MINISTRY OF HEALTH OF UKRAINE

NATIONAL PIROGOV MEMORIAL MEDICAL UNIVERSITY
VINNYTSIA

GUIDANCE
OF HISTOLOGY OF NERVOUS SYSTEM AND SENSORY ORGANS, HYSTOLOGY OF SKIN, HYSTOLOGY OF CARDIOVASCULAR AND ENDOCRINE SYSTEM, HYSTOLOGY OF HEMOPOIETIC AND IMMUNE RESPONSE ORGANS

part II
SPECIAL HISTOLOGY

TRAINING AND TEACHING MANUAL
FOR 1st AND 2nd COURSE STUDENTS
OF MEDICAL FACULTY

Student _____

_____

Group _____

VINNYTSIA – 2022

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

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

CENTRAL NERVOUS SYSTEM

Checking your primary level of the knowledge:

1. Classifications of the nervous system.
2. Organization of the central nervous system (CNS).
3. What is cytoarchitectonics?
4. What is myeloarchitectonics?
5. Cell types of the cerebral cortex.
6. Six layers of the cerebral cortex.
7. What is cortical column?
8. Granular and agranular cortex.
9. White matter fiber bundles.
10. Molecular layer of the cerebellum.
11. Purkinje layer of the cerebellum.
12. Granular layer of the cerebellum.
13. Deep cerebellar nuclei.
14. Blood brain barrier (BBB) structure and function.
15. General structure of the spinal cord.
16. Cells of the spinal cord.
17. The ventral horn.
18. Intermediate substance.
19. The dorsal horn.

Standard answers for theoretical questions.

1. Classifications of the nervous system.

➢ There are two classifications of the nervous system: anatomical and physiological. According to the **anatomical classification** nervous system is divided into the central and peripheral. **The central nervous system** consists of encephalon (brain) and spinal cord. **The peripheral nervous system** consists of nerve endings and ganglia.

➢ According to the physiological classification nervous system is divided into somatic-sensory and autonomic. **Somatic nervous system** consists of the motor neuron pathways that innervate skeletal muscles**. The sensory nervous system** comprises cranial nerves and spinal nerves. **The autonomic nervous system** (ANS) consists of three subsystems: the sympathetic nervous system, the parasympathetic nervous system and the enteric nervous system. The autonomic nervous system is that part of PNS consisting of motor neurons that control internal organs. The ANS regulates the activities of cardiac muscle, smooth muscle, endocrine glands, and exocrine glands.

2. Organization of the central nervous system (CNS).

➢ The central nervous system (CNS) consists of the brain and the spinal cord, which are located in the cranial cavity and spinal canal, respectively. In the brain, the **gray matter** forms an outer covering or **cortex** and the **white matter** forms an inner core or **medulla**.

The cortex of gray matter in the brain contains nerve cell, bodies, axons, dendrites, and glial cells and it is the site of synapses. In addition to the gray matter of the cortex, islands of gray matter, **nuclei**, are found in the deep portions of the cerebrum and cerebellum. The white matter contains only axons of nerve cell plus the associated glial cells and blood vessels.

Whereas many of the axons going to or coming from a specific location are grouped into bundles called **tracts**. Each functional region of the gray matter has a characteristic variety of cell bodies associated with a meshwork of axonal, dendritic, and glial processes.

3. What is cytoarchitectonics?

➢ **Cytoarchitecture** also known as **cytoarchitectonics** is the study of the cellular composition of the body's tissues under the microscope. Applied particularly to the study of the central nervous system, cytoarchitectonics is one of the ways to analyze the brain, by obtaining sections of the brain and staining them with chemical agents that reveal how neurons are "stacked" into layers.

4. What is myeloarchitectonics?

➢ The study of nerve fibers arrangement (primarily axons) into layers forms the subject of **myeloarchitectonics**, an approach complementary to cytoarchitectonics.

5. Cell types of the cerebral cortex.

➢ **The stellate (granule) cells** come in a wide assortment of shapes but mostly star shaped. They are typically small (< 10 micrometres) multipolar neurons. Their short axons do not leave the cortex and dendrites extending in all directions.

Pyramidal cells are shaped as they are named. They range in size from 10 micrometres in diameter to 70-100 micrometres of the **giant pyramidal cells (*Betz cells*)** of the motor cortex. A long apical dendrite leaves the top of each pyramidal cell and ascends vertically to the cortical surface. A series of basal dendrites emerges from nearer the base of the cell and spreads out horizontally. Most or all pyramidal cells have long axons that leave the cortex to reach either other cortical areas or to various subcortical sites. Therefore, pyramidal cells are the **principal output neurons**.

Horizontal cells (of Cajal) are prominent during development but most disappear after birth. They are small, fusiform, horizontally place cells are found in the most superficial layer of the cerebral cortex.

Fusiform cells are found in the deepest cortical layer. They are spindle-shaped with a tuft of dendrites emerging from each end of the spindle and ascending toward the surface of the cortex. They are, however, otherwise like pyramidal cells with an axon that leaves the cortex.

Cells of Martinotti are small multipolar cells. They are found in all layers but are more abundant in the deeper cortical layers. They are unusual in the fact that they have an axon that ascends to the surface.

6. Six layers of the cerebral cortex.

I. The molecular layer consists largely of fibers, most of which travel parallel to the surface and few cells.

II. The external granular layer contains small pyramidal and numerous stellate neurons.

III. The external pyramidal layer contains small and medium-size pyramidal neurons, as well as non-pyramidal neurons.

IV. The internal granular layer contains different types of granule and pyramidal neurons.

V. The internal pyramidal layer contains large pyramidal neurons (the Betz cells).

VI. The layer of polymorphic cells contains cells with diverse shapes, many of which have a spindle or fusiform shape.

7. What is cortical column?

- The basic functional and structural unit of cortex is called **cortical column** or **cortical module**. A cortical column is a group of neurons in the brain cortex which can be successively penetrated by a probe inserted perpendicularly to the cortical surface, and which have nearly identical receptive fields.
- The cortex appears to be organized into vertical columns about 50-500 microns wide. There are two thalamo-cortical afferents fibers, main target of which is stellate (granule) cells of the internal granular layer and one cortico-cortical fiber which is axon of Betz cells of internal pyramidal layer within a cortical column.

8. Granular and agranular cortex.

- **Granular type (sensory cortex)** contains packed stellate cells and very small amount of pyramidal cells. Layer II and IV are large and densely packed and layer IV is most developed in this type. **Agranular type (motor cortex)** has almost absent layers II and IV as the granular cells are poorly developed. Pyramidal cells in layers V and VI are large and densely packed. Layers V and VI are most developed in this type. The fibers given off from these areas are associated with motor function.

9. White matter fiber bundles.

- **Association axons** interconnect both nearby and distant parts of the cortex on one side. **Commissural fibers** interconnect the cerebral cortices on the two sides of the brain. **Projection bundles** carry information into and out of the cerebral cortex, from and to subcortical structures.

10. Molecular layer of the cerebellum.

- Molecular layer is outermost layer of the cerebellar cortex. It contains two types of inhibitory interneurons: the **stellate** and **basket cells**. **Stellate cells** are neurons with several dendrites radiating from the cell body giving them a star shape. It also contains the dendritic arbors of Purkinje neurons and parallel fiber tracts from the granule cells. Stellate cells form inhibitory synapses onto Purkinje cell dendrites. **Basket cells** are multipolar, interneurons that function to control the overall potentials of Purkinje cells. The dendrites of basket cells are free branching, dilated and knotty. Basket cells have shown to form axo-somatic inhibitory synapses with Purkinje cells. The branched axonal arborizations give rise to the name as they appear as baskets surrounding the soma of the Purkinje cell.

11. Purkinje layer of the cerebellum.

- Purkinje layer is the middle layer. It contains only one type of cell body—that of the large Purkinje cell. It is extremely large flask-shaped cell bodies. Purkinje cells are the primary integrative neurons of the cerebellar cortex. Purkinje cell dendrites are large arbors with hundreds of branches reaching up into the molecular layer. Each parallel fiber from the granule cells runs **orthogonally** through these arbors, like a wire passing through many layers. Purkinje neurons have inhibitory synapses—with the neurons of the **deep cerebellar** and **vestibular nuclei in the brainstem**. Each Purkinje cell receives excitatory input from

100,000 to 200,000 parallel fibers. Purkinje cells also receive input from the inferior olivary nucleus via climbing fibers. A good mnemonic for this interaction is the phrase "climb the olive tree", given that climbing fibers originate from the inferior olive.

