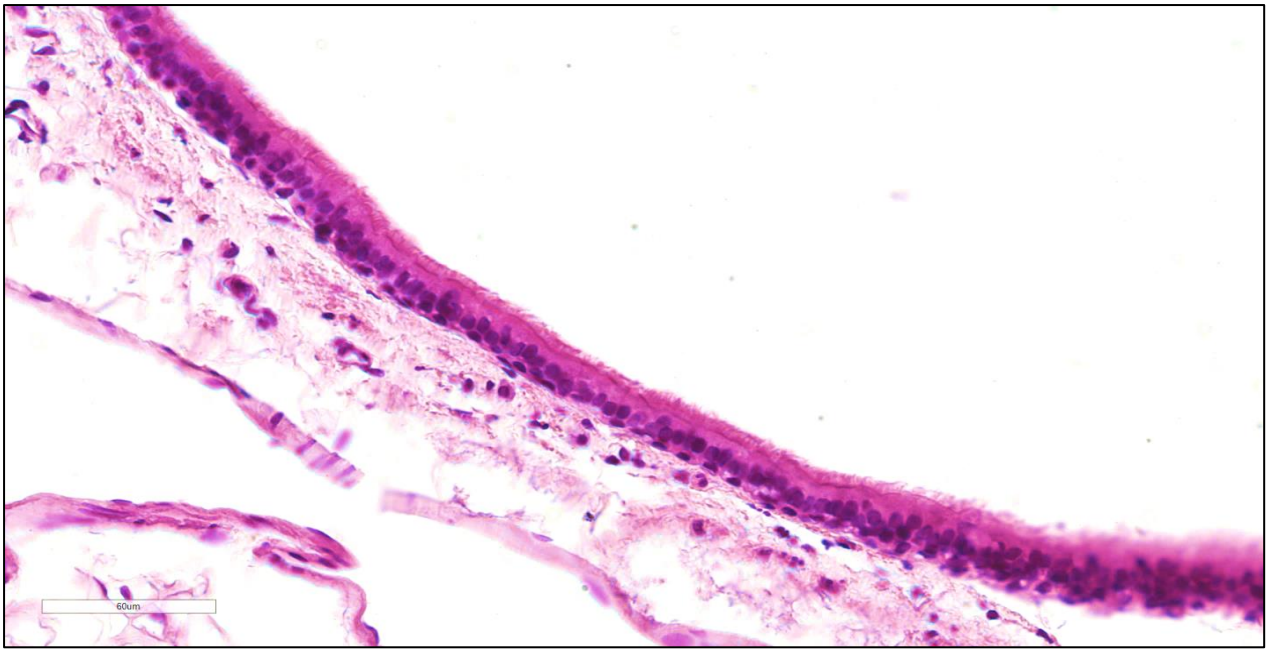

Fig. 4 B. Trachea. Pseudostratified columnar (ciliated) epithelium. The arrow indicates the cilia on the apical surface of epithelial cells. Hematoxylin and eosin staining

1.5. Stratified squamous non-keratinized epithelium (cornea)

This is a section of anterior segment of eye (Fig. 5 A). A tough external fibrous layer consisting of the sclera and the transparent cornea, which forms the anterior one-sixth of the eye. External layer of cornea is covered by stratified squamous non-keratinized epithelium.

Stratified squamous non-keratinized epithelium is located in places subject to friction and lines moist surfaces such as the cornea, oral cavity, esophagus, anus, vagina.

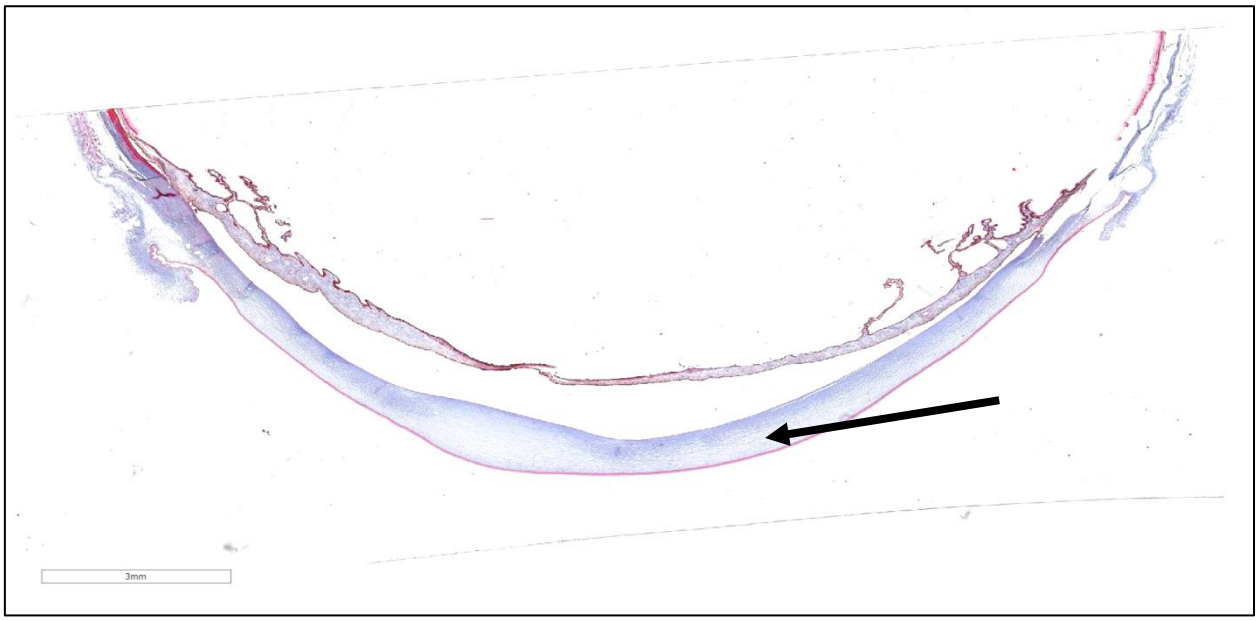

Fig. 5 A. Cornea. The arrow indicates the cornea. Mallory's trichrome staining

The epithelium is composed of 5-6 layers of cells, which lie on basement membrane (Fig. 5 B). Superficial cells are flattened.

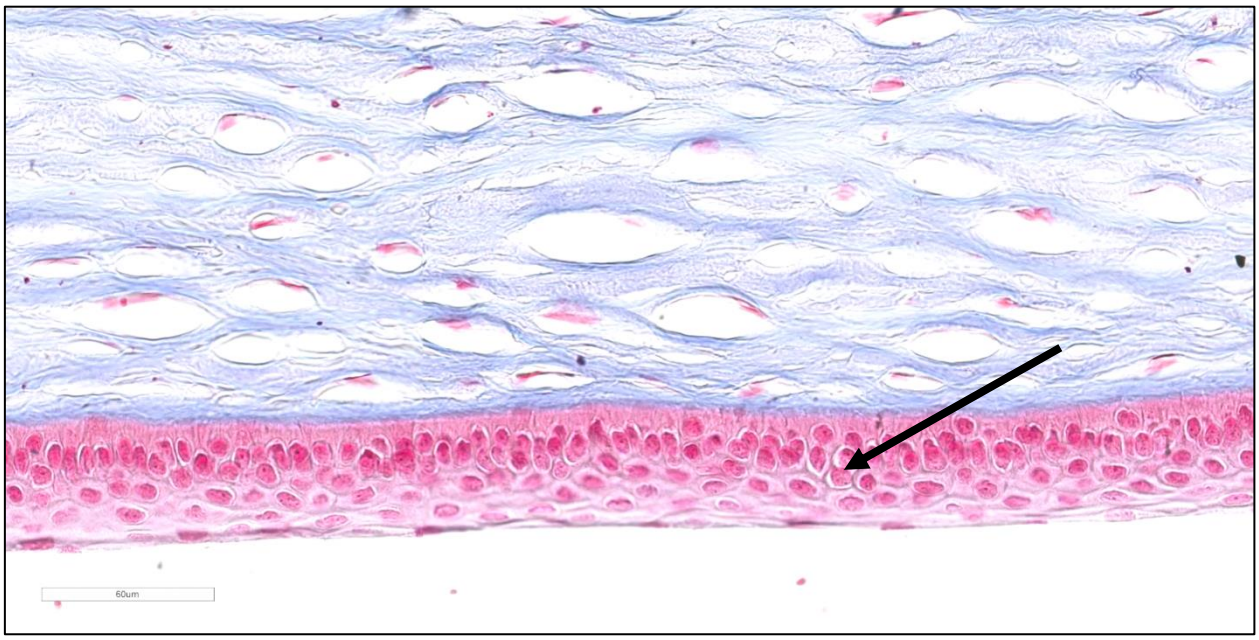

Fig. 5 B. Cornea. The arrow indicates the stratified squamous non-keratinized epithelium. Mallory's trichrome staining

1.6. Stratified squamous keratinized epithelium (thick skin)

This is a section of thick skin of soles and palms, the superficial layer of which (epidermis) is formed by stratified squamous keratinized epithelium (Fig. 6 A).

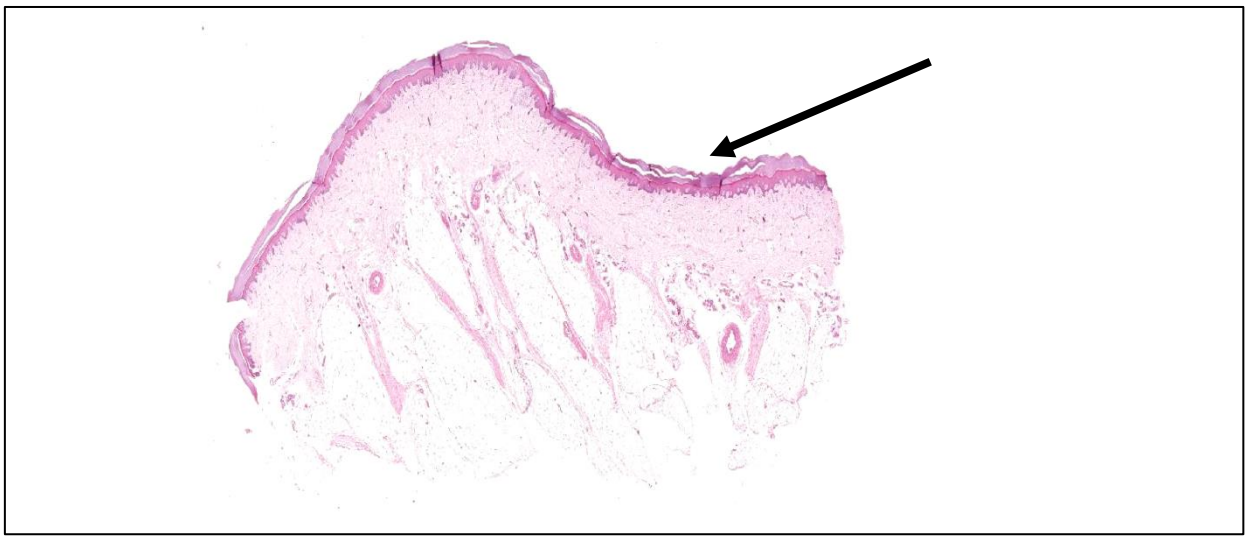

Fig. 6 A. Thick skin. The arrow indicates the epidermis. Hematoxylin and eosin staining

The epithelium is composed of several layers of cells, which lie tight to each other on the basement membrane (Fig. 6 B). Superficial cells are flattened. They turn into dead protein scales that don't contain nuclei, so this type of epithelium is called keratinized.

Stratified squamous keratinized epithelium covers dry surfaces such as the skin.

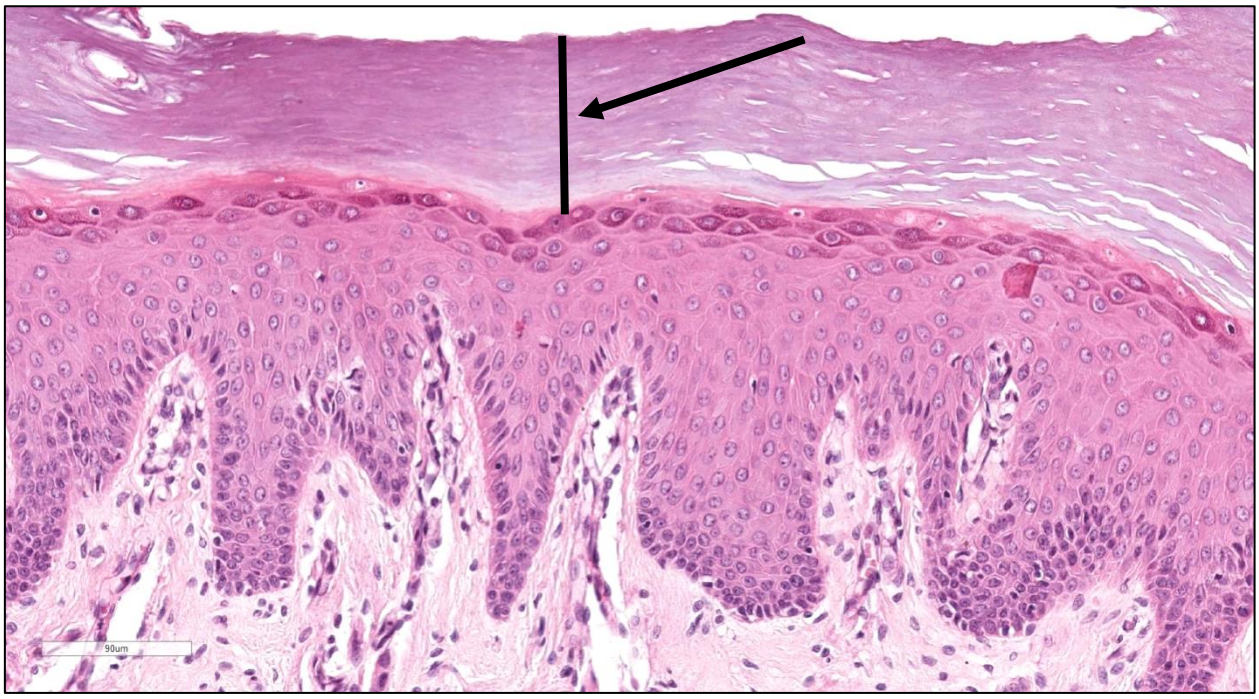

Fig. 6 B. Thick skin. Stratified squamous keratinized epithelium. The arrow indicates the stratum corneum of epidermis. Hematoxylin and eosin staining

1.7. Transitional epithelium (ureter)

This is a cross section of ureter, which wall is lined with transitional epithelium (Fig. 7A).

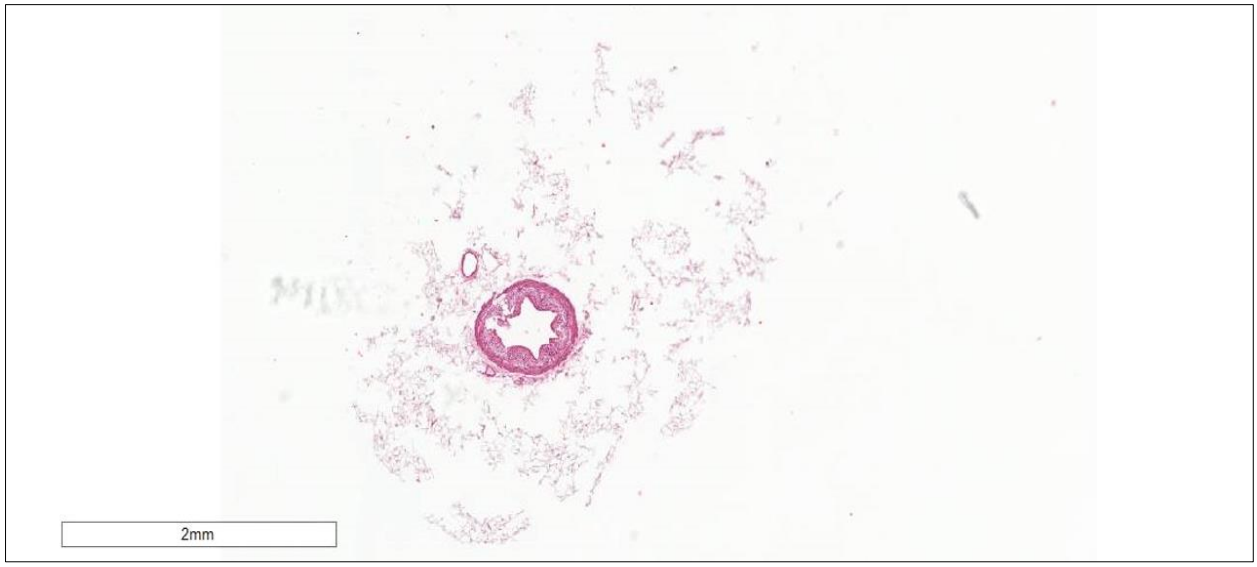

Fig. 7 A. Ureter. Hematoxylin and eosin staining

The transitional epithelium is stratified and consists of epithelial cells, which are organized in several layers located on the basement membrane (Fig. 7B). The superficial layer (1) is formed by large dome-shaped cells in the unstretched state of the organ wall, and they become flattened when stretched. The intermediate layer (2) is represented by polygonal cells. Basal layer (3) - small cells with oval nuclei lying on the basement membrane.

Transitional epithelium (urothelium) lines the mucous membrane of the urinary tract organs.

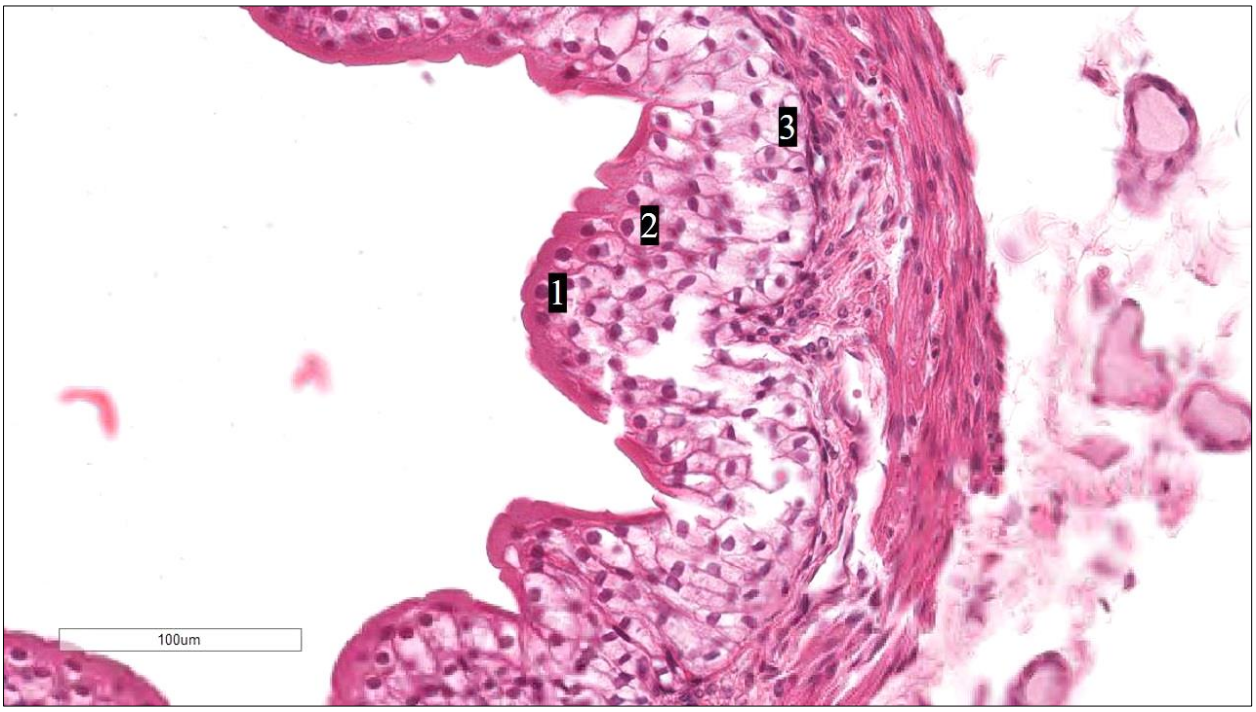

Fig. 7 B. Transitional epithelium (ureter). 1 – Superficial layer; 2 – Intermediate layer; 3 – Basal layer. Hematoxylin and eosin staining

2. CONNECTIVE TISSUE

2.1. Loose connective tissue

This is a section of thick skin of palms and soles, where papillary layer of dermis is composed of loose connective tissue (Fig. 8 A).

Fig. 8 A. Thick skin. The arrow indicates the papillary layer of dermis. Hematoxylin and eosin staining

Loose connective tissue contains a large amount of the ground substance, in which collagen, reticular and elastic fibers are randomly arranged. This type of tissue consists of a wide variety of cell types, where the main ones are fibroblasts and fibrocytes (Fig. 8 B).

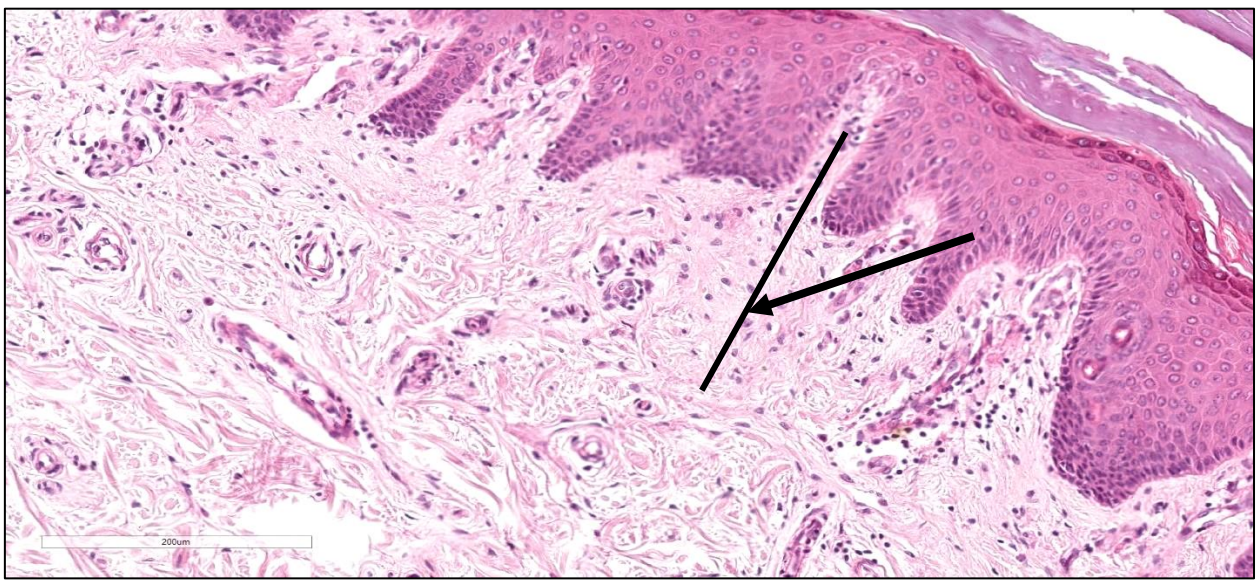

Fig. 8 B. Thick skin. The arrow indicates the loose connective tissue. Hematoxylin and eosin staining

Loose connective tissue is the most common type of connective tissue. This type of tissue forms the papillary layer of the dermis, part of the peritoneum and pleura, the mucosa of hollow organs, surrounds blood vessels and nerves.