12. Granular layer of the cerebellum.

- The innermost layer contains the cell bodies of two types of cells: the numerous and tiny **granule cells**, and the larger **Golgi cells**.

Incoming (mossy) fibers enter the granular layer and form excitatory synapses with the granule cells and the cells of the deep cerebellar nuclei. The granule cells send their T-shaped axons into the molecular layer.

Golgi cells provide inhibitory feedback to granule cells, forming a synapse with them and projecting an axon into the molecular layer. **Mossy** and **climbing fibers** carry sensorimotor information into the deep nuclei, which in turn pass it on to various premotor areas.

13. Deep cerebellar nuclei.

- The four deep cerebellar nuclei are in the center of the cerebellum, embedded in the white matter. These nuclei receive **inhibitory** inputs from Purkinje cells in the cerebellar cortex and **excitatory** inputs from mossy fiber pathways.

From lateral to medial, the four deep cerebellar nuclei are the **dentate, emboliform, globose,** and **fastigial**.

14. Blood brain barrier (BBB) structure and function.

Structure of the BBB: endothelial lining, basal membrane of endothelial cells and glial cells (astrocytes).

Functions of the BBB:

- Protects the brain from "foreign substances" in the blood that may injure the brain
- Protects the brain from hormones and neurotransmitters in the rest of the body
- Maintains a constant environment for the brain

General Properties of the BBB

- Large molecules do not pass through the BBB easily.
- Low lipid (fat) soluble molecules do not penetrate into the brain.
- However, lipid soluble molecules, such as barbiturate drugs, rapidly cross through into the brain.

The barrier is ineffective or absent in the neurohypophysis, substantia nigra and locus ceruleus.

15. General structure of the spinal cord.

- The spinal cord is organized into two discrete parts. The **outer part** contains ascending and descending nerve fibers. These fibers are divided into longitudinal columns. They constitute the white matter of the cord. The **inner part** contains cell bodies of neurons and nerve fibers. This is the gray matter of the spinal cord. Spinal gray matter is butterfly-shaped or H shaped. It extends from the ependymal cells lining the central canal to the surrounding white matter. Spinal gray matter is divided bilaterally into **dorsal horn, intermediate substance,** and **ventral horn**. At thoracolumbar levels, intermediate substance features a **lateral horn.**

16. Cells of the spinal cord.

- Spinal neurons within the gray matter are either **efferent neurons** (axons enter ventral roots), **projection neurons** (axons join white matter tracts), or **interneurons** (axons remain within gray matter).

17. Ventral horn.

- Ventral motor neurons, also called **anterior horn cells**, are large basophilic cells. Because the motor neuron conducts impulses away from the CNS, it is an **efferent neuron**. The axon of a motor neuron leaves the spinal cord, passes through the ventral (anterior) root. The axon is myelinated except at its origin and termination. Near the muscle cell, the axon divides into numerous terminal branches that form neuromuscular junctions with the muscle cell.
- **Medial motor nuclei** innervate muscles of the trunk and are found in all spinal segments. **Lateral** collections of **motor neurons**, which innervate limb muscle, are seen in segments of the cervical and lumbosacral enlargements.

18. Intermediate substance.

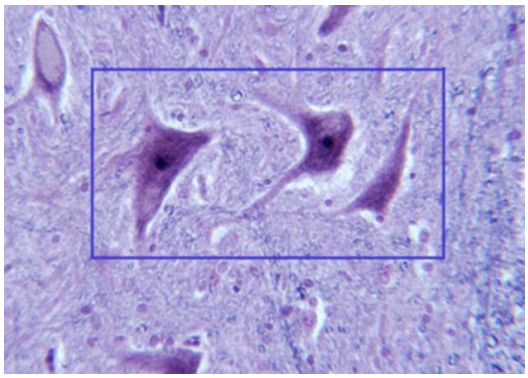
- In the intermediate substance, one nucleus is found only in thoracic and cranial lumbar segments of the spinal cord. The **intermediolateral nucleus**, which forms a **lateral horn**, is composed of sympathetic preganglionic neurons.

19. The dorsal horn.

- The cell bodies of **sensory neurons** are located in ganglia that lie on the dorsal root of the spinal nerve. The dorsal horn surface is capped by a **marginal nucleus** which is thin and not distinct in transverse sections. A population of small neurons forms a very distinctive **substantia gelatinosa**. The remainder of the dorsal horn may be considered **nucleus proprius**. **The nucleus thoracicus**, located medially in the base of

the dorsal horn, is present in thoracolumbar segments; axons from the nucleus form the dorsal spinocerebellar tract.

PRACTICAL QUESTIONS



In this picture:

1. What types of neurons are visible?

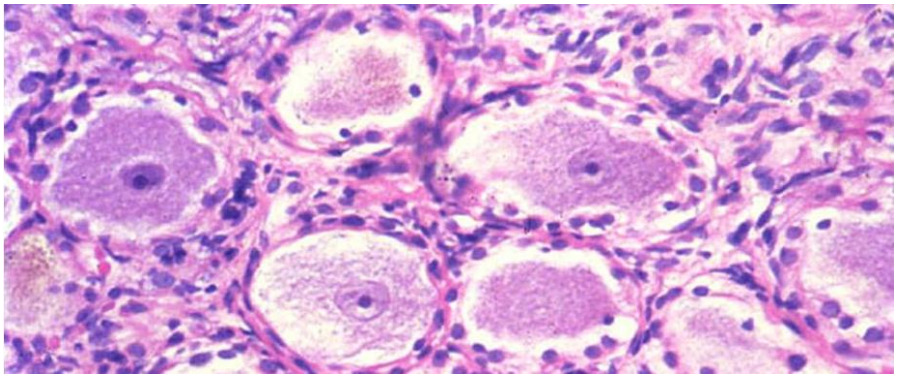
_____

2. Besides motor neurons, what other cell types are visible?

_____

3. What part of the spinal cord is this?

_____



In the above picture:

4. What types of neurons are visible?

_____

5. Besides motor neurons, what other cell types are visible?

_____

6. What nerve root is this?

_____

7. Fill in the name of the cerebral cortex layer in the picture below.

a. _____

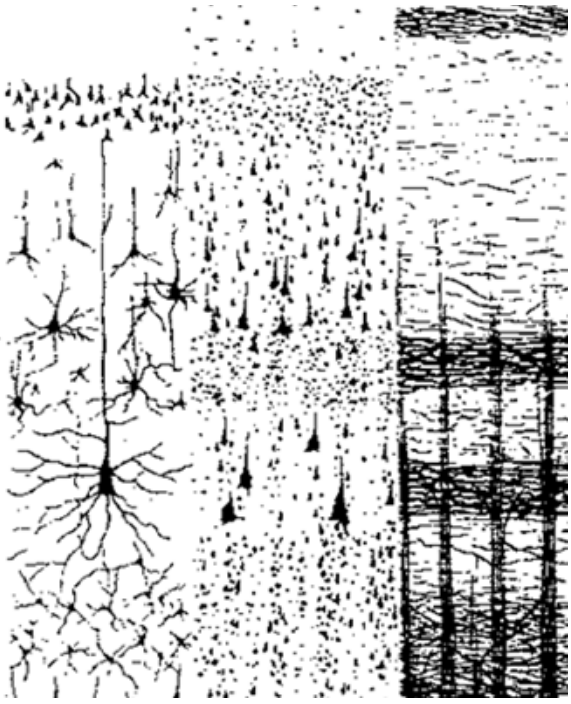
b. _____

c. _____

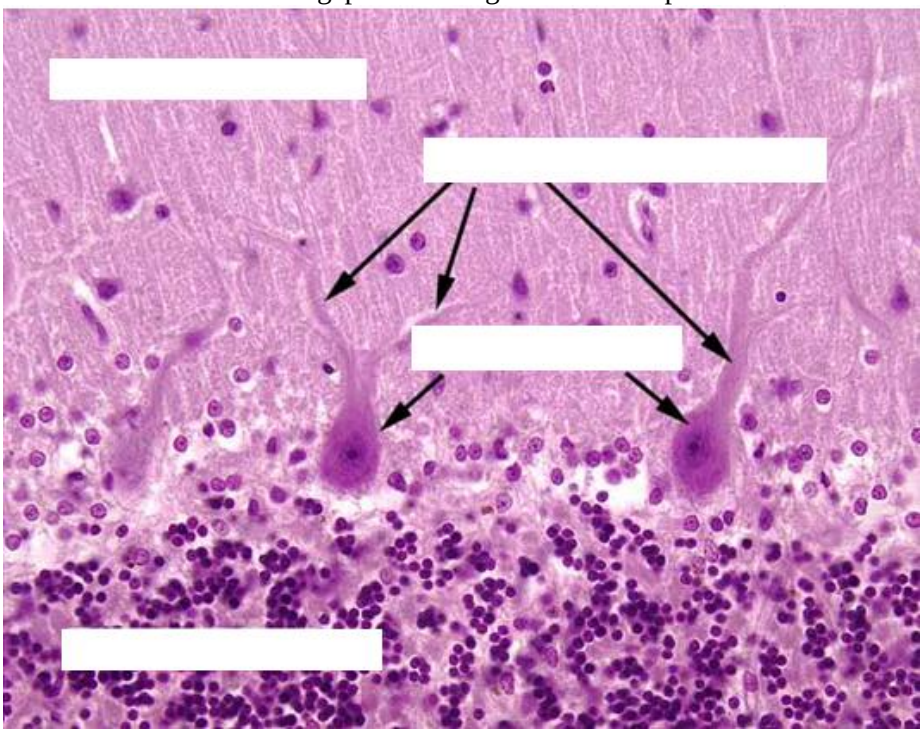
d. _____

e. _____

f.

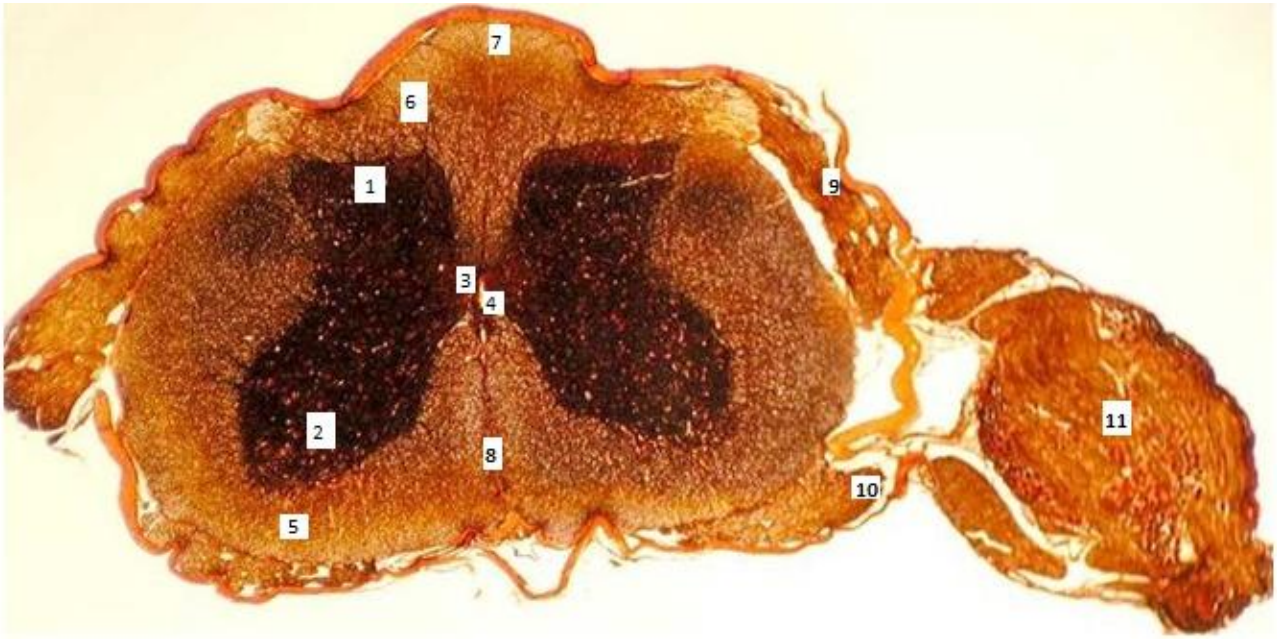


8. Fill in the white gaps with designations in the picture below.



9. What part of the brain is it?

_____



10. In the above picture: Identify the region labeled 1.

_____

11. What type of neuronal cell bodies is found in region 1?

_____

12. Identify the region labeled 2.

_____

13. Identify the structure labeled 3.

_____

14. Identify the opening labeled 4.

_____

15. Identify the fluid found in opening 4.

_____

16. What structures can be found in the region labeled 5?

_____

17. What structures can be found in the region labeled 6?

_____

18. Identify the cleft labeled 7.

_____

19. Identify the cleft labeled 8.

_____

20. Identify the structure labeled 9.

_____

21. What type of fibers does structure 9 contain?

_____

22. Identify the structure labeled 10.

_____

23. What type of fibers does structure 10 contain?

_____

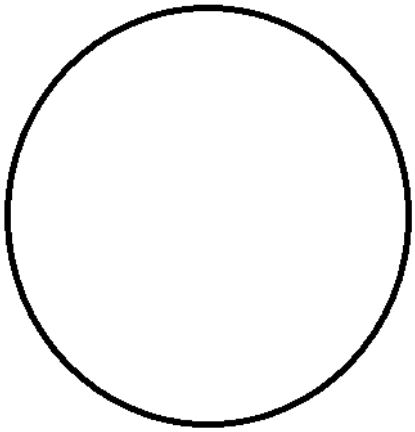
24. Identify the structure labeled 11?

_____

25. What does structure 11 contain?

_____

SLIDE 1



Cerebral cortex
Dye: impregnation of silver

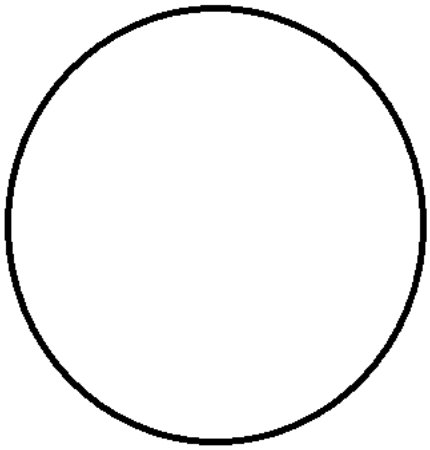
SLIDE'S DESIGNATION

1. Molecular layer
2. External granular layer
3. External pyramidal layer

a. Small and middle pyramidal cells layer
b. Large pyramidal cells layer

4 Internal granular layer
5 Internal pyramidal layer
6 Multiform layer
7 Blood vessels

SLIDE 2



Cerebellum
Dye: impregnation of silver

SLIDE'S DESIGNATION

1. Cerebellar gyri
2. Cerebellar cortex
    a. Molecular layer
    b. Ganglionic layer
    c. Granular layer
3. White matter

A part of the central nervous system has layerwise allocation of neurocytes, among which there are cells of such forms: stellate, fusiform, horizontal, pyramidal. What part of the CNS has this structure?
A. *Cortex of large hemispheres
B. Cerebellum
C. Hypothalamus
D. Medulla oblongata
E. Spinal cord

An organ of nervous system which consists of grey and white substances is presented in a histological specimen. Grey substance is located on the periphery and consists of 6 layers: molecular, external granular, external pyramidal, internal granular, internal pyramidal and the layer of polymorphic cells.
A. *Cerebral cortex
B. Cerebellum
C. Pons cerebelli
D. Spinal ganglion
E. Spinal cord

Precentral gyrus section of the cerebral cortex is presented in the histological specimen. Indicate which layers mostly developed in this case.
A. *Pyramidal external and internal and layer of polymorphic cells
B. Molecular
C. External and internal granular
D. Molecular and layer of polymorphic cells
E. Molecular, pyramidal external and internal

One of sections of central nervous system has layerwise arrangement of neurocytes. There are cells of the following forms: stellate, fusiform, horizontal, pyramidal among them. What section of central nervous system is this structure typical for?
A Cortex of cerebrum
B Spinal cord
C Cerebellum
D Medulla oblongata
E Hypothalamus

A specimen, dyed by the method of silver impregnation, is being investigated. Pyramidal cells of different size are seen in this specimen. Short processes come off their tips and lateral surfaces; one long process comes off the base of the cells. Name the specimen.
A. *Cerebral cortex
B. Spiral organ of the inner ear
C. Retina of the eye
D. Cortex of the cerebellum
E. Spinal ganglion

As a result of an injury, the integrity of the anterior spinal cord root was broken. Specify the neurons and their processes that had been damaged:
A *Axons of motor neurons
B Motor neuron dendrites
C Axons of sensory neurons
D Dendrites of sensory neurons
E Dendrites of association neurons

As a result of trauma a patient has damaged anterior roots of the spinal cord. What structures have been affected?
A *Axons of motoneurons and axons of neurons of lateral horns
B Central processes of sensitive neurons of spinal ganglions
C Peripheral processes of sensitive spinal ganglions
D Axons of neurons of lateral horns
E Dendrites of neurons of spinal ganglions

Alcohol intoxication, as a rule, is accompanied by the coordination of movements' disorder and imbalance caused by the damage of cerebellum structural elements. The function of what cells of cerebellum is affected first of all?
A. *Purkinje's cells
B. Basket cells
C. Betz cells
D. Stellate cells
E. Granule cells

Cerebellar cortex is revealed in a specimen impregnated with silver salts. It includes pyriform, basket, stellate and granule cells. What neurons constitute molecular layer?
A. *Basket, small and large stellate cells
B. Stellate and pyramidal cells
C. Granule cells and large stellate cells
D. Large stellate cells and spindle cells
E. Pyriform cells

Cerebellar cortex is revealed in a specimen impregnated with silver salts. It includes pyriform, basket, stellate and granule cells. Which from mentioned above cells is efferent neuron of cerebellum?
A. *Pyriform cells
B. Stellate cells
C. Granule cells
D. Pyramidal cells
E. Spindle cells

An organ of nervous system, which consists of grey and white substances, is represented in a histological specimen. Grey substance is located in the center and consists of efferent neurons, projection neurons and interneurons. Name this organ.
A. *Spinal cord
B. Pons cerebelli
C. Cerebral cortex
D. Cerebellum
E. Spinal ganglion

55-year-old patient has disorder of the movements' coordination and balance as a result of permanent using of alcohol and developing intoxication. What nervous structures of the CNS have been disordered?
A. *Purkinje cells of the cerebellum
B. Basket cells of the cerebellum
C. Stellate cells of the cerebellum
D. Motor neurons of the spinal cord
E. Olive of the medulla oblongata

15-year-old patient was admitted to the clinic with diagnosis poliomyelitis. This disease is accompanied with disorder of movements. What nervous structure destruction can explain this disorder?
A. *Motor neurons of the spinal cord
B. Sensory neurons of the spinal ganglions
C. Vegetative nucleuses of the spinal cord
D. Substantia gelatinosa
E. Neurons of the cerebellum

A patient with poliomyelitis (which characterized by spinal cord damage) has disorder of skeletal muscles function. What neurons destruction can explain this disorder?
A. *Motor neurons
B. Pseudounipolar
C. Associative (interneurons)
D. Pseudounipolar and associative (interneurons)
E. Interneurons and motor

An organ of nervous system, which consists of grey and white substances, is presented in a histological specimen. Grey substance is located on the periphery. Neurons in the grey matter form three layers molecular, Purkinje, and granular. What organ has this structure?
A. *Cerebellum
B. Spinal cord
C. Cerebral cortex
D. Medulla oblongata
E. Pons

A specimen, dyed by the method of silver impregnation, is being investigated. Pyriform cells with 2-3 climbing up prominent dendrites are seen in this specimen. Name the specimen.
A. *Cortex of the cerebellum
B. Spiral organ of the inner ear
C. Retina of the eye
D. Cerebral cortex
E. Spinal ganglion

Grey substance was revealed during microscopic investigation of the CNS. Neurons of it form three layers molecular, Purkinje and granular. Name neurons which form second layer?
A. *Pyriform cells
B. Small stellate cells
C. Granule cells
D. Large stellate
E. Basket cells

In the microspecimen of the spinal cord nucleus neurons of which form motor ending in the skeletal muscles have to be analyzed. Indicate this nucleus
A. *Nucleus proprius of the ventral horn
B. Nucleus thoracicus
C. Intermediolateral nucleus
D. Nucleus proprius of the dorsal horn
E. Nucleus proprius of grey substance

As a result of trauma anterior roots of the spinal cord were damaged in a 47-year-old patient. What neurons processes were damaged?
A. *Axons of motor somatic and vegetative nucleuses neurons
B. Axons of sensory pseudounipolar neurons
C. Dendrites of sensory pseudounipolar neurons
D. Dendrites of motor and axons of lateral horns nucleuses
E. Dendrites and axons of sensory pseudounipolar neurons

The VII-X thoracic vertebrae were damaged as a result of injury in patient. The hematoma which formed by this injury compresses the dorsal roots of spinal cord. Which pathway will be suffer from the damaging effects?
A. *Tractus cuneatus
B. Tractus spino-cerebellaris dorsalis
C. Tractus corticospinalis lateralis
D. Tractus vestibulospinalis
E. Tractus rubrospinalis

Nerve cells that provide in the human body next function were found during the histological examination of the spinal cord in the anterior horns:
A. *The transmission of nerve impulses to the striated muscle tissue.
B. The transmission of signals from the thermoreceptors to cells of the optic hill.
C. The transmission of nerve impulses in the prevertebral and paravertebral ganglia of the sympathetic nervous system.
D. The transmission of nerve impulses to the secretory apparatus of the digestive system.
E. Secretion of the neurotransmitters that affect vascular tone.

There are two specimens: of the spinal cord and spinal node. Which glial cells can be seen only in specimen of the spinal cord?
A *Ependymal cells
B Protoplasmic astrocytes
C Fibrous astrocytes
D Glial macrophages
E Olygodendrocytes

Small cells with short dendrites which have appearance of a “bird’s foot”are visible in the electron microscope picture of the cerebellar cortex in the granular layer. The mossy fibers form synapses in the glomeruli of the cerebellum with dendrites of these cells. What are these cells?
A *Granular cells
B Golgi cells
C Fusiform horizontal cells
D Stellate neurons with short dendrites
E Stellate neurons with long dendrites

Large pear-shaped cells were found in the specimen of the CNS impregnated with silver salts. They are arranged in a single row, their top leaves 3-4 processes that ramify in one plane. Name this cells.
A *Purkinje cells
B Betz cells
C Dogel cells
D Golgi cells
E Martinoti cells

PERIPHERAL NERVOUS SYSTEM

Checking your primary level of the knowledge:

1. Dorsal root ganglia.
2. Peripheral nerve structure.
3. Classification of receptors.
4. Types of nerve endings.
5. Merkel's cells structure and function.
6. Free nerve endings structure and functions.
7. Pacinian corpuscles structure and functions.
8. Meissner's corpuscles structure and functions.
9. Ruffini's corpuscles structure and functions.
10. Krause's end bulb structure and functions.
11. The muscle spindle structure and functions.
12. Golgi tendon organs structure and functions.
13. The sympathetic nervous system.
14. The parasympathetic nervous system.
15. The enteric nervous system.

Standard answers for theoretical questions.

1. Dorsal root ganglia.

➢ Sensory neurons in the dorsal root ganglia are pseudounipolar. They have a single process that divides into a peripheral segment that brings information from the periphery to the cell body and a central segment that carries information from the cell body into the gray matter of the spinal cord. Because the sensory neuron conducts impulses to the CNS, it is an *afferent neuron*. Impulses are generated in the terminal receptor arborization of the peripheral segment.

2. Peripheral nerve structure.

➢ A peripheral nerve is a bundle of nerve fibers and their supporting Schwann cells held together by connective tissue and carry sensory and motor (effector) information between the organs and tissues of the body and the brain and spinal cord. Connective tissue components of a peripheral nerve

➢ The **endoneurium** includes loose connective tissue surrounding each individual nerve fiber. Other than occasional fibroblasts, the only other connective tissue cells normally found within the endoneurium are **mast cells** and **macrophages**.