2.2. Dense irregular connective tissue

This is a section of thick skin of palms and soles, where the reticular layer of dermis is composed of dense irregular connective tissue (Fig. 9 A).

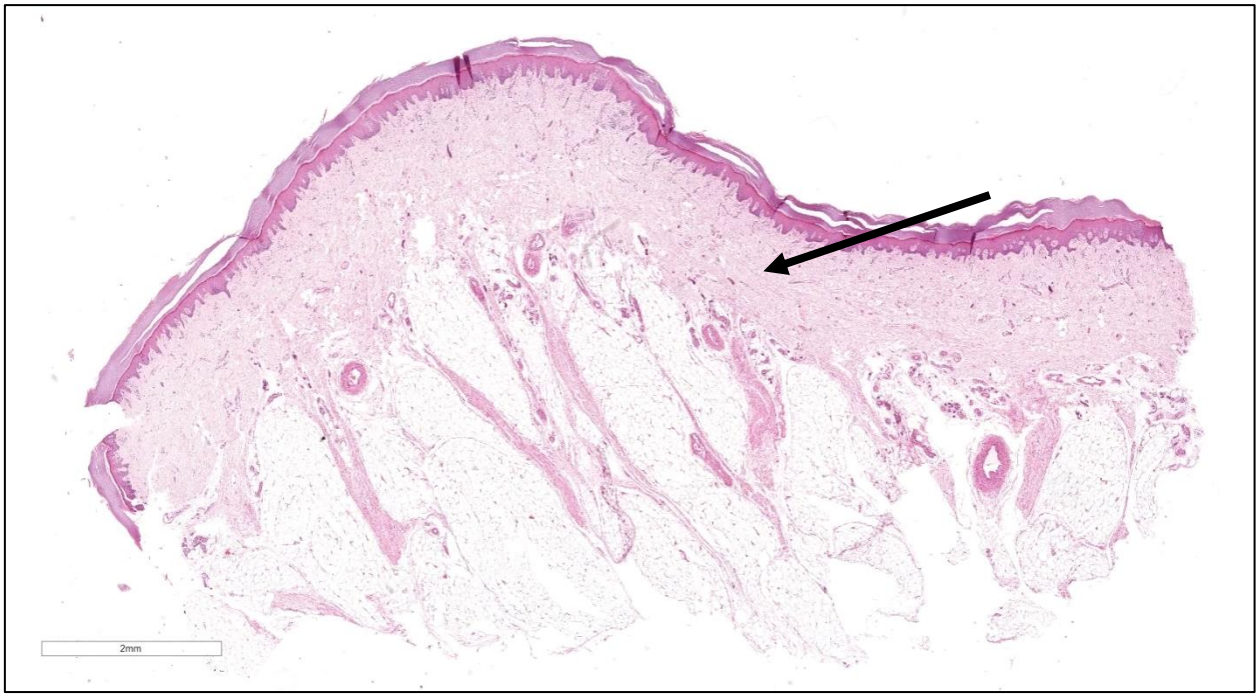

Fig. 9 A. Thick skin. The arrow indicates the reticular layer of dermis. Hematoxylin and eosin staining

Dense irregular connective tissue is characterized by a predominance of collagen fibers and a smaller amount of ground substance and cells than loose connective tissue. Collagen fibers are collected in bundles, which gives the tissue greater resistance to stress. Bundles of collagen fibers intertwine with each other, creating interesting patterns (Fig. 9 B).

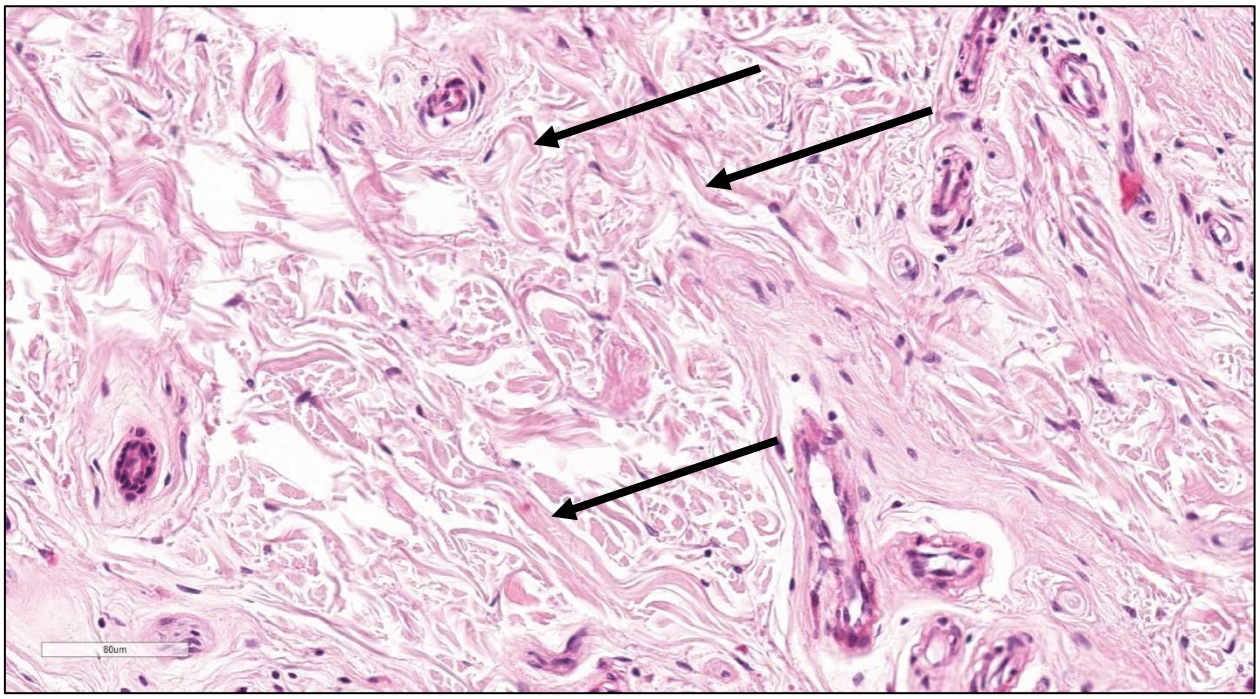

Fig. 9 B. Thick skin. Reticular layer of dermis. The arrows indicate the bundles of collagen fibers in dense irregular connective tissue. Hematoxylin and eosin staining

Dense irregular connective tissue forms the reticular layer of the dermis, the submucosa and capsules of organs, perichondrium and periosteum.

2.3. Dense regular connective tissue (tendon)

A dense regular connective tissue is determined on the longitudinal section of the tendon (Fig. 10 A).

Dense regular connective tissue is part of tendons, fascia, capsules and ligaments.

Fig. 10 A. Tendon. Hematoxylin and eosin staining

At high magnification a large number of densely packed and parallel bundles of collagen fibers are visualized. Fibroblasts and fibrocytes nuclei lie between the fibers (Fig. 10 B).

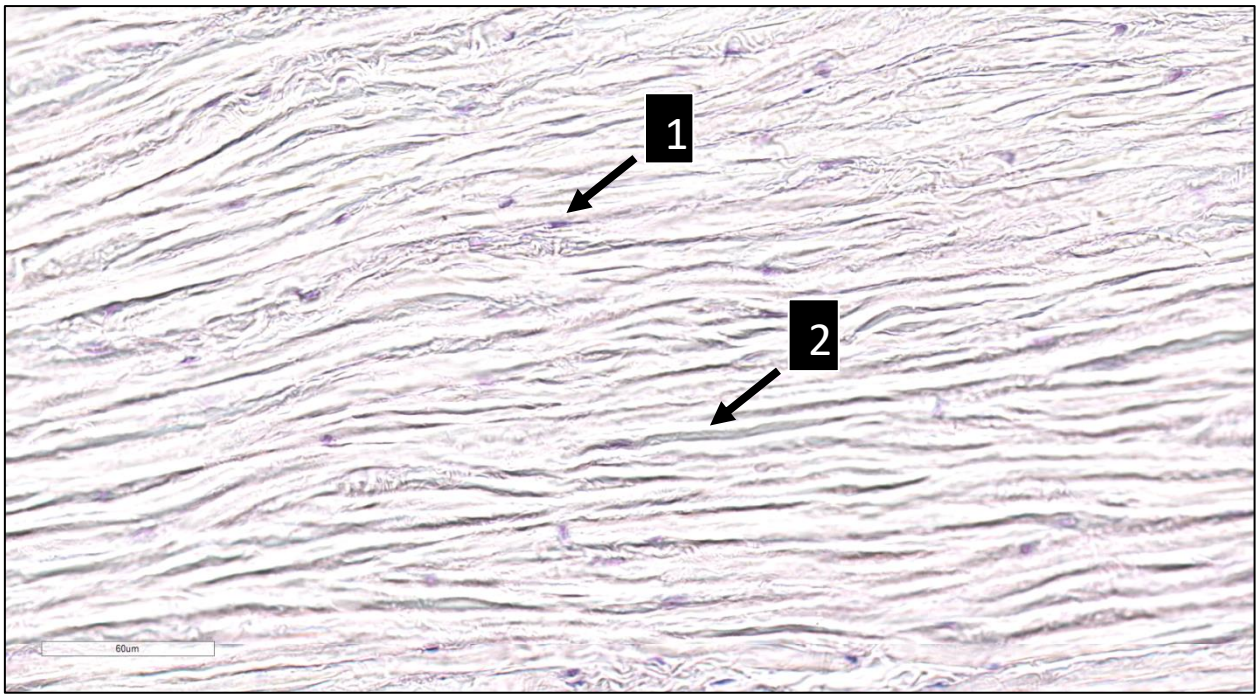

Fig. 10 B. Tendon. Dense regular connective tissue. 1 – fibrocyte nucleus; 2 – collagen fibers. Hematoxylin and eosin staining

2.4. White adipose tissue

This is a white adipose tissue (Fig. 11 A).

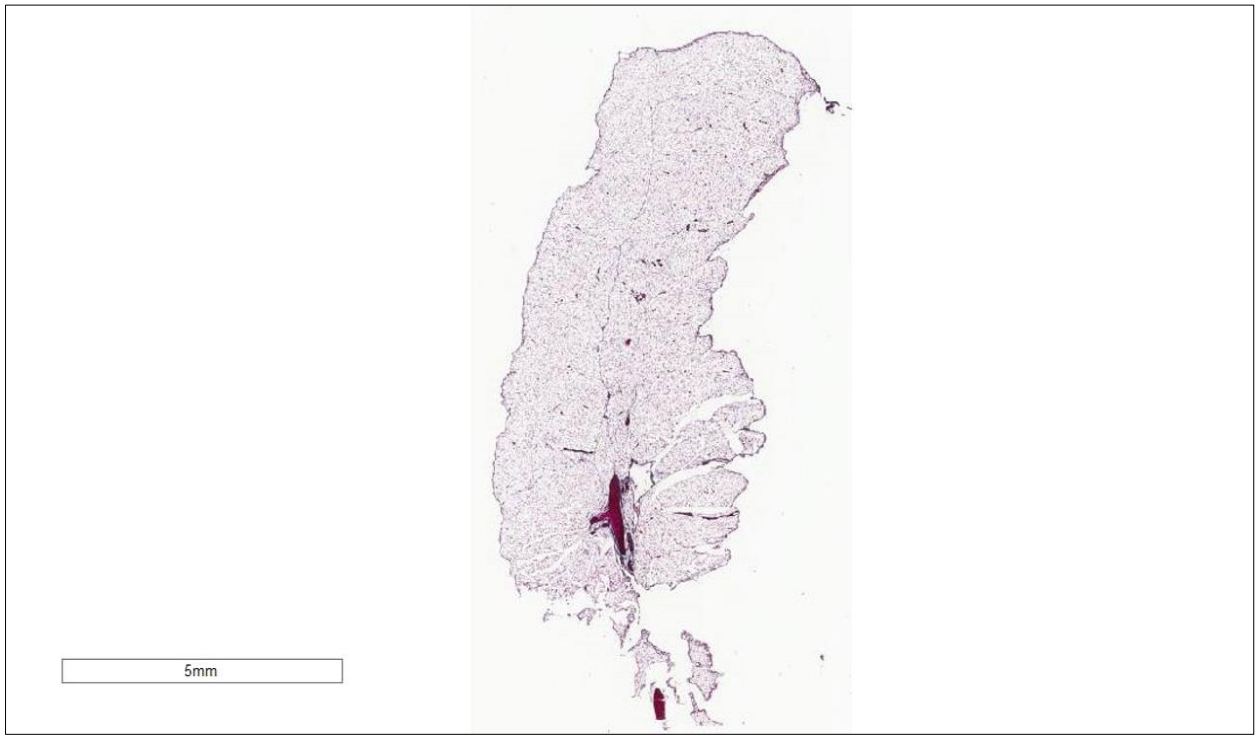

Fig. 11 A. White adipose tissue. Mallory's trichrome staining

White adipose tissue consists of adipocytes (fat cells) (Fig. 11 B). The intracellular space of the white adipocyte is filled with one large lipid drop, which shifts the nucleus with the cell organelles to the periphery. Due to the described features, the cells have eccentrically arranged and flattened nuclei. During the material preparation, fat droplets are removed from the cells with alcohol and xylene, so we can see only a thin ring of cytoplasm on the slide, this gives the adipocyte a ring-shaped appearance.

White adipose tissue is located in subcutaneous adipose tissue, the omentum, forms of fat deposits around the internal organs.

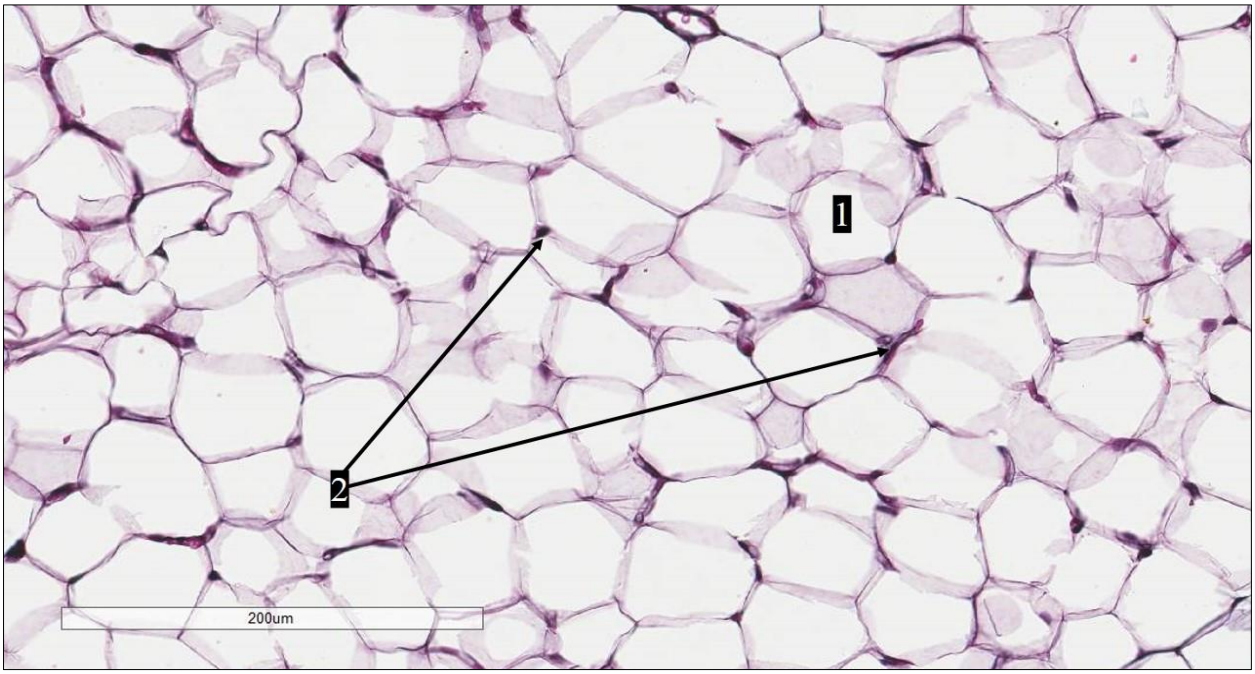

Fig. 11 B. White adipose tissue. 1 – adipocyte; 2 – nuclei of adipocytes. Mallory's trichrome staining

2.5. Brown adipose tissue

This is a section of brown adipose tissue (Fig. 12 A).

Fig. 12 A. Brown adipose tissue. Hematoxylin and eosin staining

At high magnification brown adipocytes are determined, they have structural differences between white adipocytes. Adipocytes of brown adipose tissue are smaller, the cytoplasm contains not one large, but many small lipid droplets; the cell nucleus is located in the center (Fig.12 B). The brown color of the tissue is caused by a large number of blood capillaries and numerous mitochondria containing pigment cytochrome.

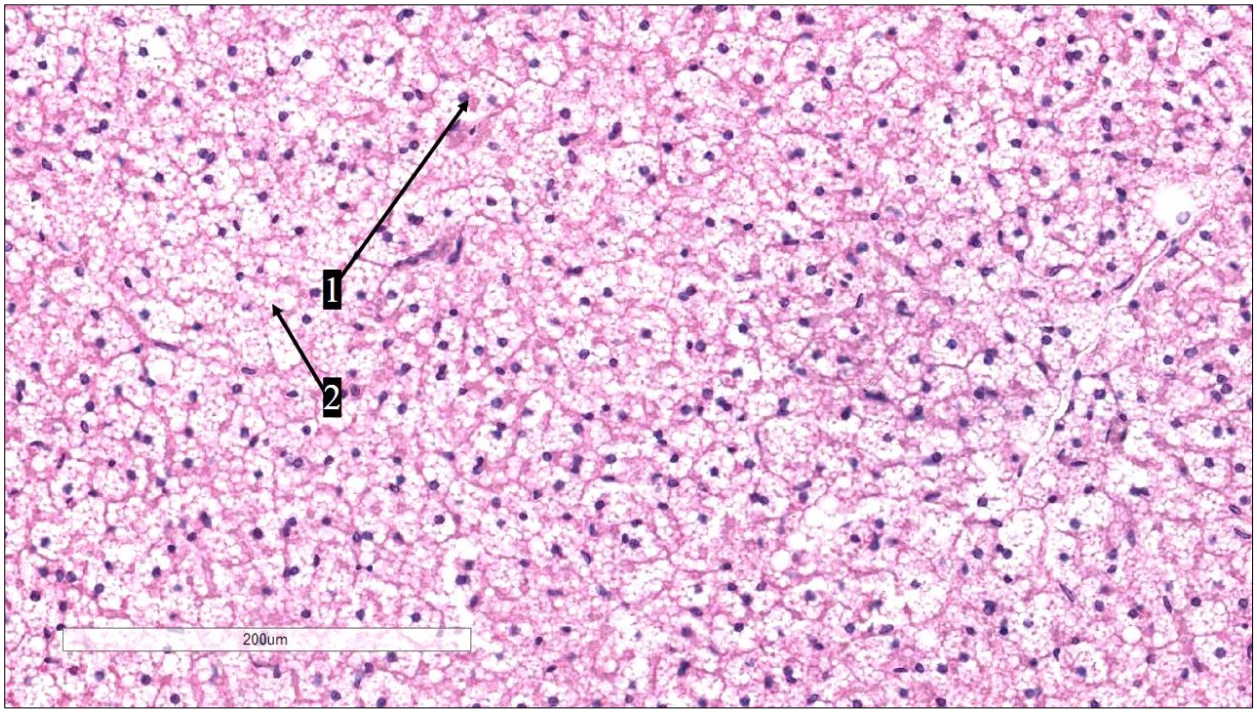

Fig. 12 B. Brown adipose tissue. 1 – nuclei of brown adipocytes; 2 – cytoplasm of brown adipocytes, which contains a lot of small lipid droplets. Hematoxylin and eosin staining

Brown adipose tissue in humans occurs mainly in newborns in the neck, shoulder blades, armpits, behind the sternum, in the hilum of the kidney, the roots of the lungs and lumps of Bicha on the cheeks. The content of brown adipose tissue decreases with age.

2.6. Fibrous cartilage

This is a section of fibrous cartilage (Fig.13 A).

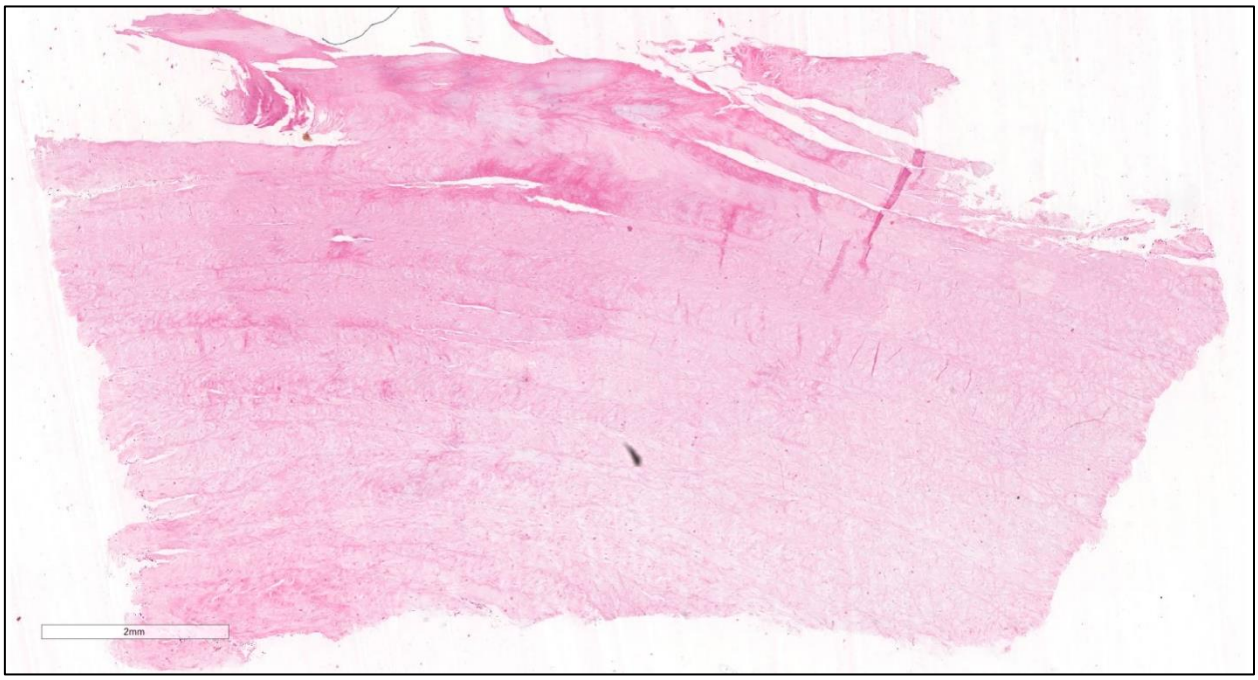

Fig. 13 A. Fibrous cartilage. Hematoxylin and eosin staining

At high magnification we can detect chondrocytes located in lacunae (Fig. 13 B). They have an elongated shape, rounded nucleus, and a narrow rim of pale cytoplasm. Chondrocytes are organized in chains (“columns”) between thick bundles of collagen fibers. The matrix of fibrous cartilage is acidophilic due to the large amount of type I collagen. Fibrous cartilage has no prominent perichondrium.