➢ The **perineurium** includes specialized connective tissue surrounding each nerve fascicle. The cells that compose this layer contain an appreciable number of actin filaments. Typically only fibroblasts, a small number of resident macrophages, and occasional mast cells are present within the nerve compartment.

➢ The **epineurium** includes dense irregular connective tissue that surrounds a peripheral nerve and fills the spaces between nerve fascicles. The blood vessels that supply the nerves travel in the epineurium.

3. Receptors may be classified as the following.

•Exteroceptors react to stimuli from the external environment—for example, temperature, touch, smell, sound, and vision.

• **Enteroceptors** react to stimuli from within the body— for example, the degree of filling or stretch of the alimentary canal, bladder, and blood vessels.

• **Proprioceptors,** which also react to stimuli from within the body, provide sensation of body position and muscle tone and movement.

4. Types of nerve endings.

➢ The simplest receptor is a bare axon called a **non capsulated (free) nerve ending**. This ending is found in epithelia, in connective tissue, and in close association with hair follicles.

➢ **Sensory nerve endings** with connective tissue sheaths are called **encapsulated endings**. Many encapsulated endings are mechanoreceptors located in the skin and joint capsules (Krause's end bulb, Ruffini's corpuscles, Meissner's corpuscles, and Pacinian corpuscles). **Muscle spindles** are encapsulated sensory endings located in skeletal muscle. Functionally related Golgi tendon organs are encapsulated tension receptors found at musculotendinous junctions.

5. Merkel's cells structure and function.

➢ Merkel's cells are epidermal cells that function in cutaneous sensation. They are dendritic cells located in the stratum basale and most abundant in skin of the fingertips. Merkel's cells have **80-nm dense-cored neurosecretory granules**. They are closely associated with the expanded terminal bulb of afferent

myelinated nerve fibers. The combination of the neuron and epidermal cell, called a **Merkel's corpuscle**, is a sensitive **mechanoreceptor**.

6. Free nerve endings structure and functions.

- Free nerve endings are the most numerous neuronal receptors in the epidermis**.** The endings are "free" in that they lack a connective tissue or Schwann cell investment. Such neuronal endings subserve multiple sensory modalities including fine touch, heat, and cold, without apparent morphologic distinction. Networks of free dermal endings surround most hair follicles and attach to their outer root sheath. Other nerve endings in the skin are enclosed in a connective tissue capsule.

7. **Pacinian corpuscles structure and functions.**

- Pacinian corpuscles are large ovoid structures found in the deeper dermis and hypodermis (especially in the fingertips). They are composed of a myelinated nerve ending surrounded by a capsule structure. The nerve enters the capsule at one pole with its myelin sheath intact. The myelin is retained for one or two nodes and is then lost. The unmyelinated portion of the axon extends toward the opposite pole from which it entered, and its length is covered by a series of tightly packed, flattened Schwann cell lamellae that form the inner core of the corpuscle. The remainder or bulk of the capsule, the outer core, is formed by a series of concentric lamellae. Each lamella is composed of flattened cells that correspond to the cells of the endoneurium outside the capsule.

Pacinian corpuscles respond to **pressure** and **vibration** through the displacement of the capsule lamellae. This displacement effectively causes depolarization of the axon.

8. **Meissner's corpuscles structure and functions.**

- Meissner's corpuscles are touch receptors that are particularly responsive to **low frequency stimuli** in the papillary layer of hairless skin (e.g., the lips and the palmar and volar surfaces, particularly those of the fingers and toes). Generally, they are tapered cylinders. Within these receptors, one or two unmyelinated endings of myelinated nerve fibers follow spiral paths in the corpuscle. The cellular component consists of flattened Schwann cells that form several irregular lamellae through which the axons course to the pole of the corpuscle.

9. Ruffini's corpuscles structure and functions.

- Ruffini's corpuscles respond to mechanical displacement of adjacent collagen fibers.

Ruffini's corpuscles are the simplest encapsulated mechanoreceptors. They have an elongated fusiform shape. Structurally, they consist of a thin connective tissue capsule that encloses a fluid-filled space. The neural element consists of a single myelinated fiber that enters the capsule, where it loses its myelin sheath and branches to form a dense arborization of fine axonal endings, each terminating in a small knoblike bulb. The axonal endings respond to displacement of the collagen fibers induced by sustained or continuous mechanical stress, thus they respond to **stretch** and **torque**.

10. **Krause's end bulb structure and functions.**

- Krause's end bulbs **(**the bulboid corpuscles**)** are **thermoreceptors**, sensing cold temperatures. They are cylindrical or oval bodies, consisting of a thin connective tissue capsule enclosing the terminal, branched, convoluted ending of an afferent nerve fiber. They are found in the conjunctiva of the eye, in the mucous membrane of the lips and tongue, and in the epineurium of nerve trunks. They are also found in the penis and the clitoris and have received the name of genital corpuscles.

11. **The muscle spindle structure and functions.**

- The muscle spindle is a specialized stretch receptor in muscle; it consists of two types of modified muscle fibers called **spindle cells** and **neuron terminals**. Both types of modified muscle fibers are surrounded by an **internal capsule**. One type of spindle cell, the **nuclear bag fiber**, contains an aggregation of nuclei in an expanded central portion of the fiber; the other type, called a **nuclear chain fiber**, has many nuclei arranged in a chain. The muscle spindle transmits information about the degree of stretching in a muscle.
- The **sensory (afferent) nerve fibers** that carry information from the muscle spindle have endings that are spirally arranged around the midregion of both types of spindle cells. In addition, spindle cells receive motor (efferent) innervation from the spinal cord and brain via **motor (efferent) nerve fibers**, which are thought to regulate the sensitivity of the stretch receptor.

12. Golgi tendon organs structure and functions.

- Golgi tendon organs. Similar encapsulated receptors, Golgi tendon organs, are found in the tendons of muscle and respond to increased tension on the muscle. These receptors contain only **sensory (afferent) nerve fibers**, and they monitor muscle tension (or the force of contraction) within an optimal range.

13. The sympathetic nervous system.

➢ The nerve fibers of the sympathetic system innervate smooth muscle, cardiac muscle, and glandular tissue.

➢ In general, stimulation via sympathetic fibers increases activity and metabolic rate. Accordingly, sympathetic system stimulation is a critical component of the fight or flight response (release of a chemical called nor-adrenaline). Examples include the acceleration of the heartbeat, raising of blood pressure, shrinkage of the pupils of the eyes, and the redirection of blood away from the skin to muscles, brain, and the heart.

14. The parasympathetic nervous system.

➢ Parasympathetic fibers innervate smooth muscle, cardiac muscle, and glandular tissue.

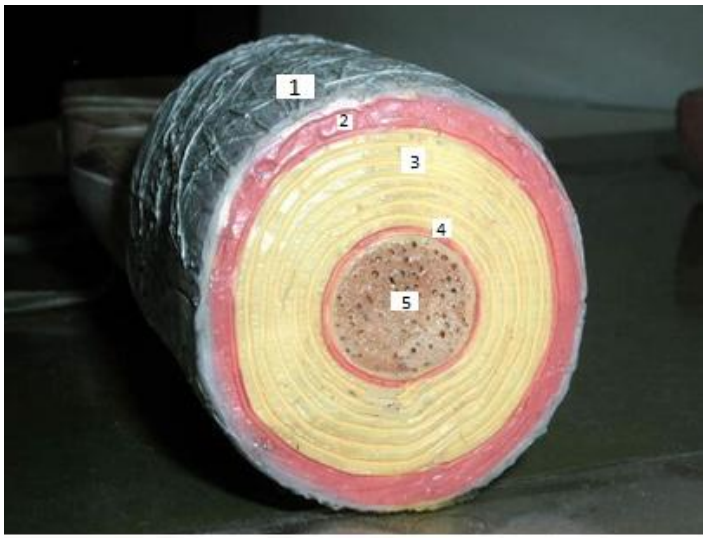
➢ In general, stimulation via parasympathetic fibers slows activity and results in a lowering of metabolic rate and a concordant conservation of energy. Accordingly, the parasympathetic nervous sub-system operates to return the body to its normal levels of function the so-called "rest and digest" state. Examples include the restoration of resting heartbeat, blood pressure, pupil diameter, and flow of blood to the skin.