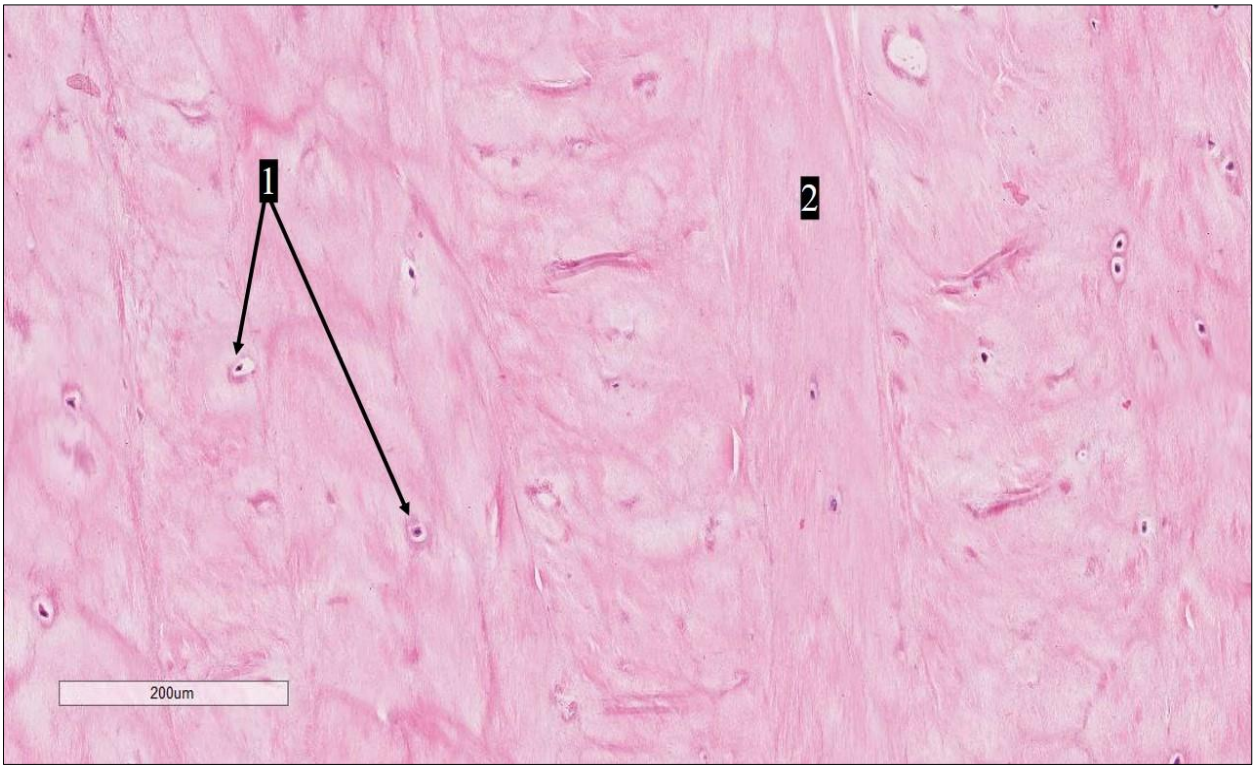

Fig. 13 B. Fibrous cartilage. 1- chondrocytes in lacunae; 2- matrix of cartilage. Hematoxylin and eosin staining

Fibrous cartilage is located at the attachment sites of tendons and ligaments, as well as forming the fibrous ring of intervertebral discs.

2.7. Hyaline cartilage

This is a section of hyaline cartilage (Fig. 14 A).

Hyaline cartilage forms the skeleton of the fetus, the cartilage of the airways, and the anterior portions of the ribs. This type of cartilage covers the articular surfaces of bones and is found in the metaphyses of tubular bones during their growth.

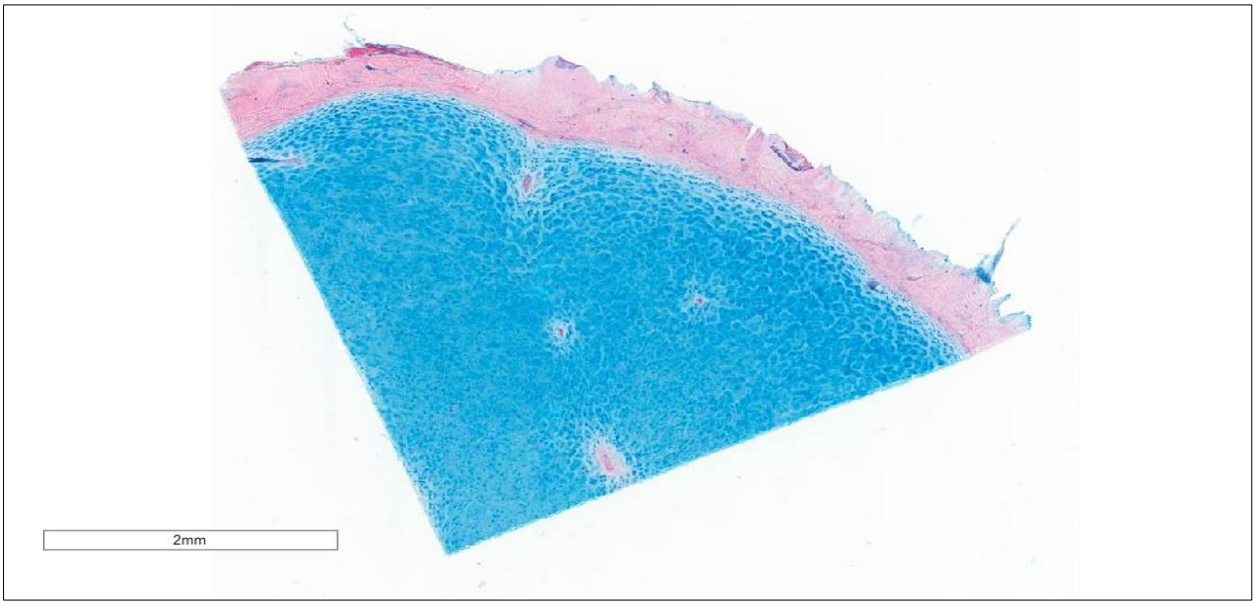

Fig. 14 A. Hyaline cartilage. Mallory's trichrome staining

On the outside, hyaline cartilage is covered by a perichondrium, consisting of two layers: the outer (fibrous) layer is represented by dense irregular connective tissue; the inner (cellular) layer contains chondrogenic cells and loose connective tissue (Fig. 14 B).

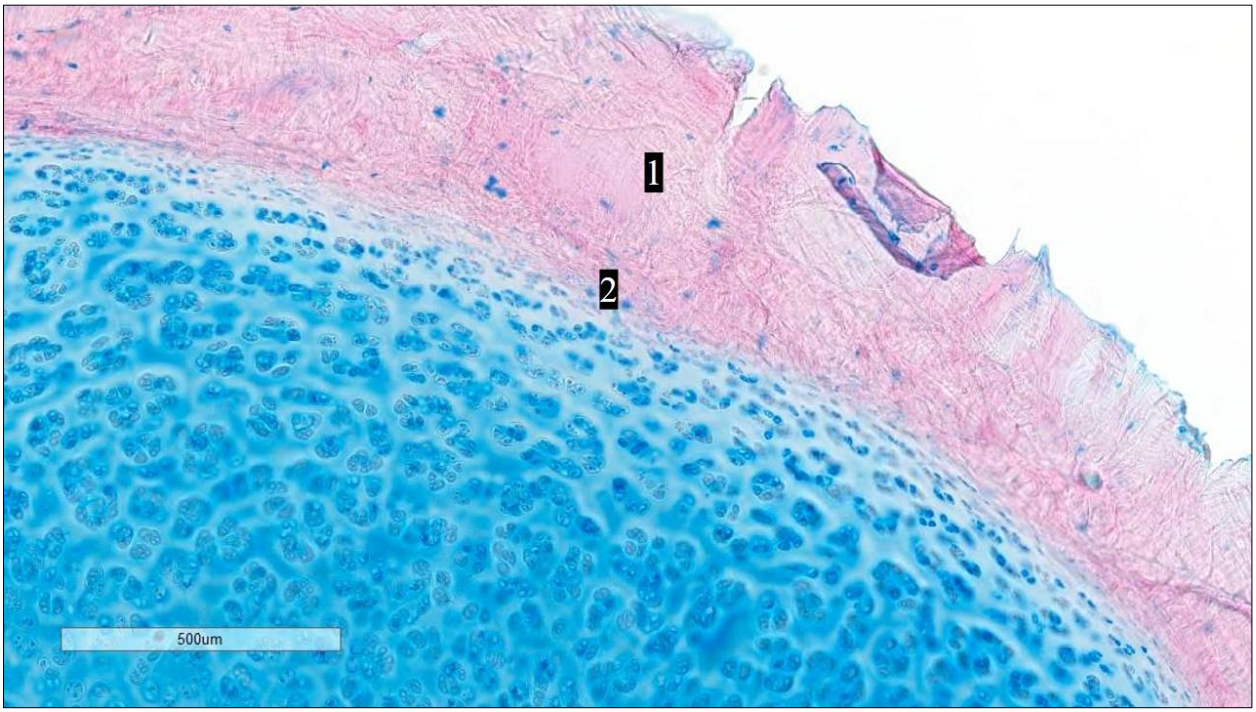

Fig. 14 B. Hyaline cartilage. Perichondrium: 1- the outer (fibrous) layer; 2- the inner (cellular) layer. Mallory's trichrome staining

The matrix of hyaline cartilage contains mature chondrocytes arranged in isogenic groups in lacunae. Collagen fibers, consisting of type II collagen, are not visible in the matrix because their refractive index is the same as the ground substance (Fig.14 C).

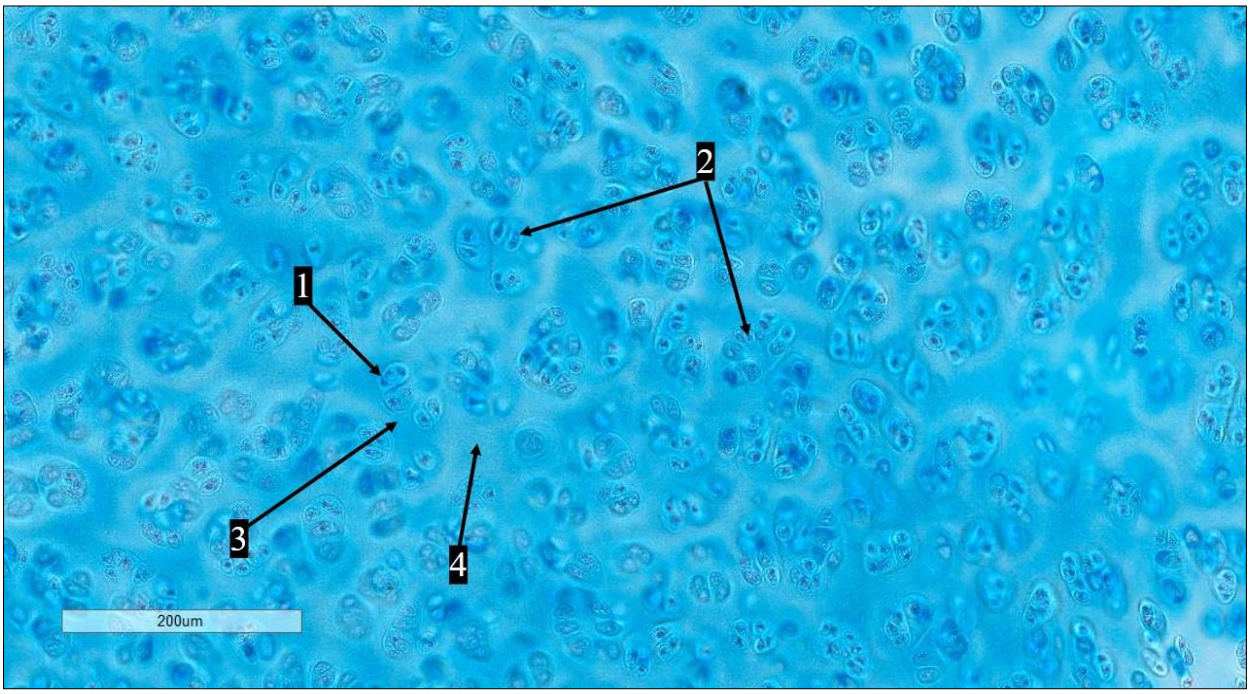

Fig. 14 C. Hyaline cartilage. 1- chondrocytes; 2- isogenic groups; 3- territorial matrix; 4- interterritorial matrix. Mallory's trichrome staining

2.8. Elastic cartilage

This is a section of epiglottis, where elastic cartilage is determined (Fig.15 A).

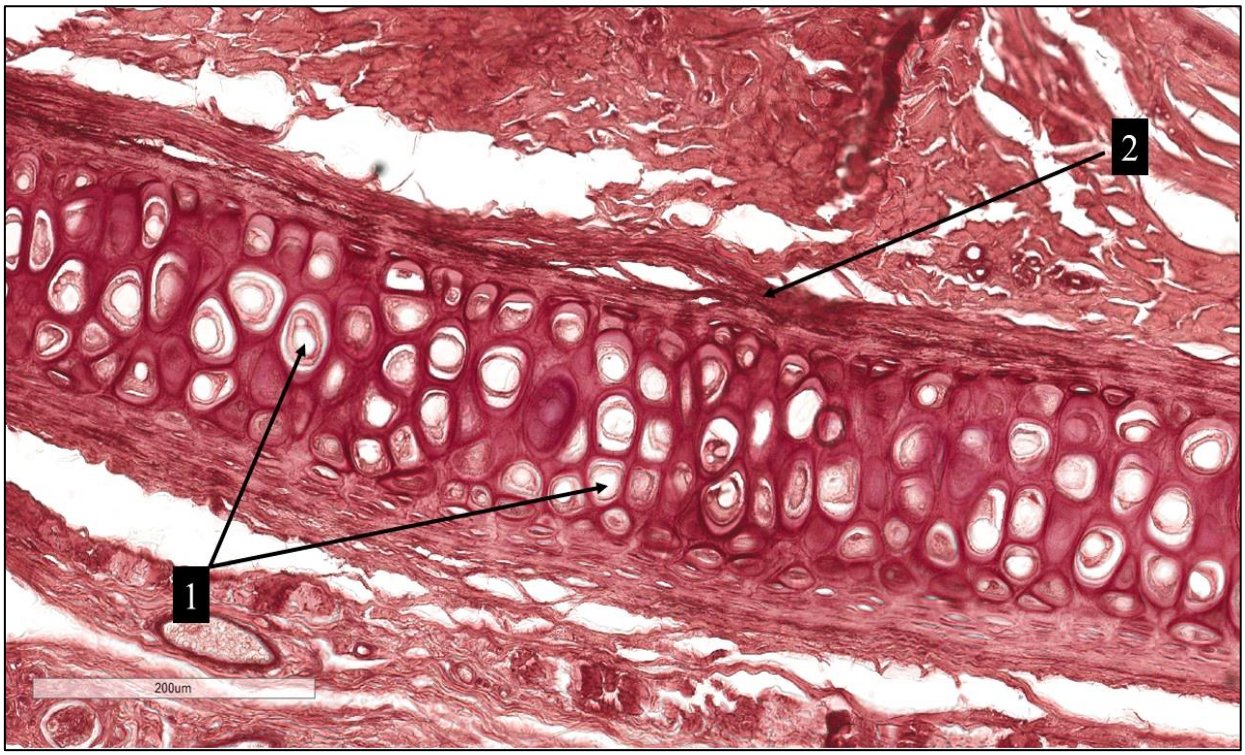

Fig. 15 A. Elastic cartilage. 1 – chondrocytes; 2 – perichondrium. Orcein staining

At high magnification, chondrocytes in lacunae are observed singly or in isogenic groups. The matrix of elastic cartilage contains a well-developed network of elastic fibers located between chondrocytes and interwoven into the perichondrium (Fig. 15 B).

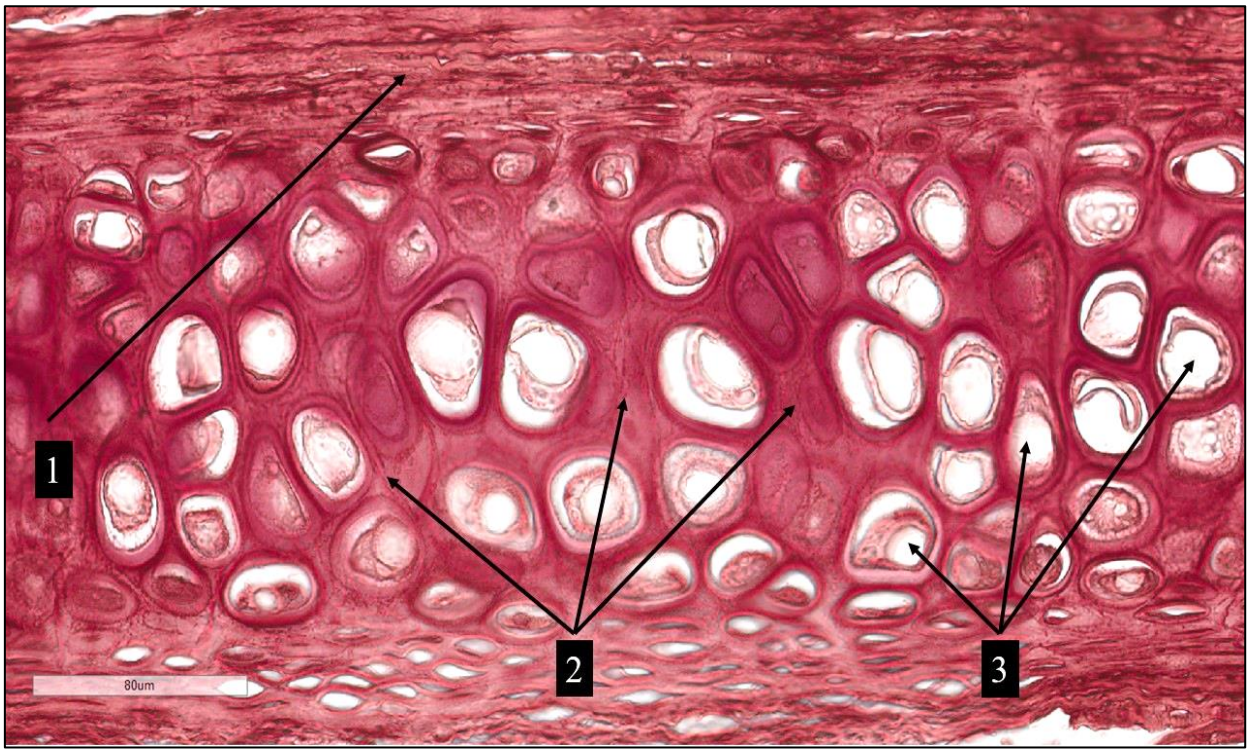

Fig. 15 B. Elastic cartilage. 1 – perichondrium; 2 – elastic fibers; 3 – chondrocytes in lacunae. Orcein staining

Elastic cartilage is characterized by its flexibility and reversibility. This type of cartilage is found in the external ear, the walls of the external auditory canal, the auditory (eustachian) tubes, the epiglottis, and the cuneiform cartilage of the larynx.

2.9. Mucous connective tissue

This is a transverse section of the umbilical cord, where the large vessels of the umbilical cord are identified (Fig. 16 A). There is mucous connective tissue between the vessels.

The ground substance of mucous connective tissue is markedly hygroscopic, containing a considerable quantity of water, which provides this tissue with high turgor and protects the umbilical cord and vessels from compression. This type of tissue is also present in the pulp of the tooth at an early age.

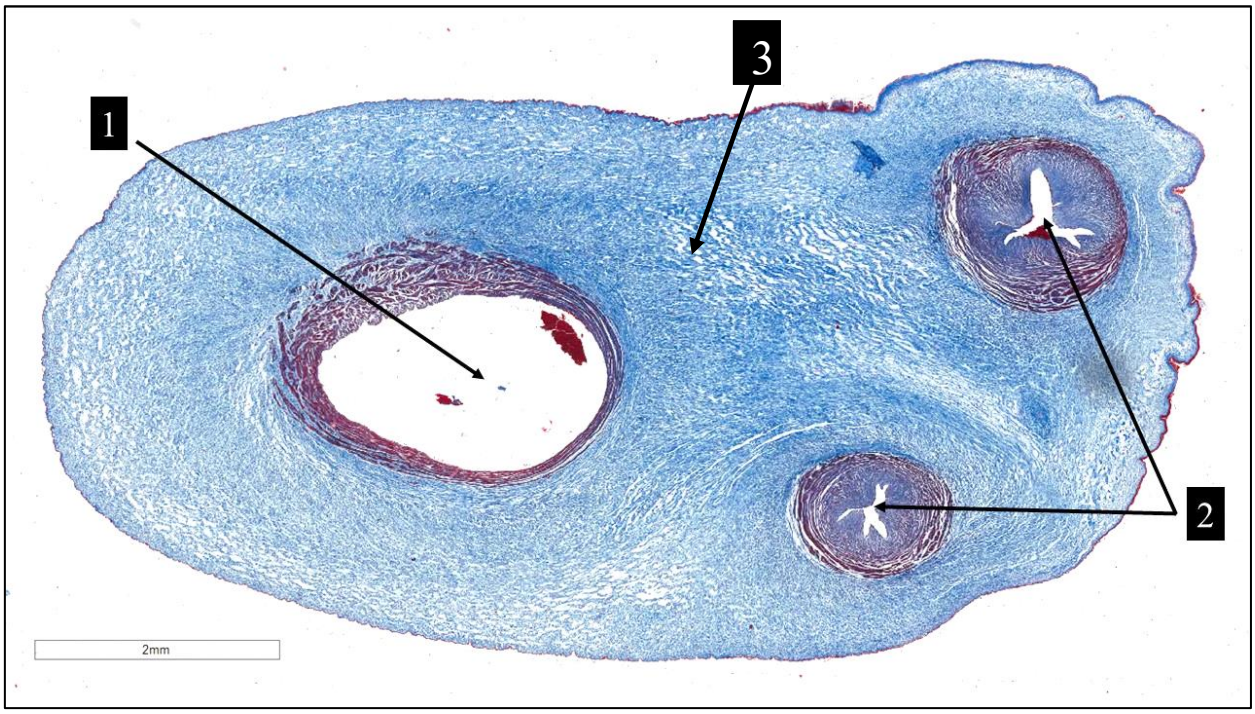

Fig. 16 A. Mucous connective tissue. Umbilical cord. 1 – vein; 2 – arteries; 3 – mucous connective tissue. Mallory's trichrome staining

Mucous connective tissue is composed of a limited number of cells, predominantly fibroblasts. Extracellular matrix contains a high concentration of hyaluronic acid and less fibers, which gives it a jelly-like consistence (Fig. 16 B).

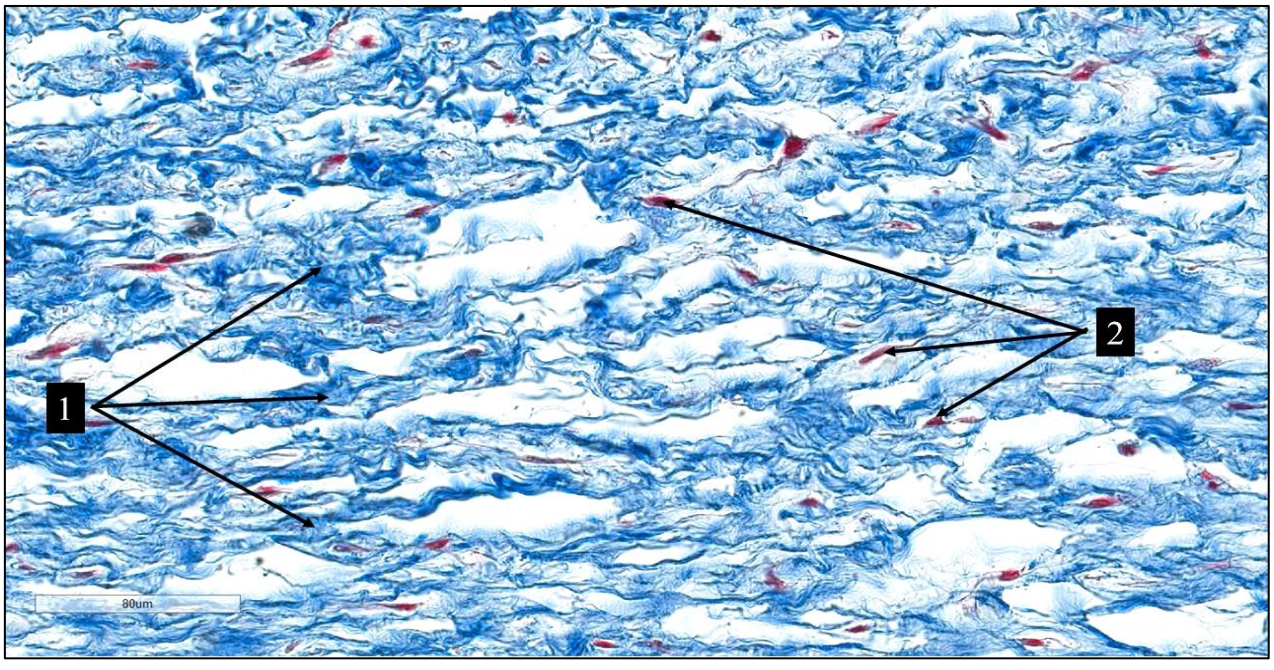

Fig. 16 B. Mucous connective tissue. Umbilical cord. 1 – amorphous ground substance; 2 – fibroblasts. Mallory's trichrome staining

2.10. Epiphyseal plate (endochondral ossification)

This is a section of the metaphysis, where the epiphyseal plate is detected. The epiphyseal plate is the area of bone growth in length (Fig. 17 A).

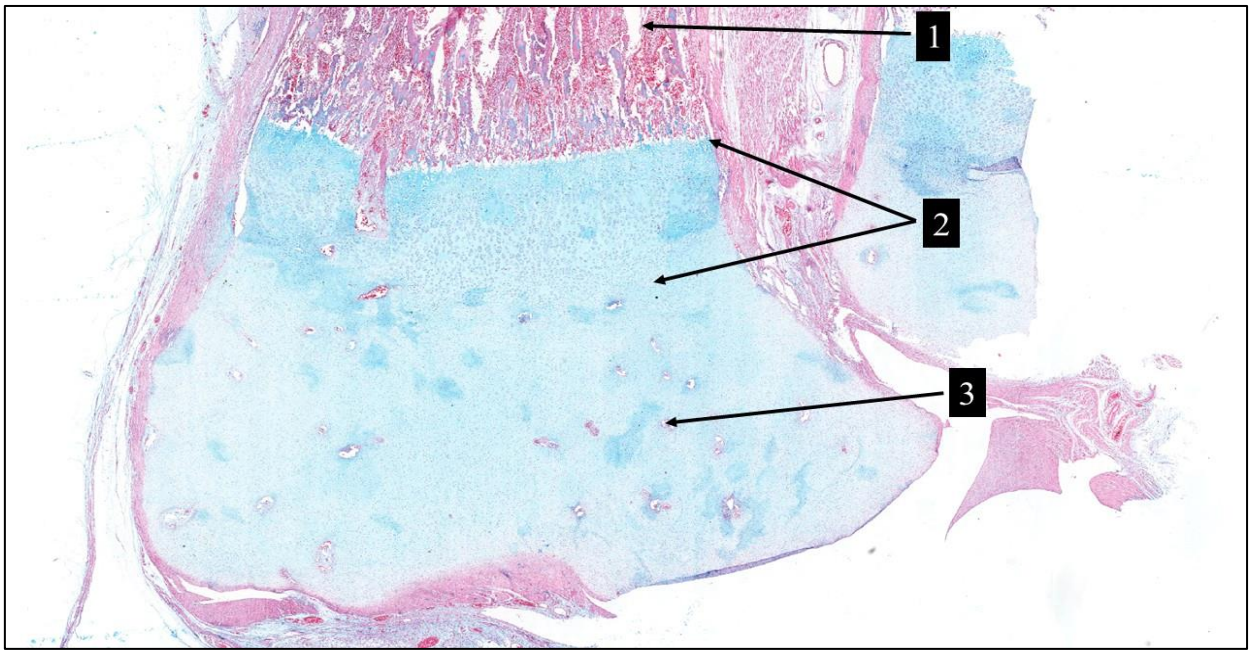

Fig. 17 A. Metaphysis (endochondral ossification). 1 – diaphysis; 2 – epiphyseal plate; 3 – epiphysis. Mallory's trichrome staining

At high magnification several distinct zones are detected within the metaphysis (Fig.17 B):

- resting zone, where morphologic changes in chondroblasts are absent;
- proliferation zone, where rapidly dividing chondrocytes are arranged in columns or stacks;

- hypertrophy zone is characterized by the presence of large chondrocytes and a reduced amount of matrix, which is preserved as narrow plates between chondrocytes;
- calcification zone is characterized by the apoptosis of chondrocytes and the calcification of thin matrix plates as a result of calcium hydroxyapatite deposition;
- ossification zone is represented by an area of bone tissue.

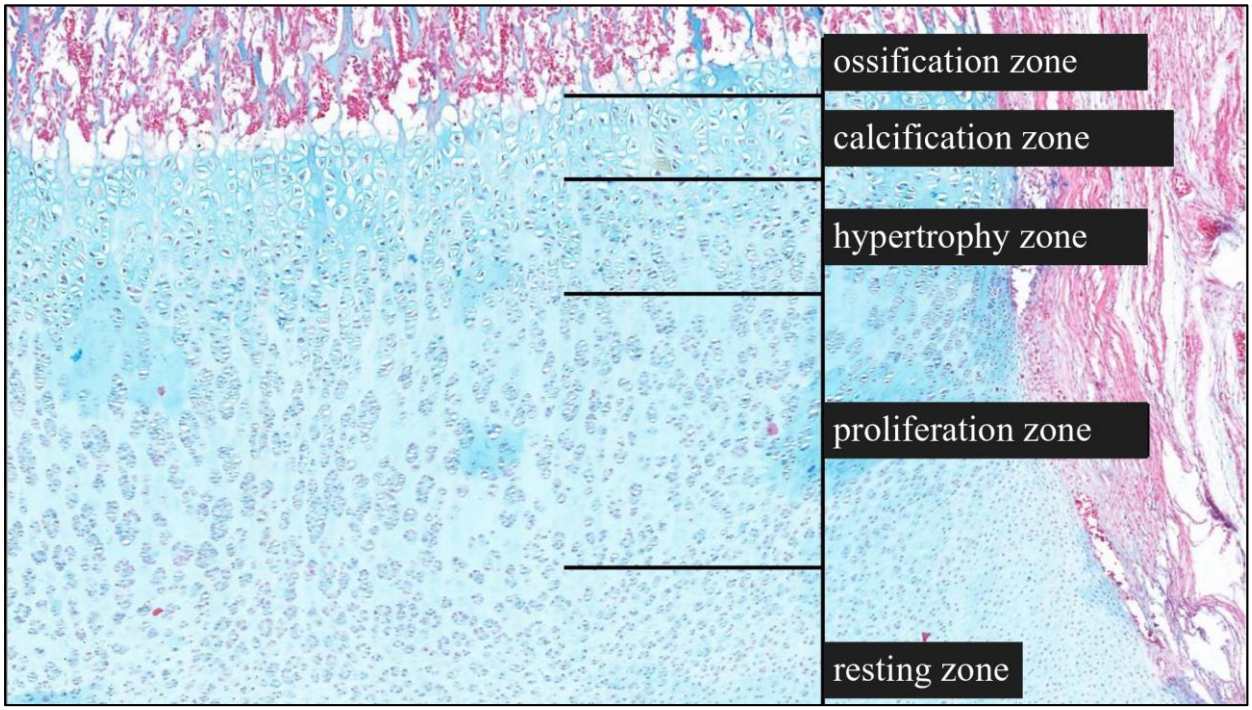

Fig. 17 B. Metaphysis (endochondral ossification). Mallory's trichrome staining

2.11. Intramembranous ossification

This slide illustrates the accumulation of mesenchymal cells in the areas of future bone tissue, where the primary ossification center or osteogenic islet are formed (Fig. 18 A).

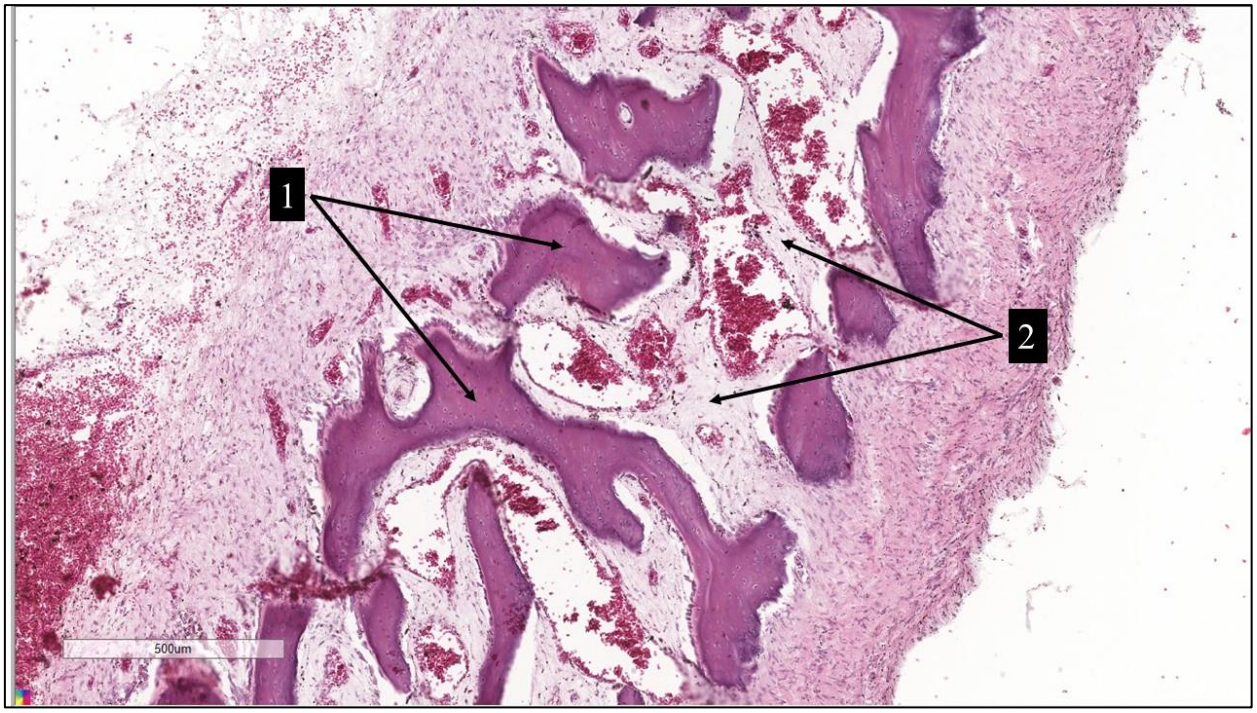

Fig. 18 A. Intramembranous ossification. 1 – bone spicules; 2 – mesenchyme. Hematoxylin and eosin staining

Mesenchymal cells differentiate into osteoblasts and secrete an osteoid around them, which subsequently calcifies and embeds the osteoblasts. The embedded osteoblasts differentiate into osteocytes, while the islets form bone beams. Ossification centers grow radially and merge with each other, replacing connective tissue (Fig. 18 B).

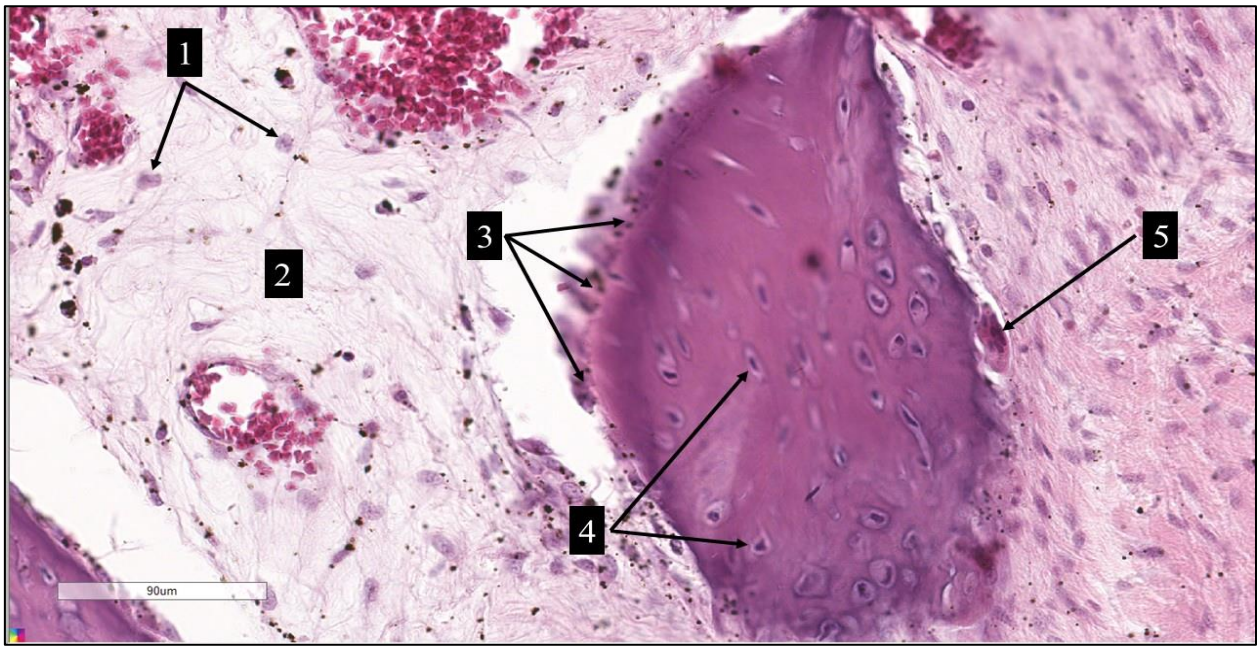

Fig. 18 B. Intramembranous ossification. 1 – mesenchymal cells; 2 – mesenchyme; 3 – osteoblasts; 4 – osteocytes; 5 – osteoclast. Hematoxylin and eosin staining

2.12. Compact bone

This is a section of the compact bone, represented by lamellar bone tissue (Fig.19 A).

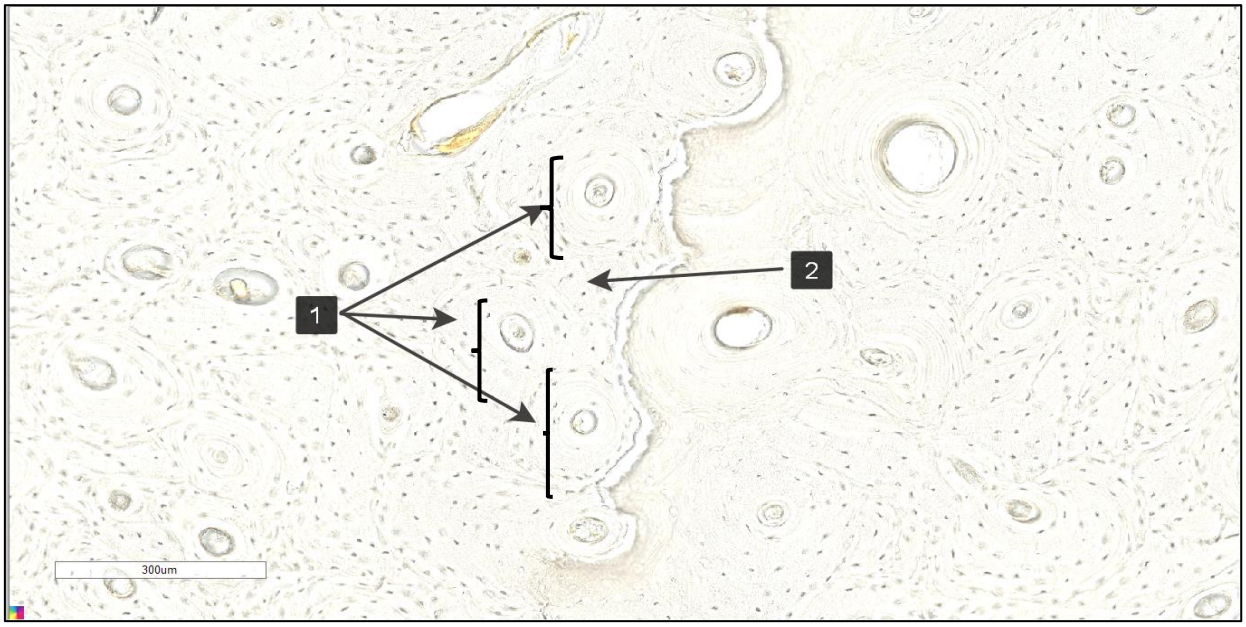

Fig. 19 A. Compact bone. 1 – osteons; 2 – interstitial bone lamellae

The osteons are surrounded by interstitial bone lamellae, which are remnants of previous osteons.

At high magnification, the osteon (a morphofunctional unit of compact lamellar bone tissue) is identified as a complex of concentric lamellae around the central channel of the osteon (Haversian Canal), where vessels and nerves pass. Between the concentric lamellae, osteocytes are observed lying in lacunae (Fig. 19 B).

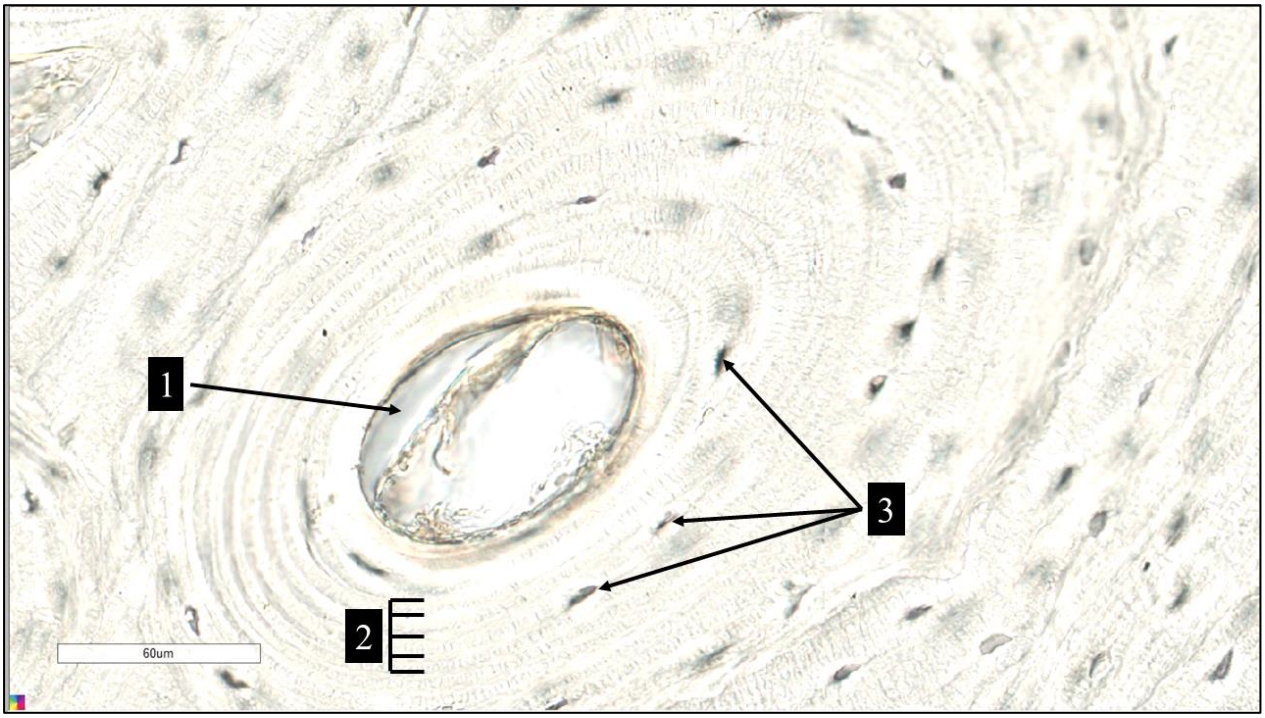

Fig. 19 B. Compact bone. Osteon. 1 – Haversian canal; 2 – concentric lamellae; 3 – osteocytes in lacunae

2.13. Spongy bone

This is a transverse section of the spongy bone tissue (Fig. 20 A). The spongy bone is composed of bone trabeculae separated by intertrabecular spaces, which form a bone marrow cavity.