➢ The preganglionic fibers of the parasympathetic system derive from the neural cell bodies of the motor nuclei of the occulomotor (cranial nerve: III), facial (VII), glossopharyngeal (IX), and vagal (X) cranial nerves. With regard to specific target organs and tissues, parasympathetic stimulation acts to decrease heart rate and decrease the force of contraction.

15. The enteric nervous system.

➢ The enteric nervous system is made up of nerve fibers that supply the viscera of the body: the gastrointestinal tract, pancreas, and gallbladder.

PRACTICAL QUESTIONS



In this picture:

1. Identify the structure labeled 1.

_____

2. Identify the membrane labeled 2.

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3. Identify the structure labeled 3.

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4. Identify the membrane labeled 4.

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5. Identify the structure labeled 5.

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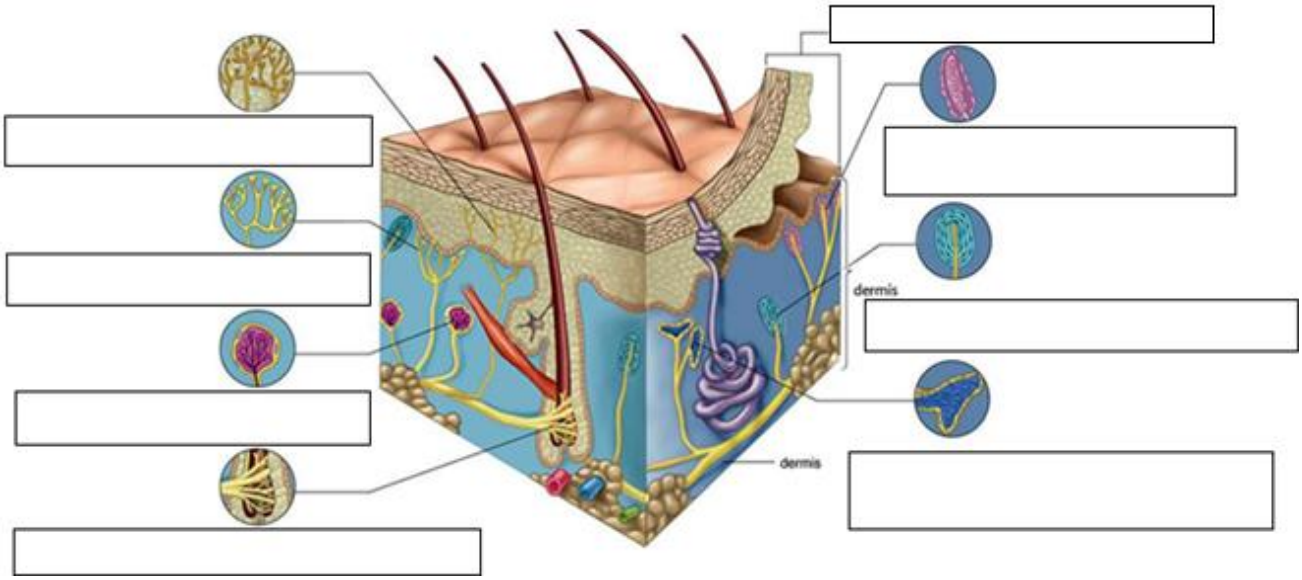
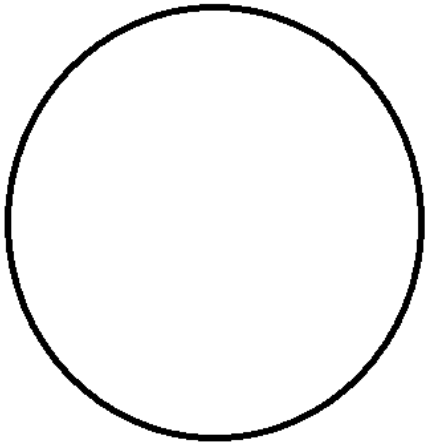
6. Fill in the white gaps with designations in the picture below.



SLIDE 1

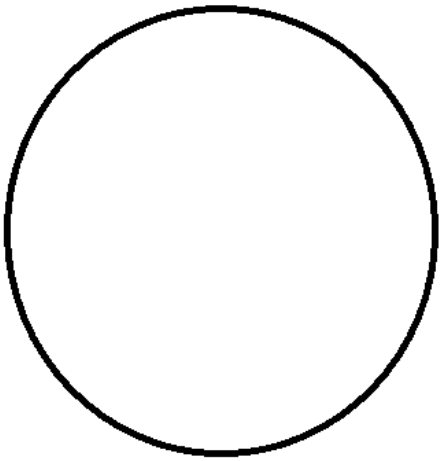


Transverse section of nerve
Dye: osmic acid

SLIDE'S DESIGNATION

1. Myelinated fibers
2. Endoneurium
3. Perineurium
4. Epineurium
5. Blood vessels
6. Fat cells

SLIDE 2



Dorsal root ganglia
Dye: hematoxylin-eosin

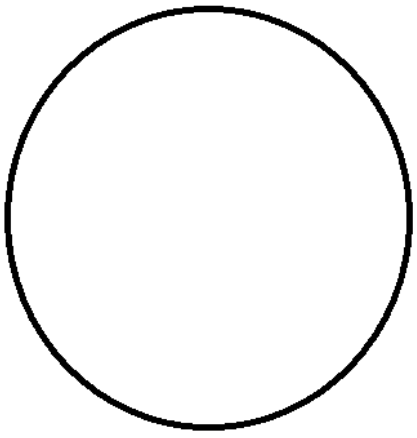
SLIDE'S DESIGNATION

1. Dorsal root
2. Dorsal root ganglia

a. Nervous cell
b. Nervous fibers
c. Capsule

3. Ventral root
4. Spinal nerve

SLIDE 3



Spinal cord
Dye: impregnation of silver
SLIDE'S DESIGNATION

1. Pia matter
2. White matter
    a. Posterior funiculus
    b. Lateral funiculus
    c. Anterior funiculus
3. Grey matter:
    a. Posterior horn
    b. Lateral horn
    c. Anterior horn
4. Central canal

Parenchyma of the organ consists of the nervous tissue in which pseudounipolar neurons are revealed. Perikaryon of the neurons is covered with glial and connective tissue membranes and located in bunches. Name this organ.
A. *Spinal ganglia (sensory ganglia)
B. Vegetative ganglion
C. Epiphysis
D. Spinal cord
E. Cerebellum

The patient of the neurological department has a loss of sensitivity which associated with disorders of pseudounipolar neurons. Pseudounipolar neurons are a type of bipolar neurons and localized in only one place of the human body. Name it.
A *Spinal nodes
B Retina
C Spiral ganglion of the ear
D Intramural autonomic ganglia
E Thalamus

An organ of nervous system, which consists of grey and white substances, is presented in a histological specimen. Grey substance is located in the center and forms butterfly. Neurons in the grey matter locate in bunches and form nucleuses. Which nucleus belongs to the central part of the vegetative nervous system?
A. *Intermediate lateral nucleus
B. Nucleus proprius of the dorsal horn
C. Nucleus proprius of the ventral horn
D. Nucleus thoracicus
E. Intermediate medial nucleus

An organ of the nervous system which has star-shaped form is presented in a histological specimen. This organ is covered with connective tissue capsule and contains multipolar neurons which have different functions. What organ is this?
A *Autonomic ganglion
B Spinal ganglion
C Spinal cord
D Cerebellum
E Medulla oblongata

The autonomic ganglion which is composed of neurons that are surrounded by a glial sheath is presented in a histological specimen. What neurons according to the morphological classification are found in the autonomic ganglia?
A *Multipolar neurons
B Unipolar neurons
C Bipolar neurons
D Pseudounipolar neurons
E -

EYE

Checking your primary level of the knowledge:

1. Structure of the eye wall.
2. Chambers of the eye.
3. The refractile media components of the eye.
4. Cornea structure.
5. Sclera structure.
6. Limbus structure
7. Iris structure.
8. Ciliary body structure.
9. Choroid structure.
10. Parts of retina.
11. Cell groups of retina
12. Three neurons of the retina.
13. Retina -10 layers.
14. The retinal pigment epithelium. (Layer I).
15. Layer of rods and cones. (Layer II).
16. Difference between rods and cones.
17. The external (outer) limiting membrane (layer III).
18. The outer nuclear layer (layer IV).
19. The outer plexiform layer (layer V).
20. The inner nuclear layer (layer VI).
21. The inner plexiform layer. (Layer VII).
22. The ganglion cell layer. (Layer VIII).
23. The layer of optic nerve fibers. (Layer IX).
24. The inner limiting membrane. (Layer X).
25. Specialized regions of retina
26. Crystalline lens structure and function.
27. Vitreous humor structure.
28. Accessory structure of the eye.
29. The eyelid content.
30. The lacrimal gland.