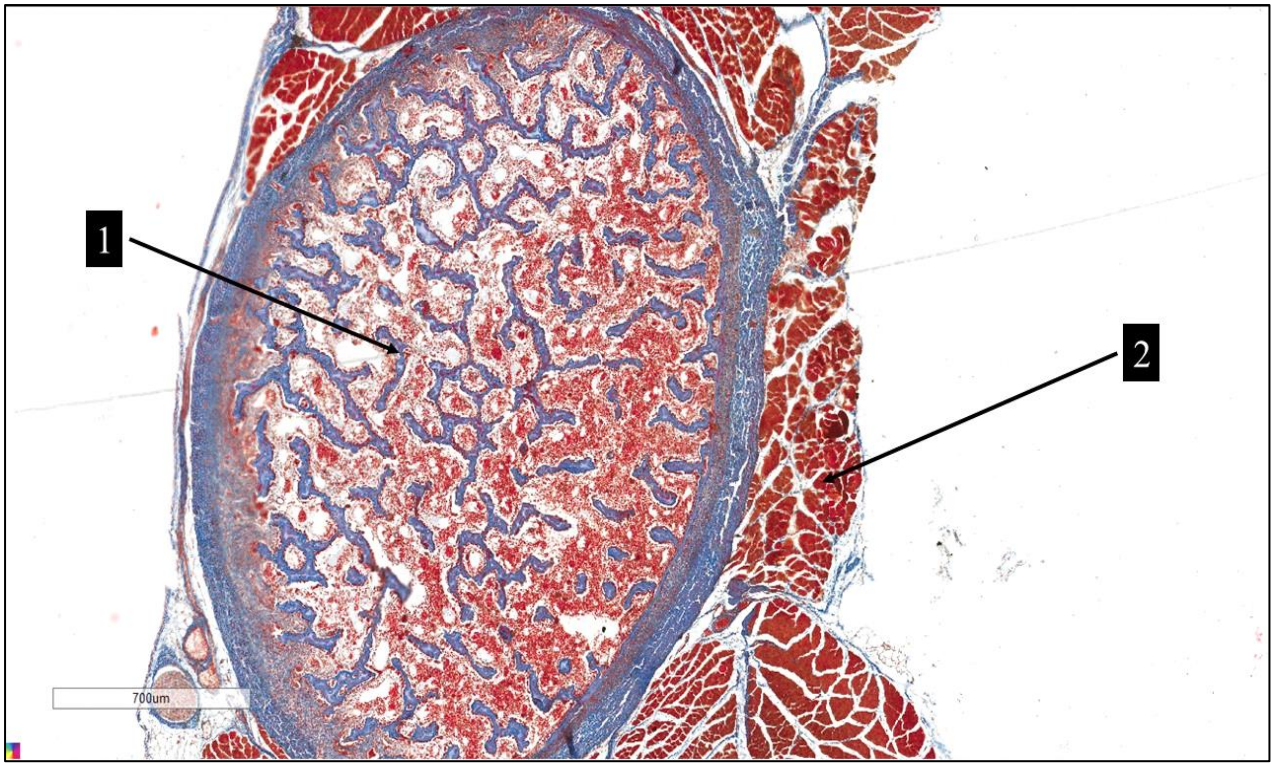

Fig. 20 A. Spongy bone. 1 – bone trabeculae; 2 - skeletal muscle tissue. Mallory's trichrome staining

From the outside, the spongy bone is covered with periosteum, which consists of 2 layers - inner and outer (Fig. 20 B). The outer (fibrous) layer is formed by dense irregular connective tissue. The inner (cellular) layer contains osteoprogenitor cells and collagen fibers. From the inside, the bone is lined by the endosteum, which consists of a layer of osteoprogenitor cells and a small amount of loose connective tissue.

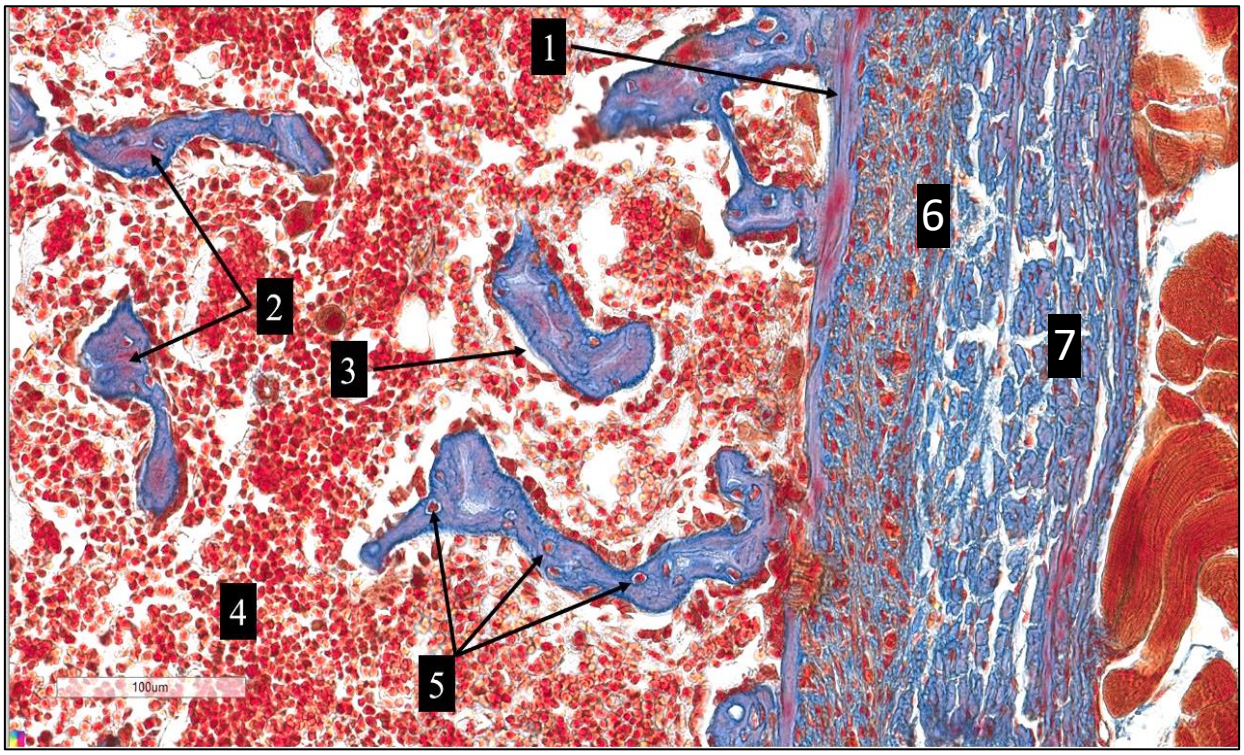

Fig. 20 B. Spongy bone. 1 – periosteum; 2 – bone trabeculae; 3 – endosteum; 4 – bone marrow; 5 – osteocytes; 6 - inner layer of periosteum; 7 - outer layer of periosteum. Mallory's trichrome staining

3. MUSCLE TISSUE

3.1. Skeletal muscle tissue

This is a longitudinal section of skeletal muscle tissue (Fig. 21 A). Skeletal muscle tissue is formed by muscle fibers, which are multinucleated cells of cylindrical shape. Between the fascicles of muscle fibers there is some loose connective tissue, known as the perimysium.

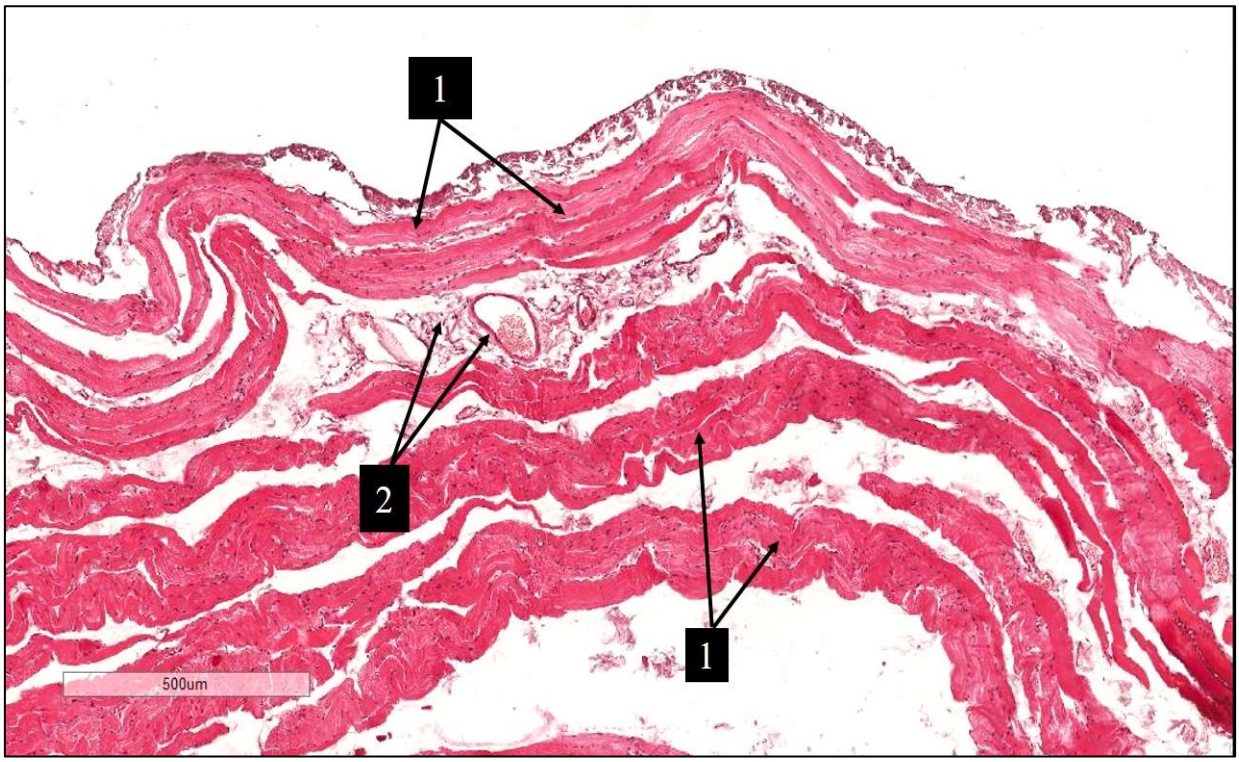

Fig. 21 A. Skeletal muscle tissue. 1- muscle fiber fascicle; 2- perimysium. Hematoxylin and eosin staining

At high magnification, the transverse striation of muscle fibers is observed (Fig. 21 B). There are numerous cell nuclei located at the periphery under the plasma membrane. Each muscle fiber is surrounded by an endomysium, which is composed mainly of reticular fibers.

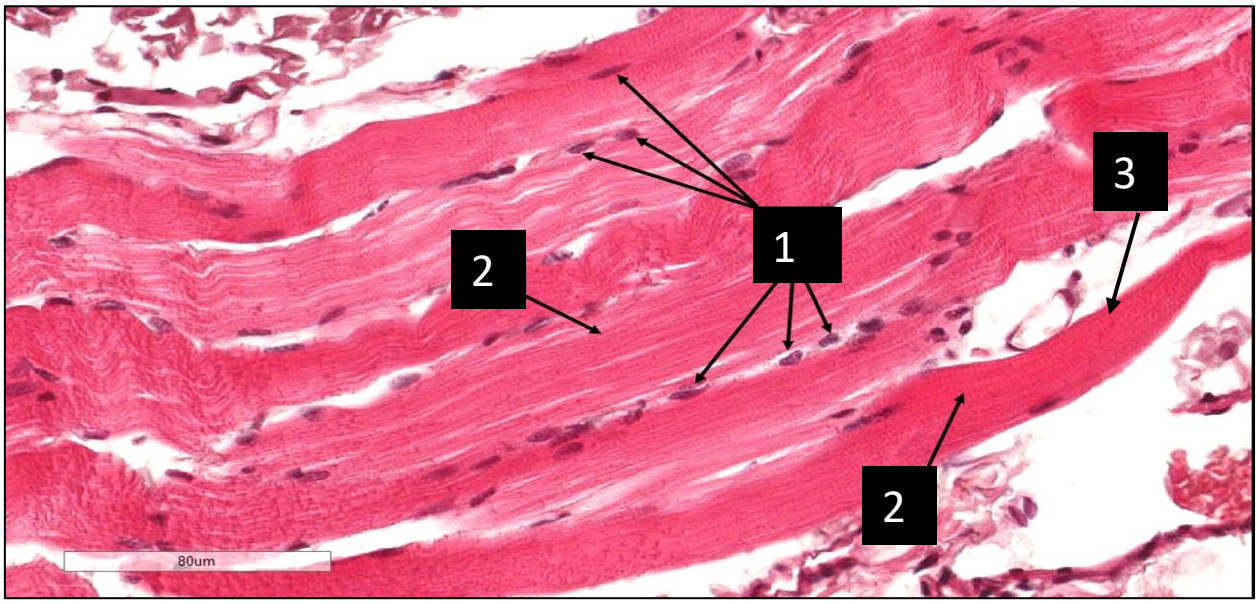

Fig. 21 B. Skeletal muscle tissue. 1 - cell nuclei; 2 - transverse striation of muscle fibers, 3 – endomysium. Hematoxylin and eosin staining

3.2. Smooth muscle tissue (duodenum)

This is a transverse section of the small intestine, with the muscular layer formed by smooth muscle tissue (Fig. 22 A).

Fig. 22 A. Duodenum. 1- muscularis externa. Hematoxylin and eosin staining

At high magnification spindle-shaped myocytes without transverse striation and with a single centrally located nucleus are observed (Fig.22 B).

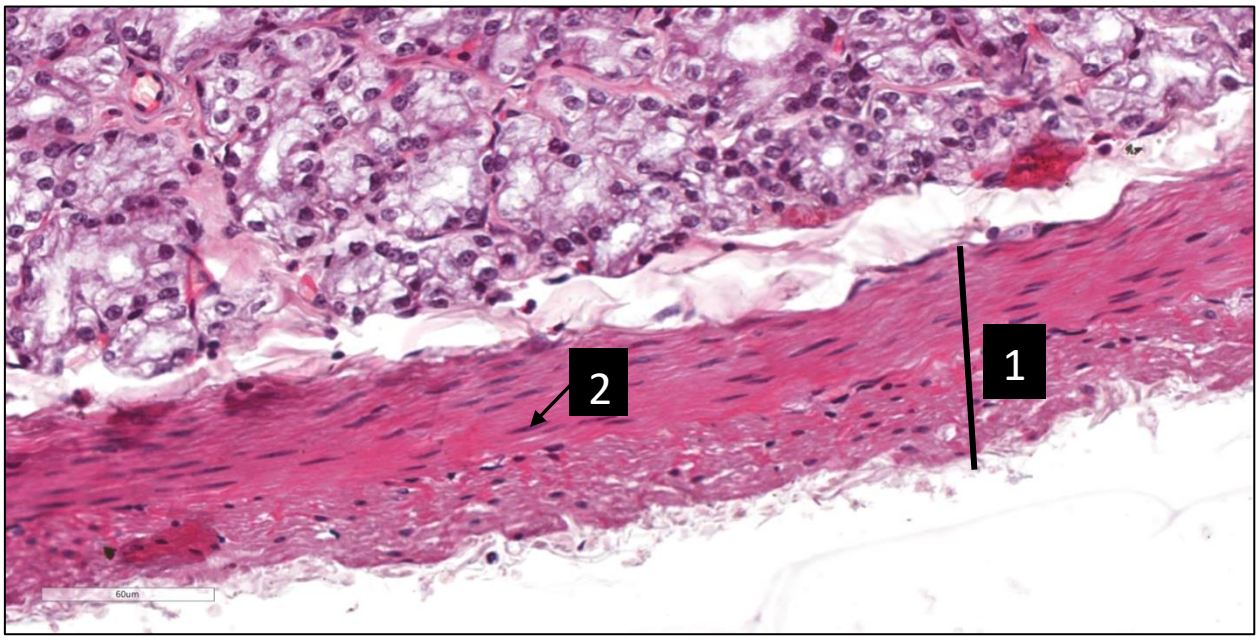

Fig. 22 B. Duodenum. 1 - smooth muscle tissue; 2 - myocyte nucleus. Hematoxylin and eosin staining

3.2. Cardiac muscle tissue

This is a section of myocardium formed by cardiac muscle tissue (Fig. 23 A).

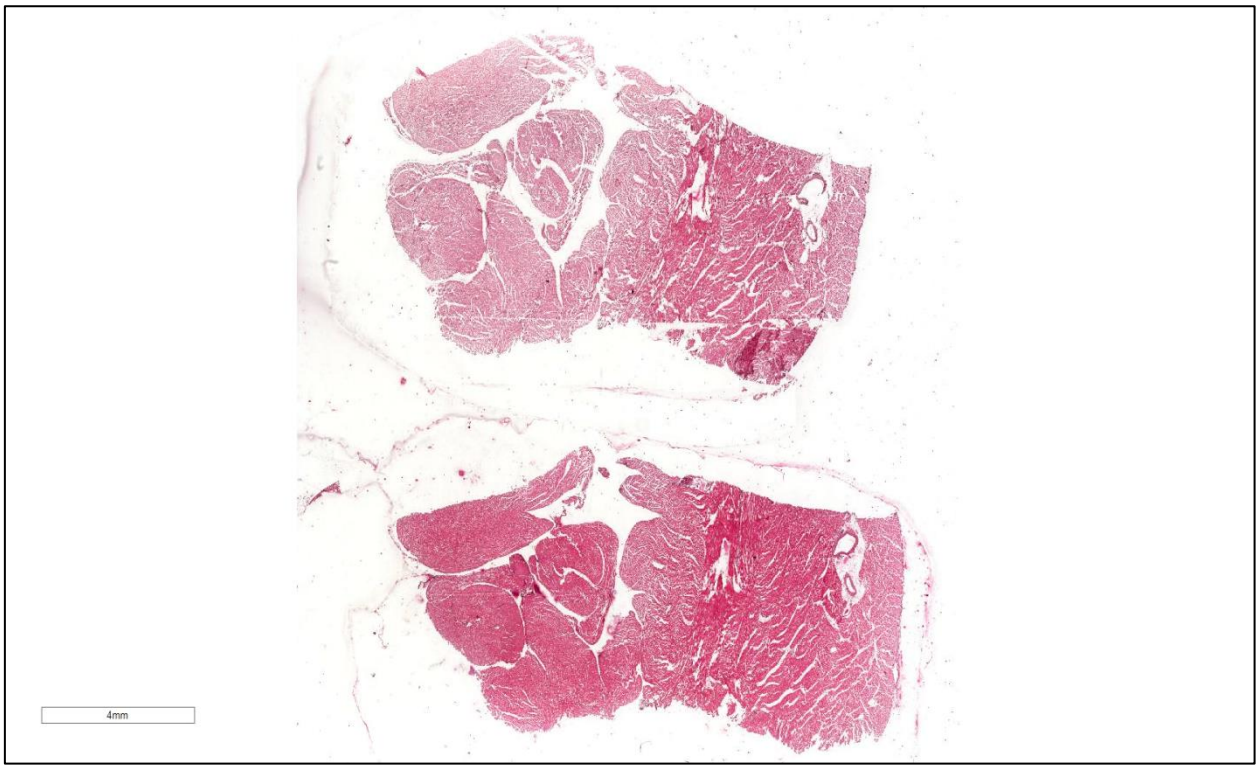

Fig. 23 A. Myocardium. Hematoxylin and eosin staining

At high magnification, branched cylindrical shape cardiomyocytes are observed. A longitudinal section reveals the presence of transverse striation in cardiomyocytes. Cardiac muscle cells are characterized by the presence of one or two centrally located nuclei. Cardiomyocytes are connected to each other through a complex of intercellular contacts (desmosomes and gap junctions) forming intercalated disks. On a longitudinal section of cardiac muscle tissue, the intercalated disks are defined as darkly stained transverse lines (Fig.23 B).

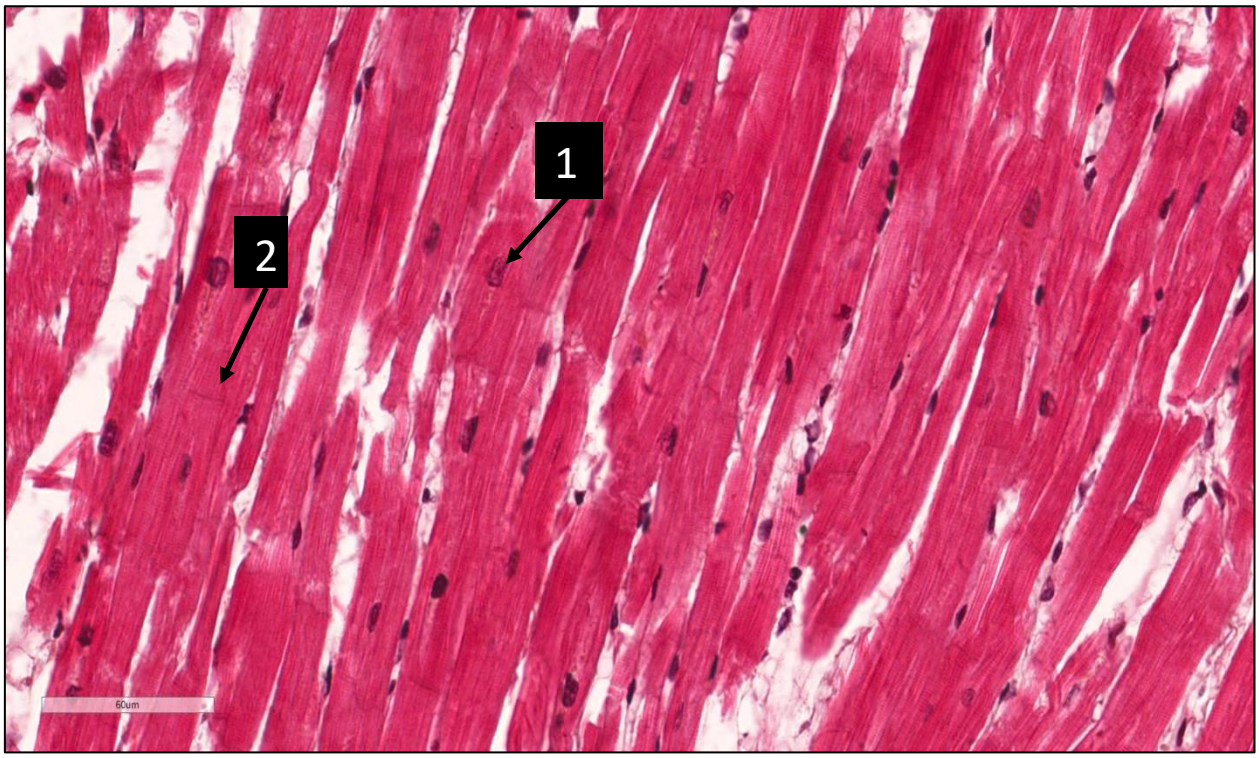

Fig. 23 B. Myocardium. 1 - cardiomyocyte nucleus; 2 - intercalated disk. Hematoxylin and eosin staining

4. NERVOUS TISSUE

4.1. Mouse brain (vascular plexus, cerebral cortex)

This is a section of the mouse brain consisting of gray matter and white matter (Fig. 24 A). The gray matter of the brain is formed predominantly by the bodies of neurons, while the white matter consists of the processes of neurons. In addition to neurons, the nervous tissue that forms the brain includes neuroglial cells.

Fig. 24 A. Mouse brain (vascular plexus, cerebral cortex). Hematoxylin and eosin staining

Upon examination of the grey matter of the brain at high magnification, 6 distinct layers of cells are identified (Fig. 24 B):

- molecular layer (1) contains a few neuron bodies and many neuroglia
- external granular layer (2) is represented by granular cells and neuroglia
- external pyramidal layer (3) consists of pyramidal cells, granular cells and neuroglia
- inner granular layer (4) - a relatively narrow layer consisting of small and large granular cells and neuroglia
- inner pyramidal layer (5) is represented by giant pyramidal cells and neuroglia. Pyramidal cells are characterized by a pyramidal shape body and a thin, long axon, which originates from the base of the cell

- multiform layer (6) consists of cells in different size and shape, most of which are fusiform. There are also Martinotti cells and neuroglia

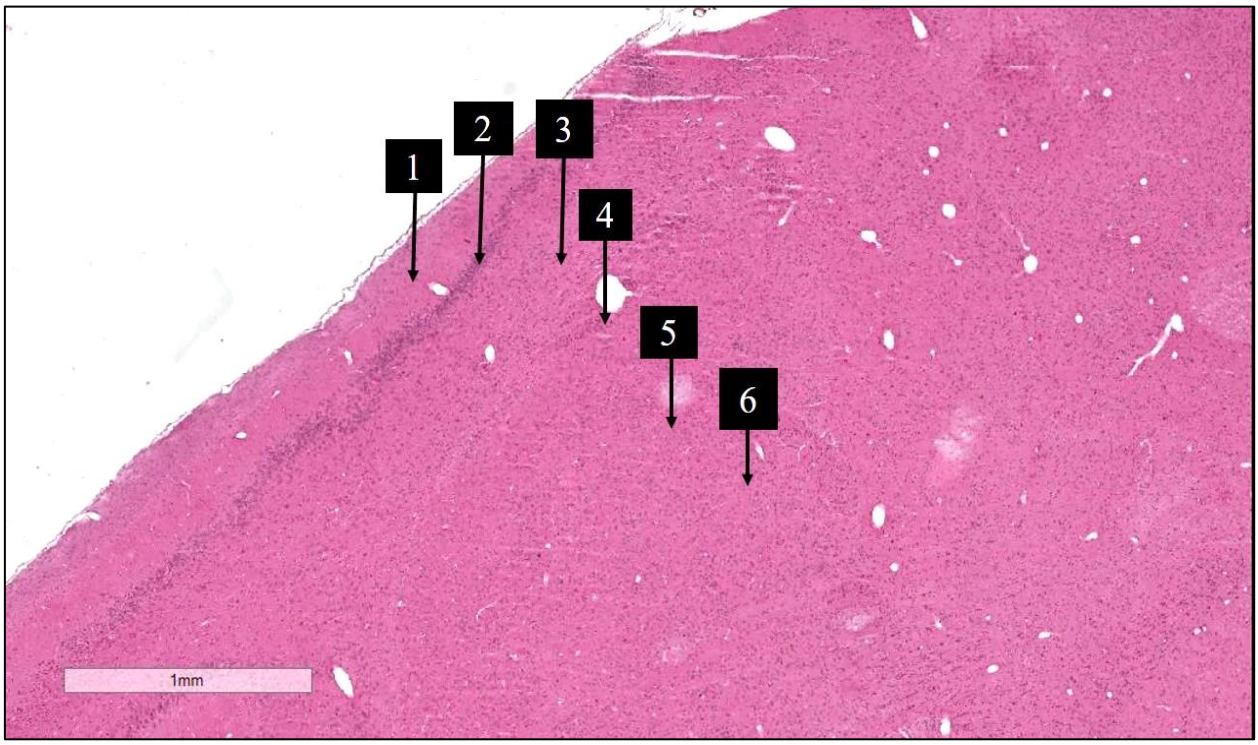

Fig. 24 B. Mouse brain (vascular plexus, cerebral cortex). 1-6 – layers of the cerebral cortex. Hematoxylin and eosin staining

Figure 24 C illustrates the white matter of the brain, which is composed of myelinated nerve fibers.

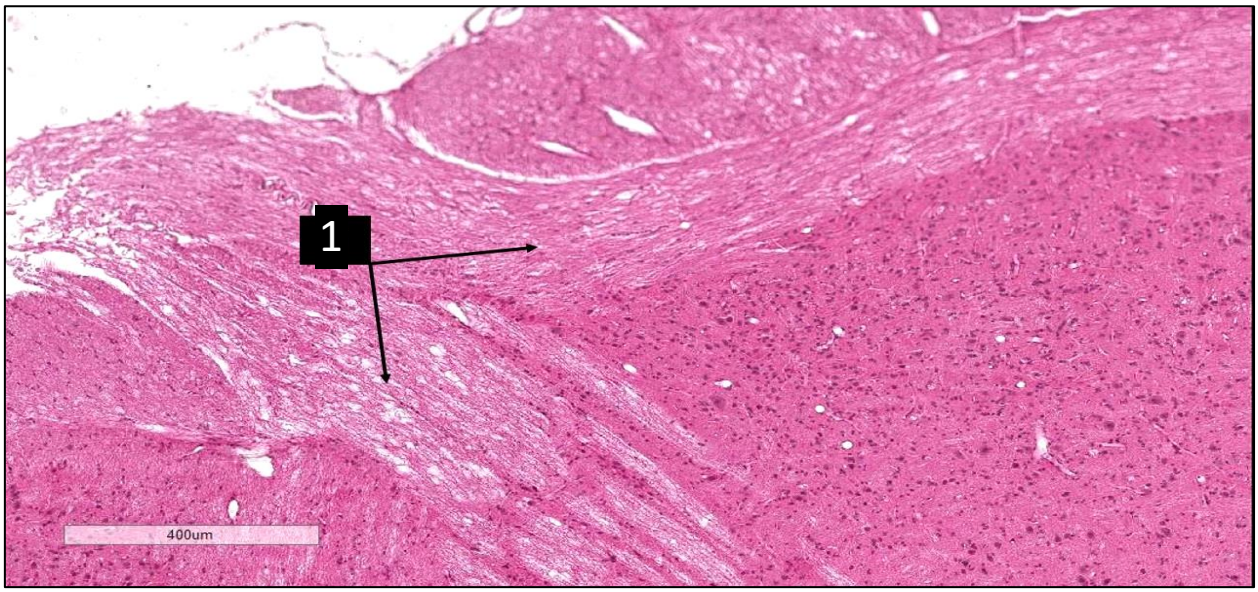

Fig. 24 C. Mouse brain (vascular plexus, cerebral cortex). 1 –white matter of brain. Hematoxylin and eosin staining

The ventricles of the cerebral hemispheres contain vascular plexuses that participate in the secretion of cerebrospinal fluid (Fig. 22 D). The surface of the vascular plexuses is covered with ependymal cells (neuroglia).

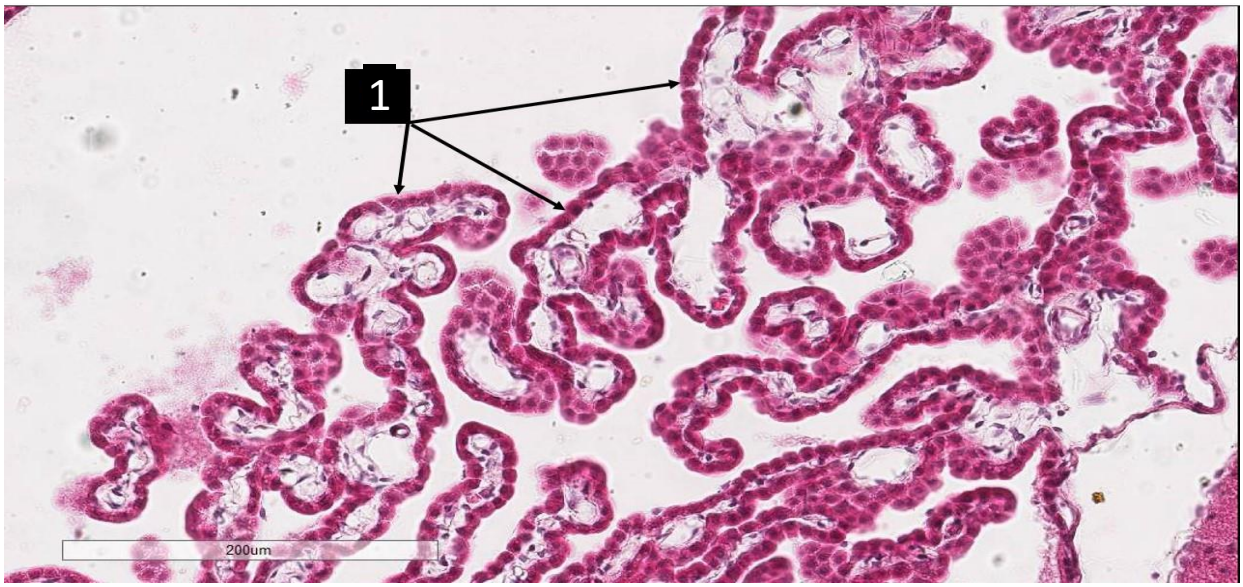

Fig. 24 D. Mouse brain (vascular plexus, cerebral cortex). 1 - ependymal cells. Hematoxylin and eosin staining

4.2. Cerebellum

This is a section of the cerebellum (Fig.25 A), where the gray and white matter boundaries are clearly delineated. The gray matter of the cerebellum is primarily composed of neuron's cell bodies, while the white matter is constituted by neuron's processes. In addition to neurons, the nerve tissue forming the cerebellum includes neuroglial cells.

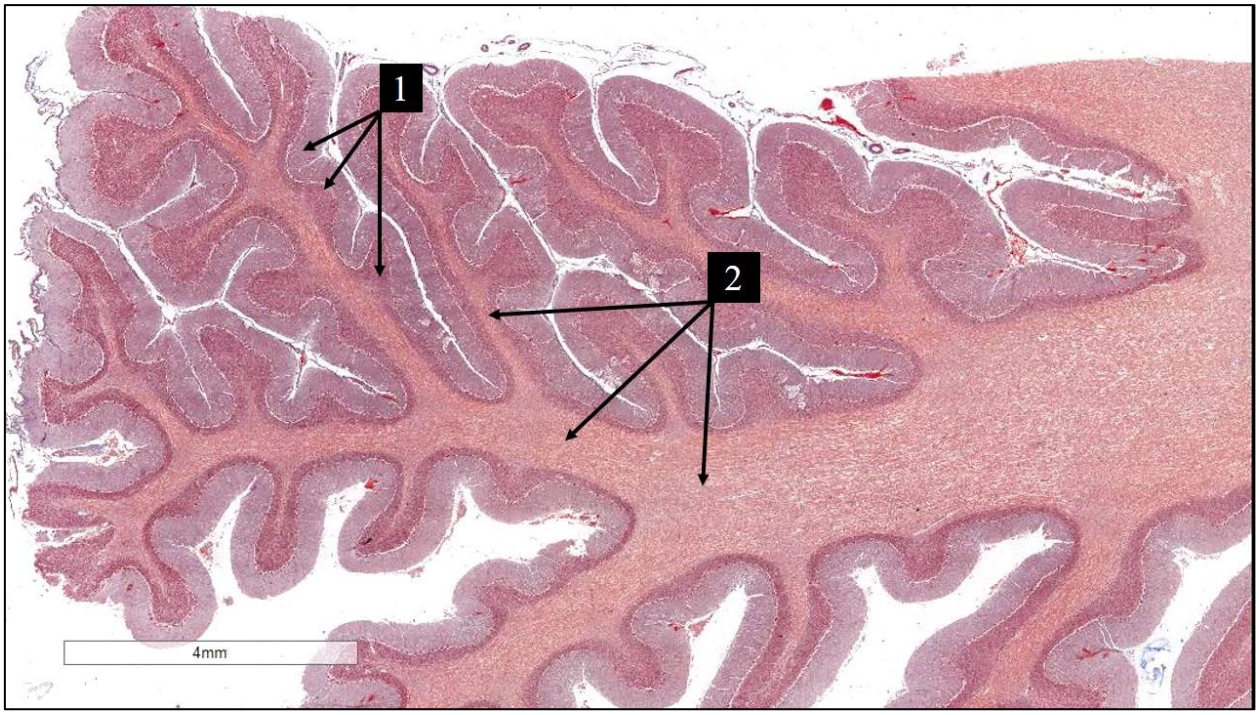

Fig. 25 A. Cerebellum. 1 - gray matter, 2 - white matter. Mallory's trichrome staining

The gray matter of the cerebellum, called the cortex, consists of 3 layers of cells (Fig. 25 B):

- The molecular layer (1) is constituted by unmyelinated outgrowths of granular cells, superficial stellate cells, and basket cells. Basket cells encase the bodies of Purkinje cells with their axons;
- the Purkinje cell layer (ganglionic layer) (2) is composed of large cells that are characteristic of the cerebellar cortex. Purkinje cells are motor neurons, arranged in a single layer, and exhibit a pear-shaped body morphology;
- granular layer (3) is represented by densely packed granular cells.

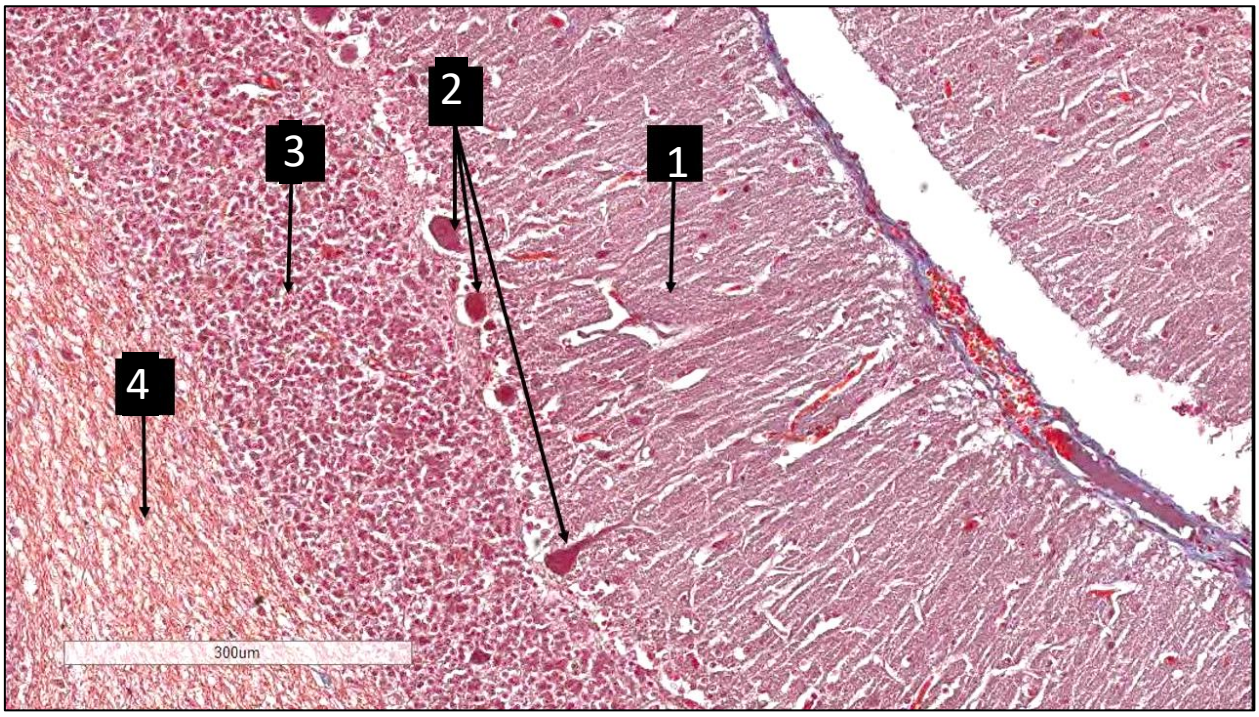

Fig. 25 B. Cerebellum. 1- molecular layer, 2 - Purkinje cell layer, 3 - granular layer, 4 - white matter. Mallory’s trichrome staining

4.3. Spinal cord

This is a section of the spinal cord (Fig. 26 A). The gray matter of the spinal cord is predominantly composed of neuron's cell bodies and exhibits a distinctive butterfly-like shape at the section. In contrast, the white matter is located in the periphery and comprises the processes of neurons. In addition to neurons, the spinal cord's nervous tissue includes neuroglial cells. In the center of the gray matter the central canal of the spinal cord is located.

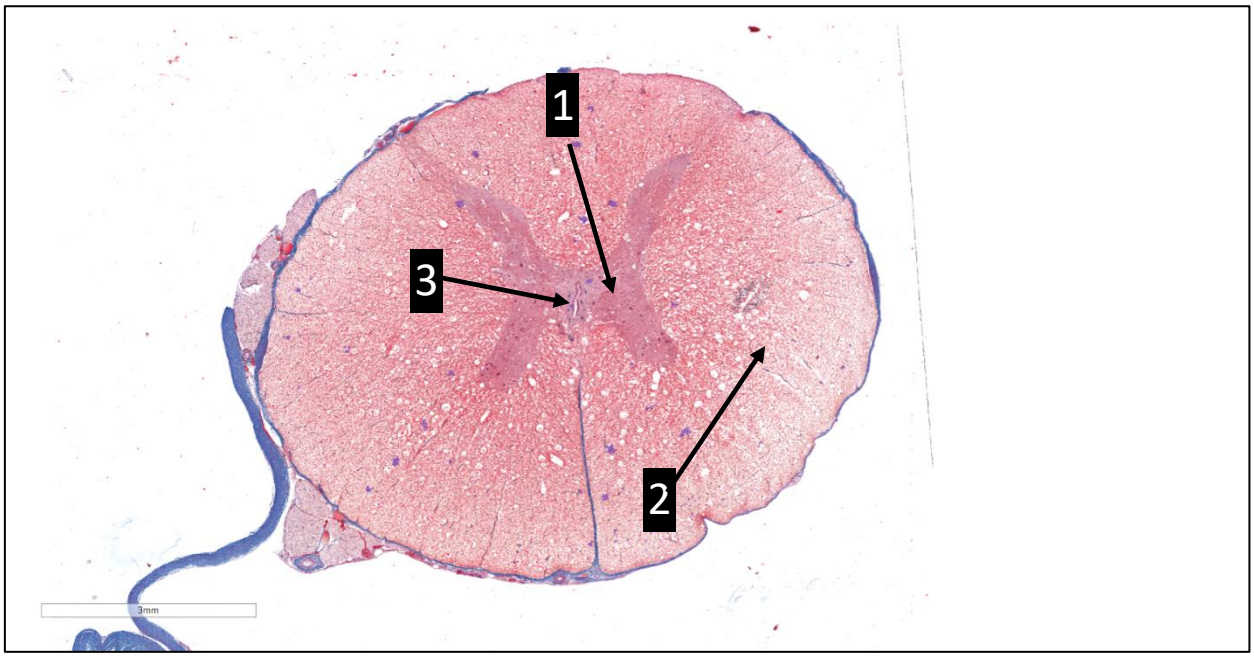

Fig. 26 A. Spinal cord. 1 - gray matter, 2 - white matter, 3 - central canal of the spinal cord. Mallory’s trichrome staining

Upon examination of the spinal cord at high magnification (Fig. 26 B), the gray matter reveals the neuron's bodies that constitute the nuclei, in addition to the myelinated nerve fibers that comprise the white matter of the spinal cord.