Standard answers for theoretical questions.

1. **Structure of the eye wall.** The wall of the eye consists of three concentric layers or coats. Corneoscleral coat is the outer or fibrous layer that includes the sclera and the cornea. Uvea is the middle layer or vascular coat that includes the choroid and the stroma of the ciliary body and iris. Retina is the inner layer that includes an outer pigment epithelium, the inner neural retina, and the epithelium of the ciliary body and iris.

2. **Chambers of the eye.** Anterior chamber occupies the space between the cornea and the iris. Posterior chamber occupies the space between the posterior surface of the iris and the anterior surface of the lens. Vitreous space occupies the space between the posterior surface of the lens and the neural retina.

3. **The refractile media components of the eye** include following structures: cornea, aqueous humor, lens and vitreous body. They alter the light path to focus it on the retina.

4. **Cornea structure.** The cornea covers the anterior one-sixth of the eye. The cornea is continuous with the sclera. The cornea is transparent. The cornea consists of five layers:

- **The corneal epithelium** is nonkeratinized stratified squamous epithelium.
- **Bowman's membrane** is a homogenous fibrillar lamina on which the corneal epithelium rests. Bowman's membrane is a barrier to the spread of infections.
- **The corneal stroma** constitutes 90% of the corneal thickness. It is composed of about 60 thin lamellae of collagen fibrils between which are found fibroblasts.
- **Descement's membrane** is an unusually thick basal lamina of the corneal endothelial cells.
- **The corneal endothelium** is a single layer of flattened cells. It provides metabolic exchange between cornea and aqueous humor.

5. **Sclera structure.** The sclera is an opaque layer consisting of dense connective tissue. Flat collagen bundles pass in various directions in planes to the surface of the sclera. Interspersed between the collagen

bundles are elastic fibers and ground substance. Fibroblasts are scattered among these fibers. The opacity of the sclera is due primarily to the irregularity of its structure. The sclera is pierced by blood vessels, nerves, and the optic nerve. The sclera is divided into three layers: episclera**,** sclera proper and lamina fusca.

6. **Limbus structure.** The limbus is the transitional zone between cornea and sclera. It is the limbus region that contains the apparatus for the outflow of aqueous humor. In the stromal layer, endothelium-lined channels called the trabecular meshwork merge to form the canal of Schlemm, which drains fluid from the anterior chamber of the eye.

7. **Iris structure.** The iris forms a contractile diaphragm anterior to the lens surface. The iris arises from the anterior border of the ciliary body. The pupil is the central aperture of this thin disc. The layers of the iris, from anterior to posterior, consist of

- fibroblasts and melanocytes
- the anterior stromal lamella
- a loose connective tissue layer that contains many small blood vessels
- the posterior membrane (the sphincter pupillae and the dilator pupillae). (The dilator pupillae is a thin sheet of smooth muscle radially oriented near the posterior border of the iris. The sphincter pupillae is a circular band of smooth muscle located at the pupillary margin. The size of the pupil is controlled by the contraction of the pupillary sphincter and dilator muscles.**)**
- a double layer of pigmented epithelial cells (to absorb light rays and responsible for variation in eye color)

8. **Ciliary body structure.** The ciliary body is a thickened anterior portion of the tunica vasculosa, located between iris and choroid. The anterior third of the ciliary body has ciliary processes. The layers of the ciliary body are similar to those of the iris, consisting of a stroma and an epithelium. The **stroma** is divided into two layers: an outer layer of smooth muscle, the ciliary muscle that makes up the bulk of the ciliary body and an inner vascular region that extends into the ciliary processes.

Ciliary processes are ridge-like extensions of the ciliary body from which zonulae fibers emerge and extend to the lens. The ciliary epithelium which covers the ciliary body has three principal functions: secretions of aqueous humor, serving as the major component of the blood-aqueous barrier and secretion and anchoring of the zonular fibers.

9. **Choroid structure.** The choroid is the portion of the vascular layer that lies between the sclera and the retina. Two layers can be identified in the choroid: choriocapillary layer, an inner vascular layer and Bruch's membrane, a thin, amorphous, hyaline membrane.

10. **Parts of retina.** It consists of two basic layers: neural retina or retina proper, an inner layer that contains the photoreceptors and retinal pigment epithelium, an outer layer. In the **neural retina**, two regions are recognized: **the nonphotosensitive region**, located anterior to the ora serrata and **the photosensitive region** located posterior to the ora serrata

11. **Cell groups of retina.** There are four groups of cells, which constitute photosensitive region of retina:

- photoreceptors − the retinal rods and cones
- conducting neurons − bipolar and ganglion cells
- association and other neurons − horizontal, centrifugal and amacrine
- supporting cells − Müllers cells and neuroglial cells

12. **Three neurons of the retina.**
The first neuron of the retina is called photoreceptor (there are two types rods and cones), second neuron is called bipolar and the last one is called ganglion. The ganglion neurons axons form optic nerve fibers.

13. **Retina 10 layers:**

- **Pigment epithelium** − the outer layer of the retina not part of the neural retina but intimately associated with it.
- **Layer of rods and cones** − contains the outer and inner segments of photoreceptor cells.
- **External (outer) limiting membrane** − the apical boundary of Müllers cells.
- **Outer nuclear layer** − contains the cell bodies (nuclei) of retinal rods and cones.
- **Outer plexiform layer** −contains the processes of retinal rods and cones and processes of the horizontal, amacrine and bipolar cells that connect to them.
- **Inner nuclear layer** − contains the cell bodies of horizontal, amacrine, bipolar and Müllers cells.
- **Inner plexiform layer** − contains the processes, amacrine, bipolar and ganglion cells that connect to each other.

- **Ganglion cell layer** − contains the cell bodies (nuclei) of large multipolar ganglion cells.
- **Layer of optic nerve fibers** − contains processes of ganglion cells that lead from the retina to the brain.
- **Internal (inner) limiting membrane** − composed of the basal lamina of Müllers cells which separating the retina from the vitreous body.

14. **The retinal pigment epithelium (RPE) structure and functions. Layer I.** It is a single layer of cuboidal cells. The cells rest on Bruch's membrane of the choroid layer. The cells of the RPE have extensions that surround the processes of the rods and cones. Melanin granules and residual bodies are present in the cytoplasm of RPE.

Functions of RPE:

- It absorbs light passing through neural retina to prevent reflection.
- It serves as a major component of blood-retinal barrier via tight junctions between RPE cells.
- It phagocytoses and disposes of membranous discs from the rods and cones of the retinal photoreceptor cells.
- It participates in restoring photosensitivity to visual pigments that were dissociated in response to light.

15. **Layer of rods and cones. Layer II.** The rods and cones are the outer segments of photoreceptor cells whose nuclei form the outer nuclear layer of the retina. Each rod and cone photoreceptor consists of outer segment, connecting stalk and inner segment. **The outer segment** of the photoreceptor is roughly cylindrical or conical in shape (hence, the descriptive name rod or cone). **The connecting stalk** contains a cilium composed of 9 peripheral microtubule doublets extending from the basal body. The connecting stalk joins the inner to the outer segment. **The inner segment** is divided into an outer ellipsoid and an inner myoid portion. This segment contains a prominent Golgi apparatus, rER, free polysomes, mitochondria and microtubules. The outer segment is the site of photosensitivity.

16. Difference between rods and cones.

Feature	Rods	Cones
Amount	120 million	7 million
Sensitivity	More sensitive to light and used during periods of low light intensity	Less sensitive to low light
Color perception	Black and white picture	The red, green or blue colors
The visual pigments	Rhodopsin	Iodopsin
Opsin	Scotopsin	Photopsin
Outer segment	Cylindrical	Conical
Discs continuity	Lose their continuity with the plasma membrane	Retain their continuity with plasma membrane

17. **The external (outer) limiting membrane** (layer III) is not a true membrane. It is a row of zonulae adherents between the apical ends of Müller's cells, i.e., the end that faces the pigment epithelium, with each other and with the rods and cones. This layer is thought to be a metabolic barrier that restricts the passage of large molecules into the inner layers of the retina.