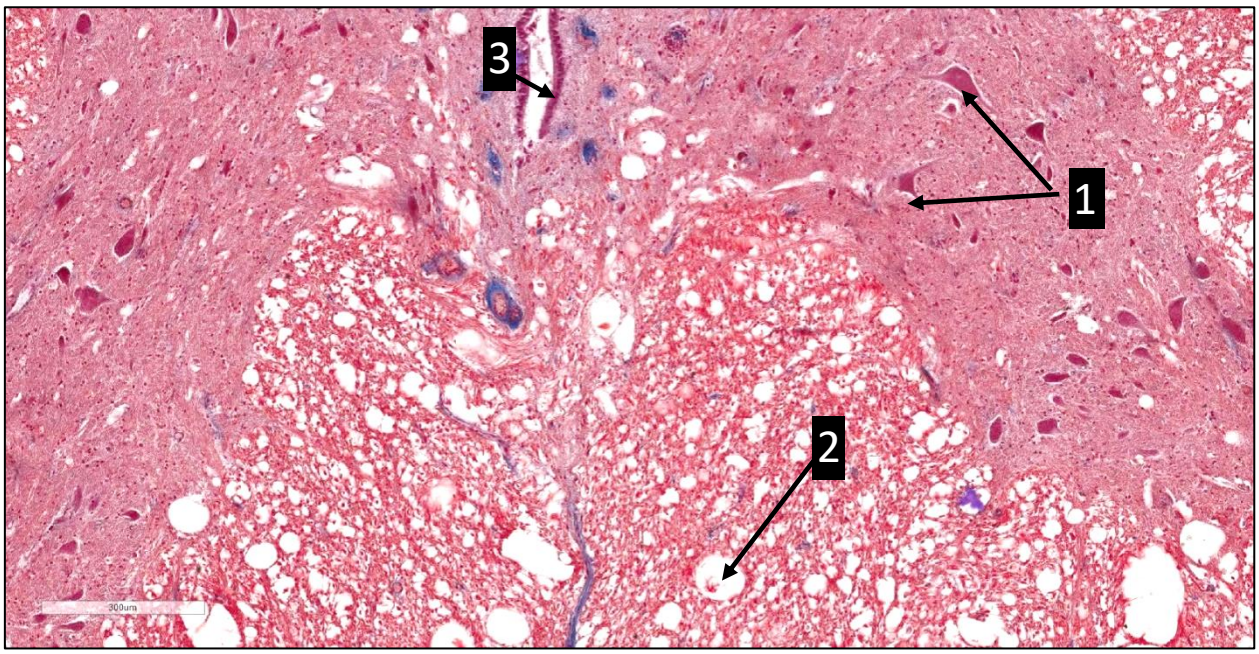

Fig. 26 Б. Spinal cord. 1 - neuron's bodies, 2 - neuron's axons, 3 - ependymal cells. Mallory’s trichrome staining

The central canal of the spinal cord is lined with ependymal cells which are involved in the secretion of cerebrospinal fluid.

4.4. Sympathetic ganglion

The preparation shows a transverse section of the sympathetic ganglion (Fig.27 A). The sympathetic ganglion is covered by a connective tissue capsule.

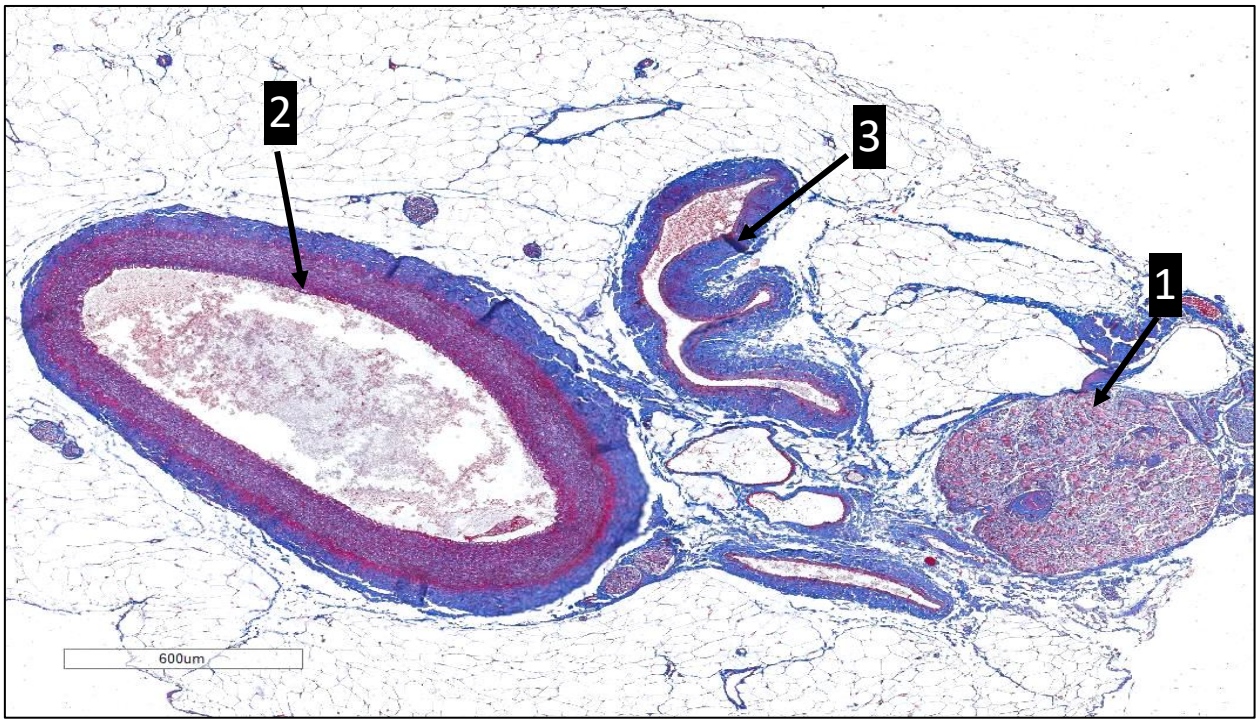

Fig. 27 A. Sympathetic ganglion. 1 - sympathetic ganglion; 2 - artery; 3 - vein. Mallory's trichrome staining

At high magnification, neuron's bodies with bundles of myelinated nerve fibers running between them are defined (Fig. 27 B). Neuron's bodies are surrounded by supporting cells of the peripheral nervous system called as satellite cells.

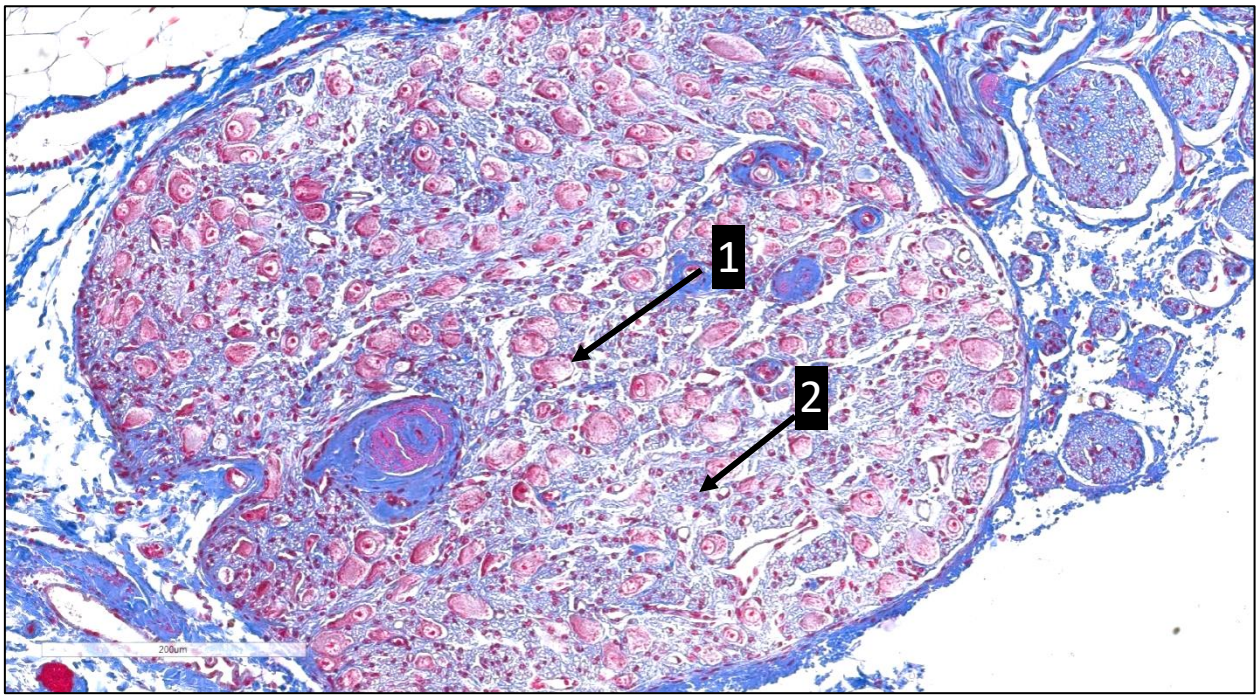

Fig. 27 B. Sympathetic ganglion. 1 - neuron's body; 2 - satellite cell. Mallory's trichrome staining

4.5. Myelinated nerve fibers

This is a longitudinal section of myelinated nerve fibers (Fig. 28 A).

Fig. 28 A. Myelinated nerve fibers. Silver staining

At high magnification (Fig. 28 B), neuron's axons (axial cylinders) covered with myelin sheaths are observed. The myelin sheath is represented by multiple layers of Schwann cell membrane that are concentric and twisted around the axial

cylinder. At the point of contact between neighboring Schwann cells, the fiber sections are devoid of a myelin sheath, exhibiting only a thinned membrane (neurolemma). These areas are known as nodes of Ranvier, and they are responsible for the saltatory ("jumping") transmission of the nerve impulse.

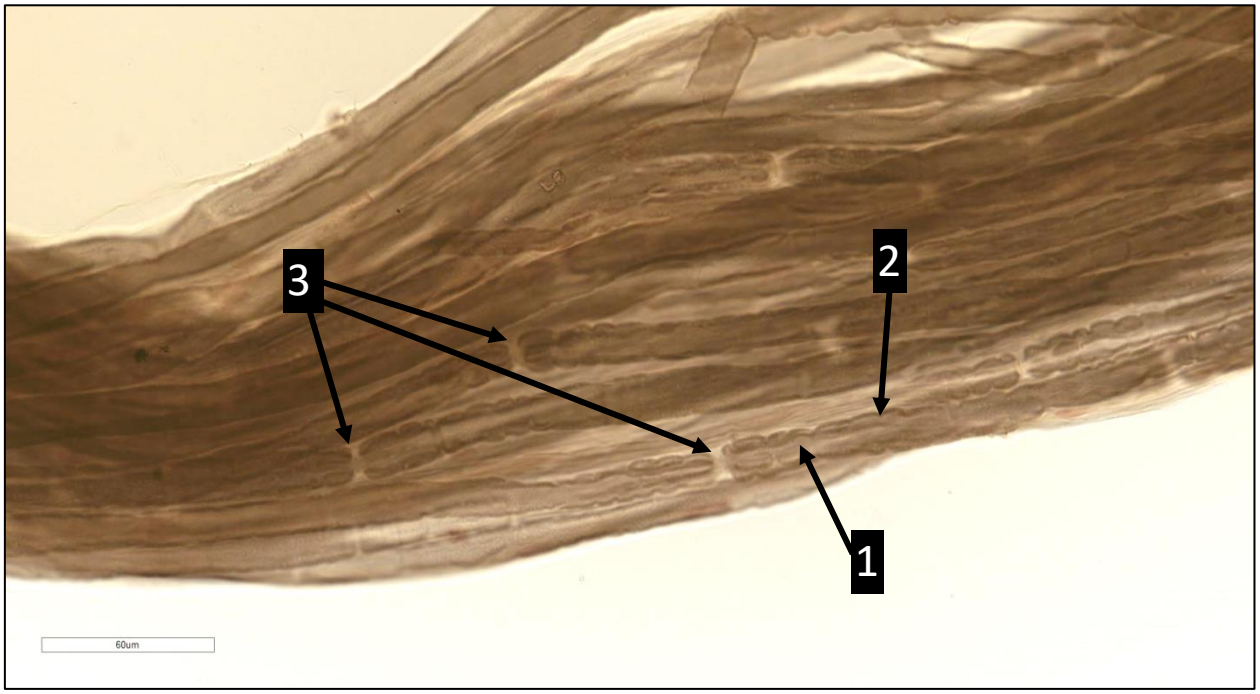

Fig. 28 B. Myelinated nerve fibers. 1 - axial cylinder, 2 - myelin sheath, 3 - nodes of Ranvier. Silver staining

4.6. Peripheral nerve

This is a cross section of a peripheral nerve, consisting of myelin fibers and a connective tissue sheath – the epineurium, a dense irregular connective tissue covering the nerve from the outside (Fig. 29 A).

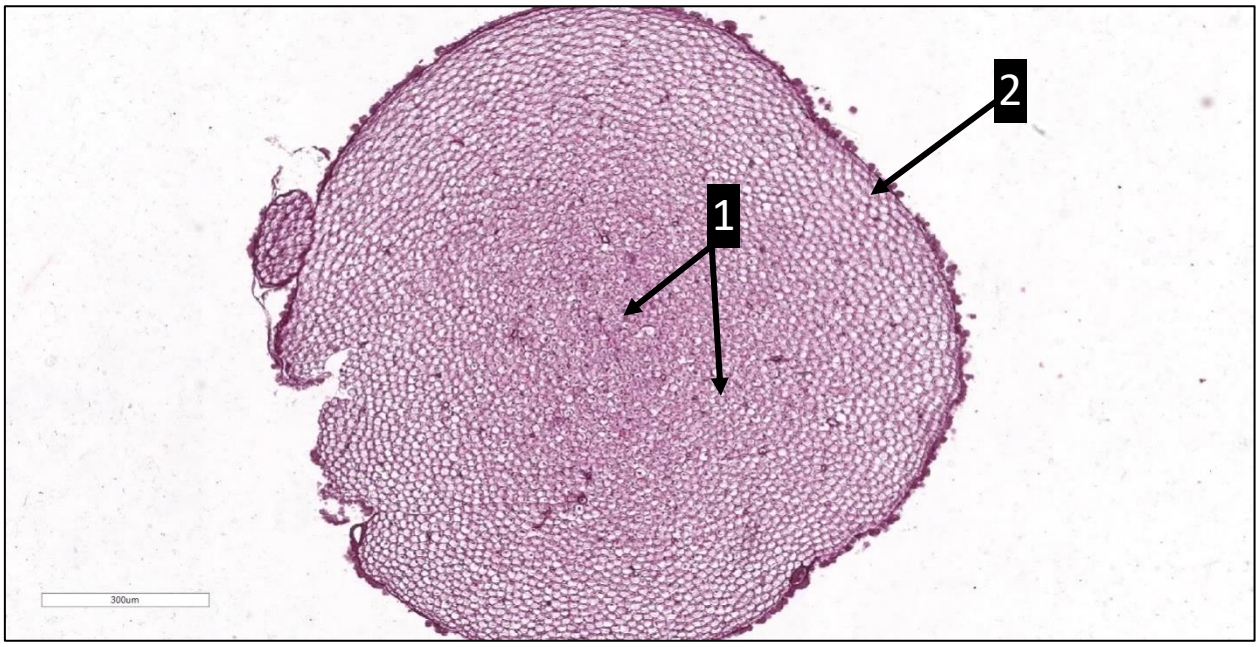

Fig. 29 A. Peripheral nerve. 1 - nerve fibers; 2 - epineurium. Hematoxylin and eosin staining

At high magnification (Fig. 29 B), neuronal axons, which are covered with weakly colored myelin sheaths formed by Schwann cells, can be observed. A loose connective tissue is located between the nerve fibers - endoneurium.

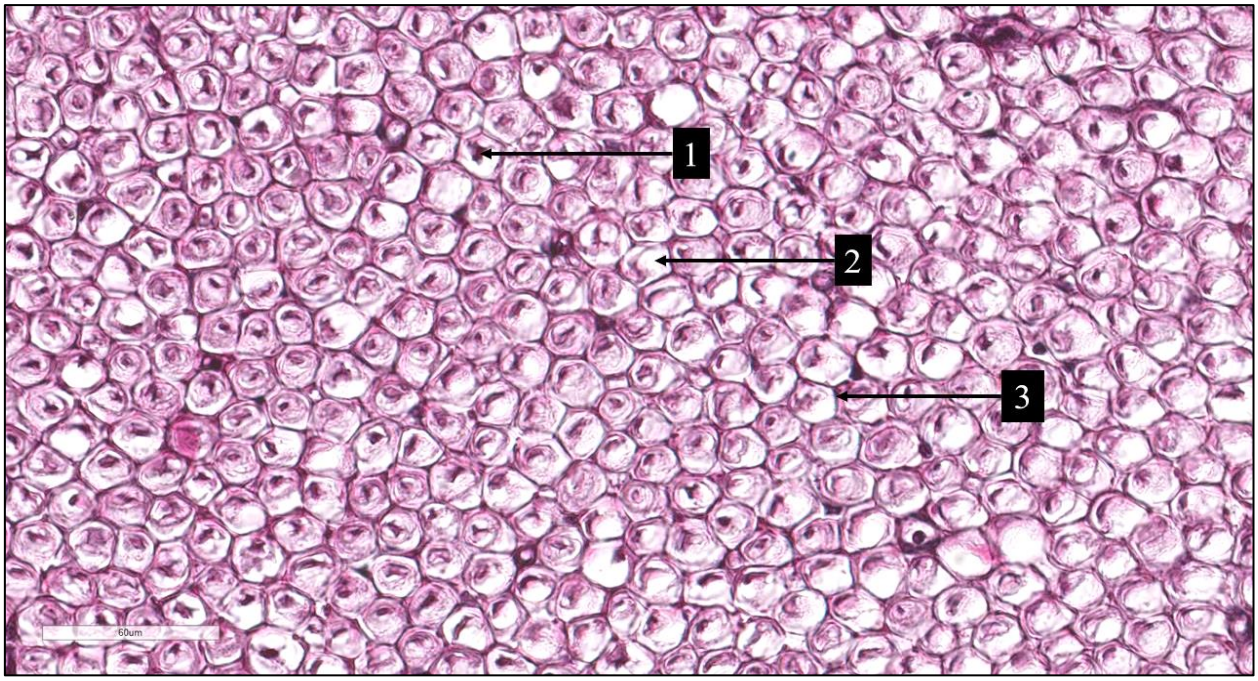

Fig. 29 B. Peripheral nerve. 1 - axial cylinder; 2 - myelin sheath; 3 - endoneurium. Hematoxylin and eosin staining

4.7. The neuromuscular spindle

This is a section of striated muscle tissue containing muscle spindles, the encapsulated proprioceptors of skeletal muscle (Fig. 30 A).

Fig. 30 A. The neuromuscular spindle. Hematoxylin and eosin staining

At high magnification (Fig.30 B), intrafusal fibers are identified, which are bundles of specialized muscle fibers oriented parallel to ordinary extrafusal muscle fibers. Sensitive nerve endings penetrate to intrafusal muscle fibers, sensing changes in the length of extrafusal muscle fibers and transmitting information to the spinal cord.

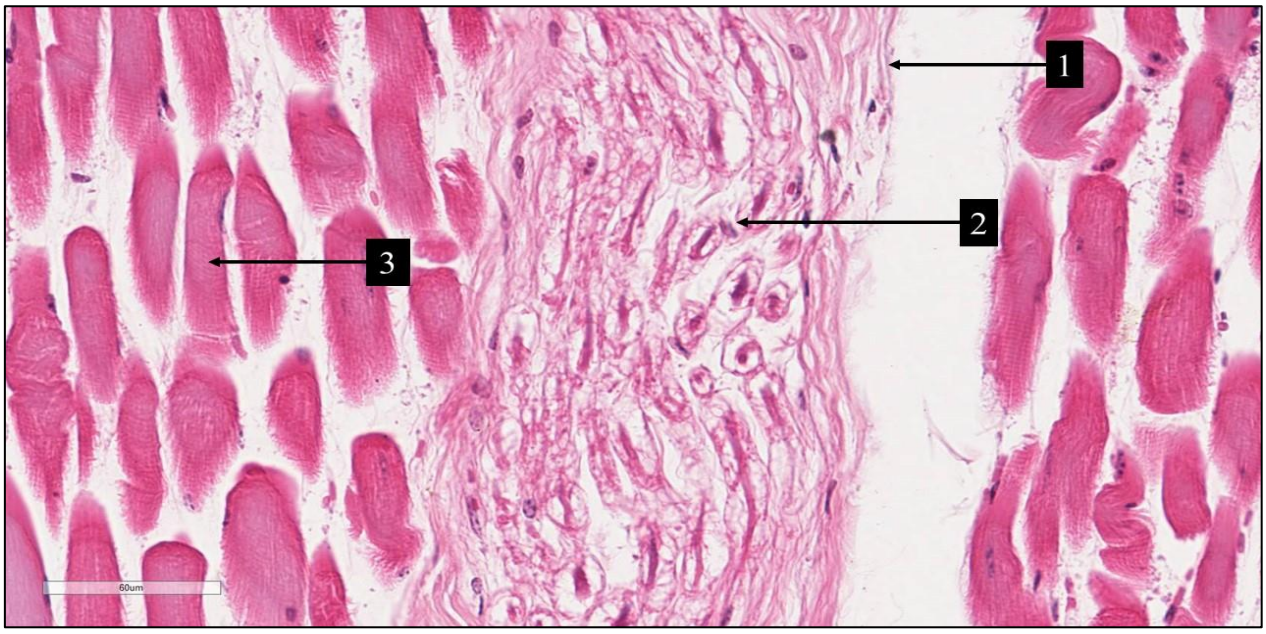

Fig. 30 B. The neuromuscular spindle. 1 - capsule; 2 - intrafusal fibers; 3 - extrafusal fibers. Hematoxylin and eosin staining

5. SKIN

5.1. Skin with hairs

This is a slice of skin from the scalp. At low magnification (Fig.31 A), the epidermis, dermis, sebaceous glands and hair follicles can be distinguished.

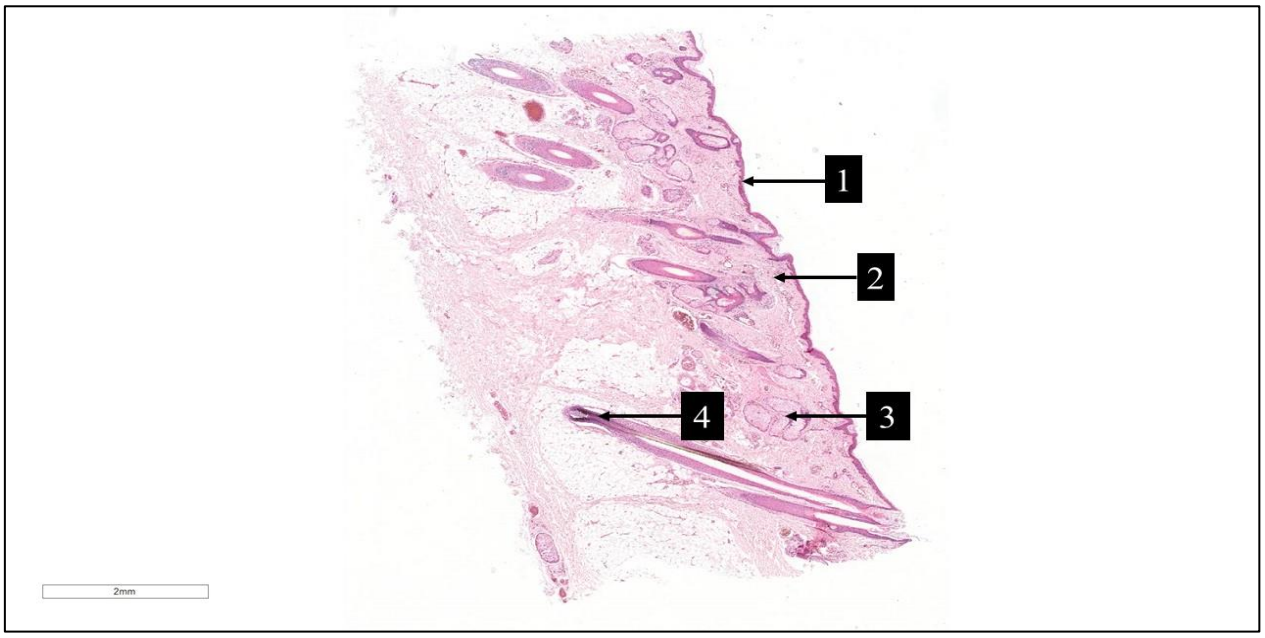

Fig. 31 A. The skin of the scalp. 1 - epidermis; 2 - dermis; 3 - sebaceous glands; 4 - hair follicle. Hematoxylin and eosin staining

At high magnification (Fig. 31 Б), layers of epidermis (stratified squamous keratinizing epithelium) are visible:

- stratum basale (8) of cylindrical basophilic keratinocytes is located on the basal membrane;
- stratum spinosum (7) - consists of several layers of large keratinocytes overlying the basal layer;

The basal and spinous layers form the Malpighian layer, which is responsible for the proliferation of keratinocytes and the replacement of those that are continually undergoing apoptosis.

- stratum granulosum (6) - lies above the stratum spinosum and in the thin skin consists of 3-5 layers of flat polygonal cells;
- stratum corneum (5) - layer of dead flat keratinocytes without nucleus, with thin plasma membrane.

In Figure 29 B, the layers of the dermis, which contain hair follicles, sebaceous glands, and sweat glands, are distinguishable:

- papillary layer (9) is a layer of loose connective tissue, comprising a high proportion of elastic fibers, situated directly beneath the basal membrane of the epidermis. It is connected to the basal membrane by dermal papillae (10) and epidermal ridges (11).
- reticular layer (12) - a thick layer of dense irregular connective tissue under the papillary layer.

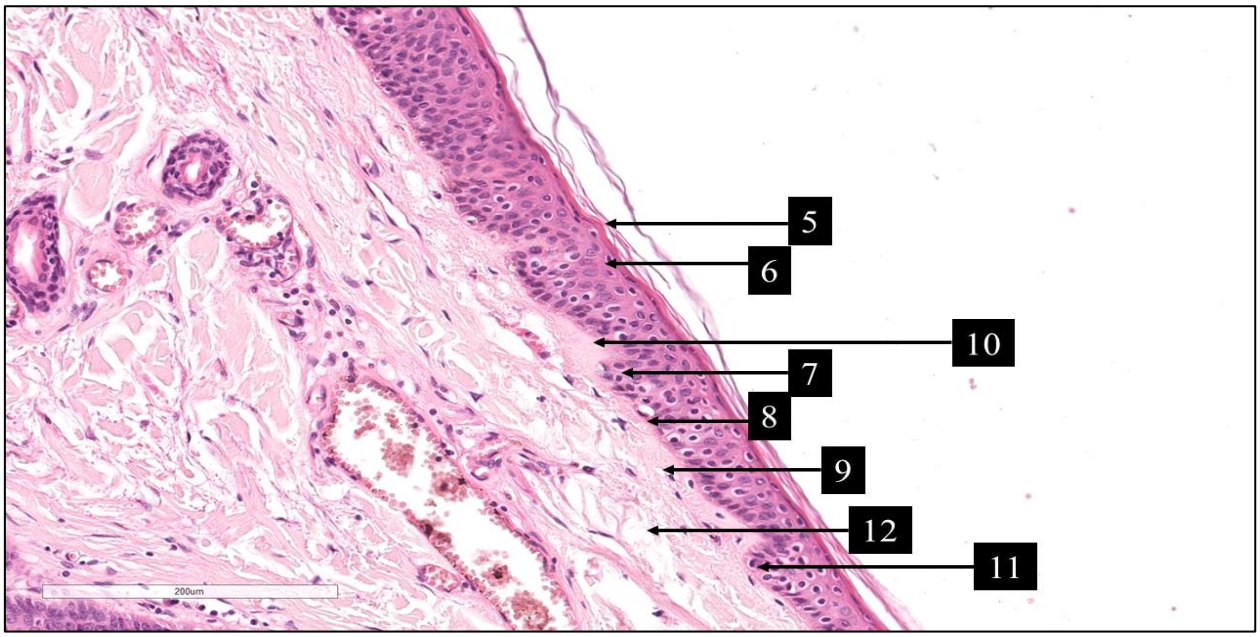

Fig. 31 Б. Skin with hair. 5 - stratum corneum of epidermis; 6 - stratum granulosum; 7 - stratum spinosum; 8 - stratum basale; 9 - papillary layer of dermis; 10 - dermal papilla; 11 - epidermal ridge; 12 - reticular layer of dermis. Hematoxylin and eosin staining

Figure 31 B shows a hair follicle at high magnification, going deep into the skin. The hair follicle has a "cap" of cells that divide quickly around a dermal papilla with nerve fibers and blood vessels. The external root sheath surrounds the hair follicle and hair shaft. The germinative matrix forms the inner root sheath, which ends at the level of the sebaceous glands' ducts.

The hair shaft is formed by the medulla and cortex. The medulla is the thin inner part of the hair shaft and is composed of partially keratinized cells. The cortex surrounds the medulla from the outside and is formed by keratinized polygonal cells covered with cuticle.

The layer of connective tissue surrounding the hair follicle forms a connective tissue sheath called as glassy membrane.

The sebaceous glands are connected to the hair, and their ducts open into the follicular canal. The secretory portion of the sebaceous glands is composed of cells which produce lipid-rich secret.

Fig. 31 B. Skin with hair. 13- dermal hair papilla; 14- hair bulb; 15- external root sheath; 16- internal root sheath; 17- hair shaft; 18- glassy membrane; 19- sebaceous gland. Hematoxylin and eosin staining

5.2. Skin receptors (Pacinian, Meissner corpuscles)

This is a section of skin that contains sensitive receptors (Fig. 32 A).

Fig. 32 A. Skin receptors (Pacinian, Meissner corpuscles). Silver staining

Meissner's corpuscles are mechanoreceptors located in the papillary layer of the dermis, have an elongated ovoid shape, thin capsule and contain nerve terminals, Schwann cells and fibroblasts. Meissner's corpuscles are found in the papillae of the skin, most abundant in the skin of the fingertips, palms, feet, and nipples.

Figure 32 B shows Pacini's corpuscles, which are a highly sensitive touch receptor and are located in the reticular layer of the dermis, hypodermis, periosteum, joint capsules, and mesentery. Its well-developed capsule consists of numerous layers of flat fibroblast-like cells separated by narrow slit-like fluid-filled spaces. The nerve terminal enters the capsule, loses myelin and is covered with several layers of flat Schwann cells, and ends at the opposite pole of the capsule, giving several straight branches. Pacini's corpuscles are larger and more rounded than Meissner's corpuscles, and on the sections resemble a sliced onion.

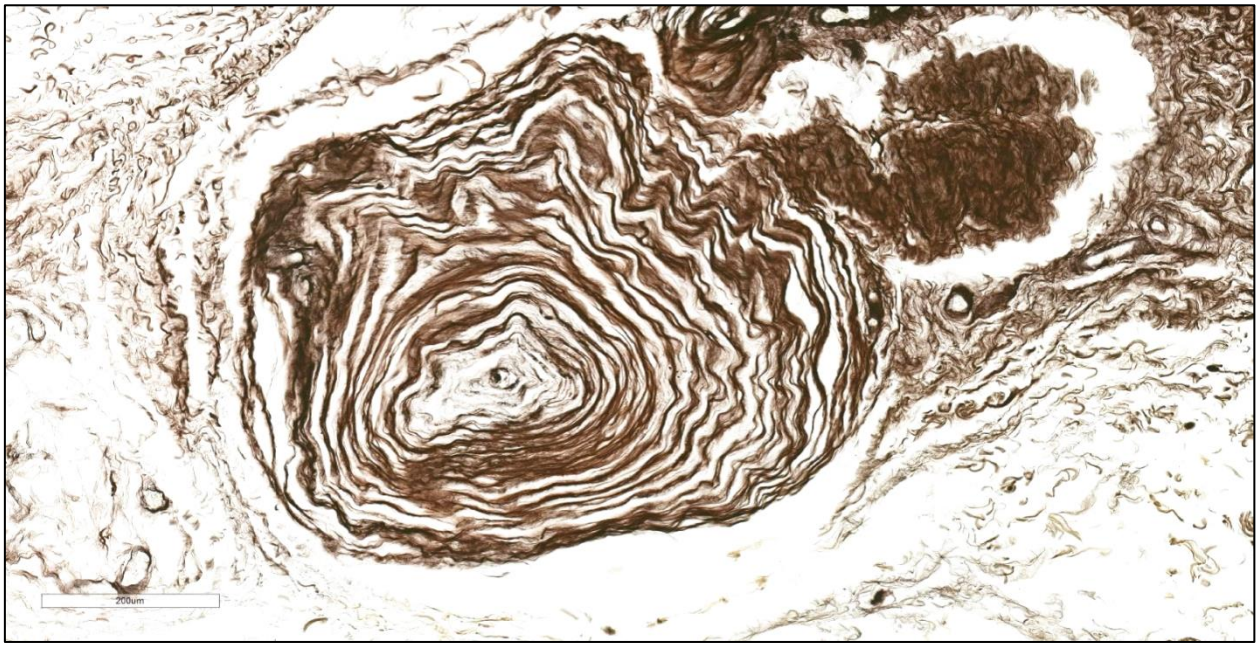

Fig. 32 Б. Skin receptors (Pacinian corpuscles). Silver staining

5.3. Thick skin

The specimen displays two distinct layers of skin, namely the epidermis and the dermis. Beneath the skin, there is a layer of subcutaneous fatty tissue, which is referred to as the hypodermis (Fig. 33 A).

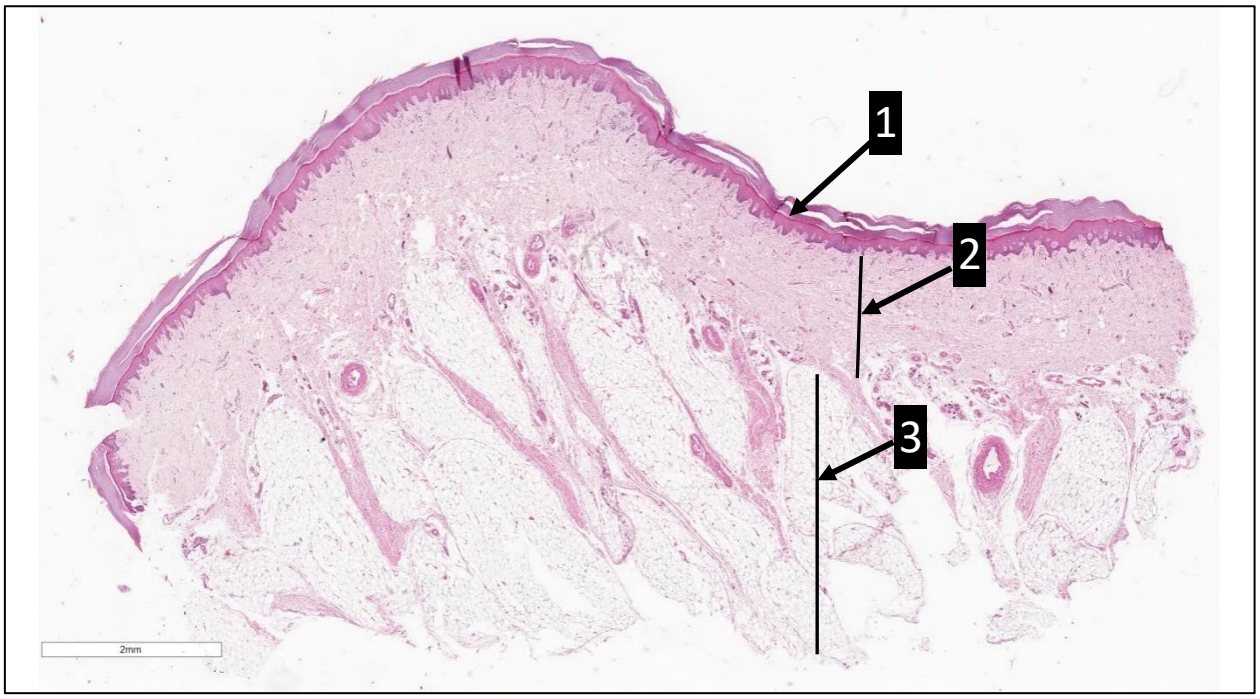

Fig. 33 A. Thick skin. 1 - epidermis; 2 - dermis; 3 - hypodermis. Hematoxylin and eosin staining

The epidermis is formed by stratified squamous keratinized epithelium. The epidermis of thick skin comprises five layers (see Fig. 33B). Stratum basale is composed of a single layer of epithelial cells (keratinocytes) situated on the basal membrane. Stratum basale contains stem cells, which are responsible for the constant renewal of the epidermis. Stratum spinosum is composed of cuboidal or flattened keratinocytes with cytoplasmic outgrowths in the form of spines. The cells of the stratum basale and stratum spinosum form the Malpighian layer, which contains stem cells. Stratum granulosum is comprised of keratinocytes, which contain basophilic granules of keratohyalin. The stratum lucidum is translucent and effectively refracts light. The stratum corneum is composed of nucleus-free keratinized cells.

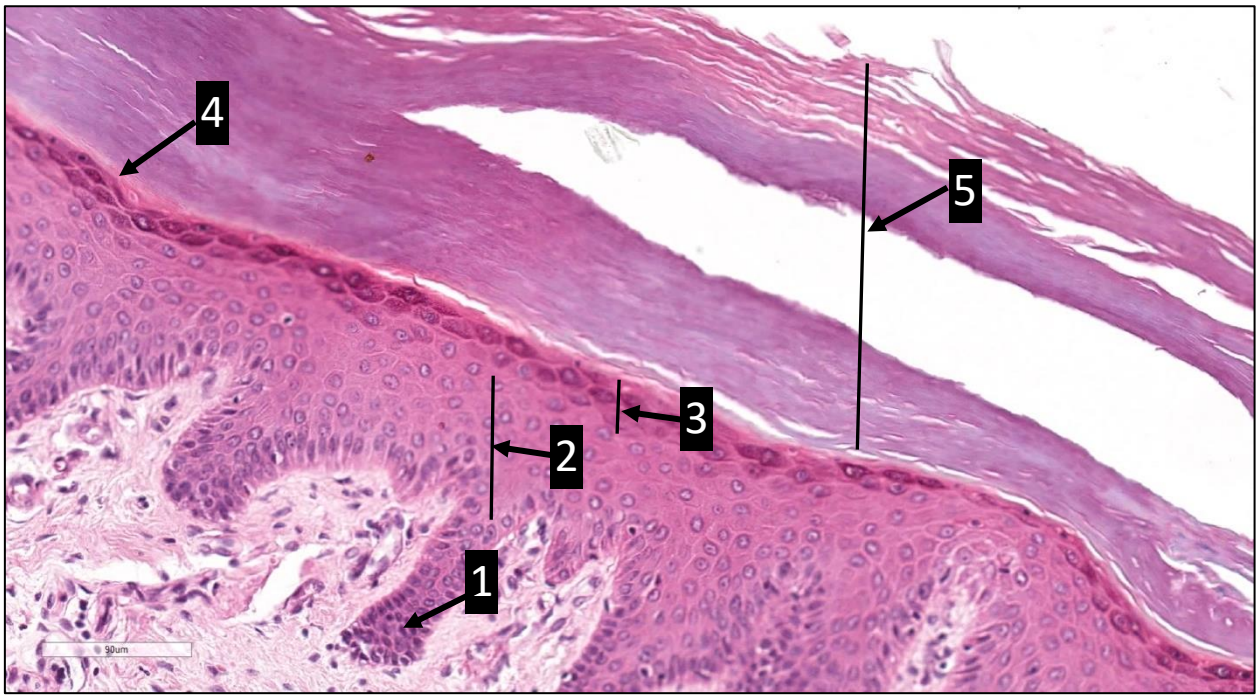

Fig. 33 Б. Thick skin. 1 - stratum basale; 2 - stratum spinosum; 3 - stratum granulosum; 4 - stratum lucidum; 5 - stratum corneum. Hematoxylin and eosin staining

The dermis consists of two layers - papillary and reticular (Fig.33 B). The papillary layer is formed by loose connective tissue, while the reticular layer is represented by dense irregular connective tissue. The dermis of thick skin contains a large number of sweat glands.

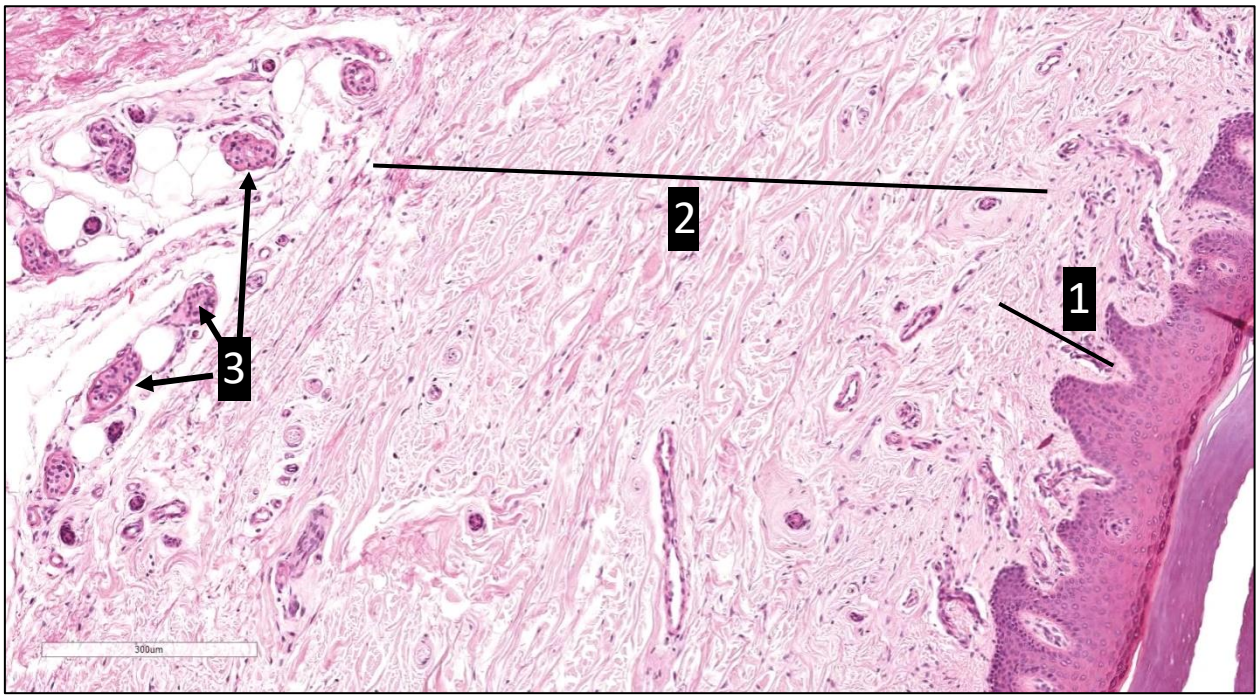

Fig. 33 B. Thick skin. 1 - papillary layer of dermis; 2 - reticular layer of dermis; 3 - sweat glands. Hematoxylin and eosin staining

5.4. Nail

The nail is a plate of keratinized epithelial cells lying on the surface of the distal phalanges of the fingers (Fig. 34). The nail plate is the stratum corneum of the epidermis and lies on the nail bed, which consists of the stratum basale and stratum spinosum of the epidermis. The matrix of the nail provides the growth of the nail plate. The stratum corneum of the epidermis forms the eponychium at the proximal part of the nail and the hyponychium at the free distal end.

Fig. 34. Nail. 1 - nail plate; 2 - nail bed; 3 - nail matrix; 4 - eponychium; 5 - hyponychium. Hematoxylin and eosin staining

6. LITERATURE

1. *Бойчук Н.В.* Гистология. Атлас для практических занятий: учебное пособие / Н.В. Бойчук, Р.Р. Исламов, С.Л. Кузнецов, Ю.А. Челышев – М.: ГЭОТАР-Медиа, 2014. – 158 с.
2. *Бойчук Н.В*. Гистология, эмбриология, цитология / Н.В. Бойчук, Р.Р. Исламов, Э.Г. Улумбеков, Ю.А. Челышев – М.: ГЭОТАР-Медиа, 2016. – 928 с.
3. *Афанасьев Ю.И.* Гистология, эмбриология, цитология / Ю.И. Афанасьев, Б.В. Алешин, Н.П. Барсуков – 7-е изд., перераб. и дополн. – М.: ГЭОТАР-Медиа, 2021. – 832 с.
4. *Данилов Р.К.* Гистология, эмбриология, цитология / Р.К. Данилов, Т.Г. Боровая – М.: ГЭОТАР-Медиа, 2018. – 520 с.
5. *Жункейра Л.К.* Гистология: атлас: учебное пособие / Л.К. Жункейра, Ж. Карнейро – пер. с англ. под. ред. В.Л. Быкова. – М.: ГЭОТАР-Медиа, 2009. – 576 с.
6. *Ross M.H.* Histology: a text book and atlas: with correlated cell and molecular biology / M.H. Ross, W. Pawlina – Sixth edition. – Philadelphia: Lippincott Williams & Wilkins, 2011. – 974 p.
7. *Ovalle K.W.* Netter's essential histology / K.W. Ovalle, P.C. Nahirney – Second edition. – Philadelphia: Elsevier, 2013. – 517 p.
8. *Leslie P. Gartner*. Textbook of Histology / Fourth edition. – Philadelphia: Elsevier, 2017. – 656 p.
9. *Плюшкина А.С.* Практикум по гистологическим препаратам «Ткани»: практикум / А.С. Плюшкина, Д.И. Андреева, А.А. Билялова, Л.Р. Гатауллина, К.Н. Султанова, Н.С. Филатов, А.П. Киясов. – Казань: Вестфалика, 2022. – 61 с.