18. **The outer nuclear layer (**layer IV) contains the nuclei of the retinal rods and cones. The cone nuclei stain lightly and are larger and more oval than rod nuclei. Rod nuclei are surrounded by only a thin rim of cytoplasm and in contrast thick rim of cytoplasm surrounds the cone nuclei.

19. **The outer plexiform layer** (layer V) is formed by the processes of retinal rods and cones and the processes of horizontal, interplexiform, amacrine, and bipolar cells. Normally, many photoreceptor cells converge onto one bipolar cell and form interconnecting neural networks. Horizontal cell dendritic processes synapse with photoreceptor cells throughout the retina.

20. **The inner nuclear layer** (layer VI) consists of the nuclei of horizontal, amacrine, bipolar, interplexiform, and Müller's cells.

21. **The inner plexiform layer. Layer VII.** It consists of synaptic connections between axons of the bipolar neurons and dendrites of ganglion cells. It also contains synapses between processes of amacrine cells and bipolar neurons, ganglion cells, and interplexiform neurons.

22. **The ganglion cell layer (VIII) consists of the cell bodies of large multipolar neurons.** These nerve cells have lightly staining round nuclei with prominent nucleoli and Nissl bodies in their cytoplasm.

An axonal process emerges from the rounded cell body, passes into the nerve fiber layer, and then goes into the optic nerve. The dendrites extend from the opposite end of the cell to ramify in the inner plexiform layer.

23. **The layer of optic nerve fibers. Layer IX.** The axonal processes of the ganglion cells form a flattened layer running parallel to the retinal surface. This layer increases in depth as the axons converge at the **optic disc.** The retinal vessels, including the superficial capillary network, are primarily located in this layer.

24. **The inner limiting membrane. Layer X.** It consists of a basal lamina separating the retina from the vitreous body. The inner limiting membrane forms the innermost boundary of the retina. It serves as the basal lamina of Müller's cells.

25. **Specialized regions of retina**. The fovea appears as a shallow depression located at the posterior pole of the optical axis of the eye. The central region is known as **fovea centralis**. Most of the layers of the retina except the layer photoreceptors are absent in this region. The fovea centralis is the area of greatest visual acuity. The visual axis of the eye passes through the fovea. Here, that layer composed entirely of cones and rods. **The macula lutea** is the area surrounding the fovea. It is yellowish due to the presence of yellow pigment (xanthophyll).

26. **Crystalline lens structure and function.** The lens is a transparent, avascular, biconvex structure. It is suspended between the edges of the ciliary body by the suspensory ligament. The lens has three principal components: lens capsule, subcapsular epithelium and lens fibers. The pull of the zonular fibers keeps the lens in a flattened condition. Release of that tension causes the lens to fatten or accommodate to bend light rays originating close to the eye so that they focus on the retina.

27. **Vitreous humor structure.** Vitreous humor is the transparent jelly-like substance that fills the posterior segment (vitreous space) of the eye. The main body of the vitreous is a homogenous gel containing about 99% of water, hyaluronic acid, widely dispersed collagen fibers, and other proteins and glycoproteins.

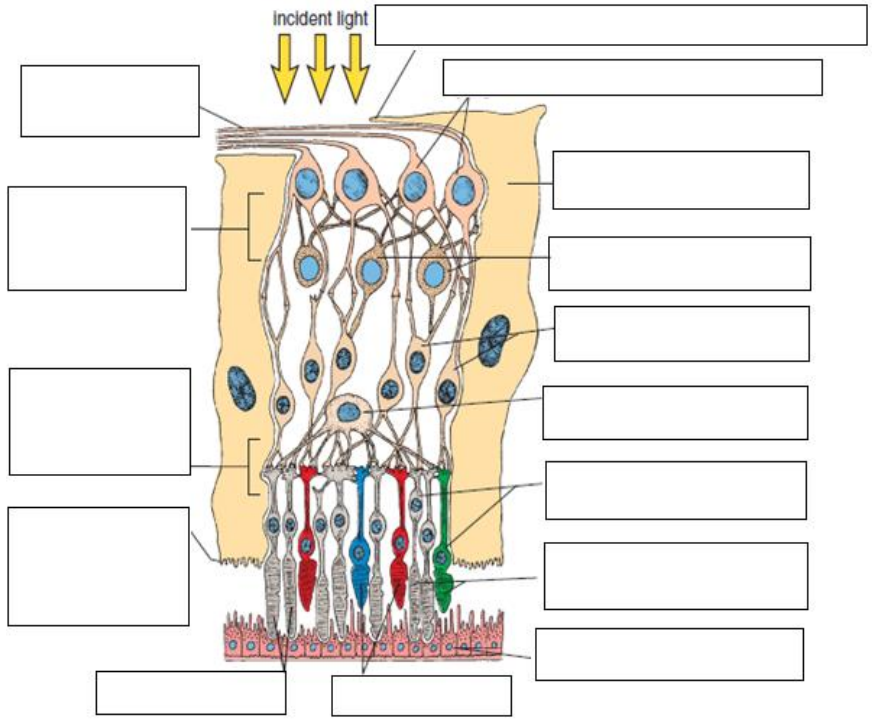
28. **Accessory structure of the eye.** The conjunctiva lines the space between the inner surface of the eyelids and the anterior surface of the eye lateral to the cornea. It consists of a stratified columnar epithelium containing numerous goblet cells and rests on a lamina propria composed of loose connective tissue. The primary function of the eyelids is to protect the eye. Within each eyelid is a flexible support, the tarsal plate, consisting of dense fibrous and elastic tissue.

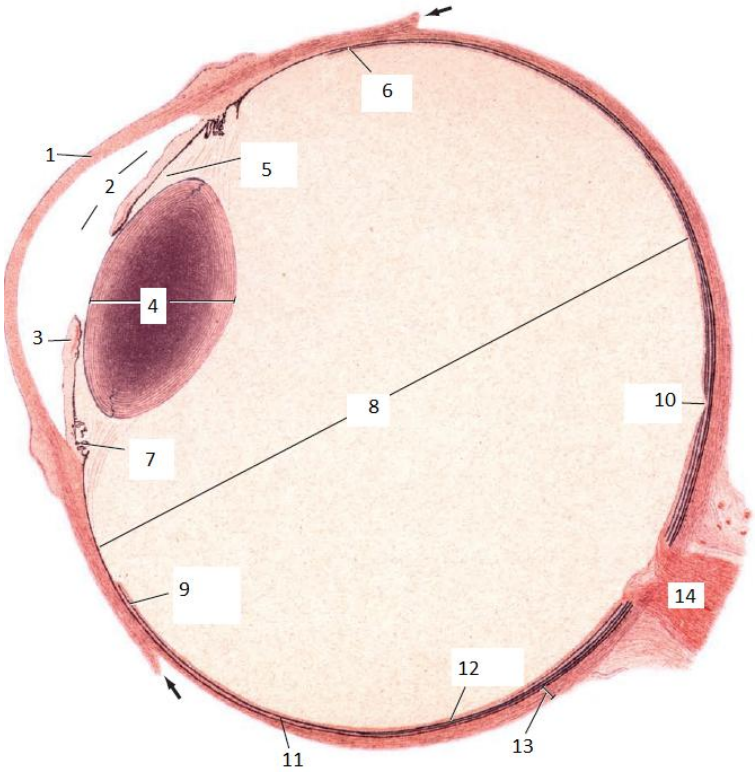
29. **The eyelid** content. **The eyelid** contains three types of glands: Meibomian glands, glands of Zeis and glands of Moll

30. **The lacrimal gland.** The lacrimal gland produces the tears that moisten the cornea and pass to the nasolacrimal duct. Tears are produced by lacrimal and tarsal glands. Tears are sterile and contain the antibacterial enzyme lysozyme. The eye is moved within the orbit by the extraocular muscles.

PRACTICAL QUESTIONS

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





2. In this picture identify the structure labeled 1.

3. Identify the structure labeled 2.

4. Identify the structure labeled 3.

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8. Identify the structure labeled 7.

9. Identify the structure labeled 8.

10. Identify the structure labeled 9.

11. Identify the structure labeled 10.

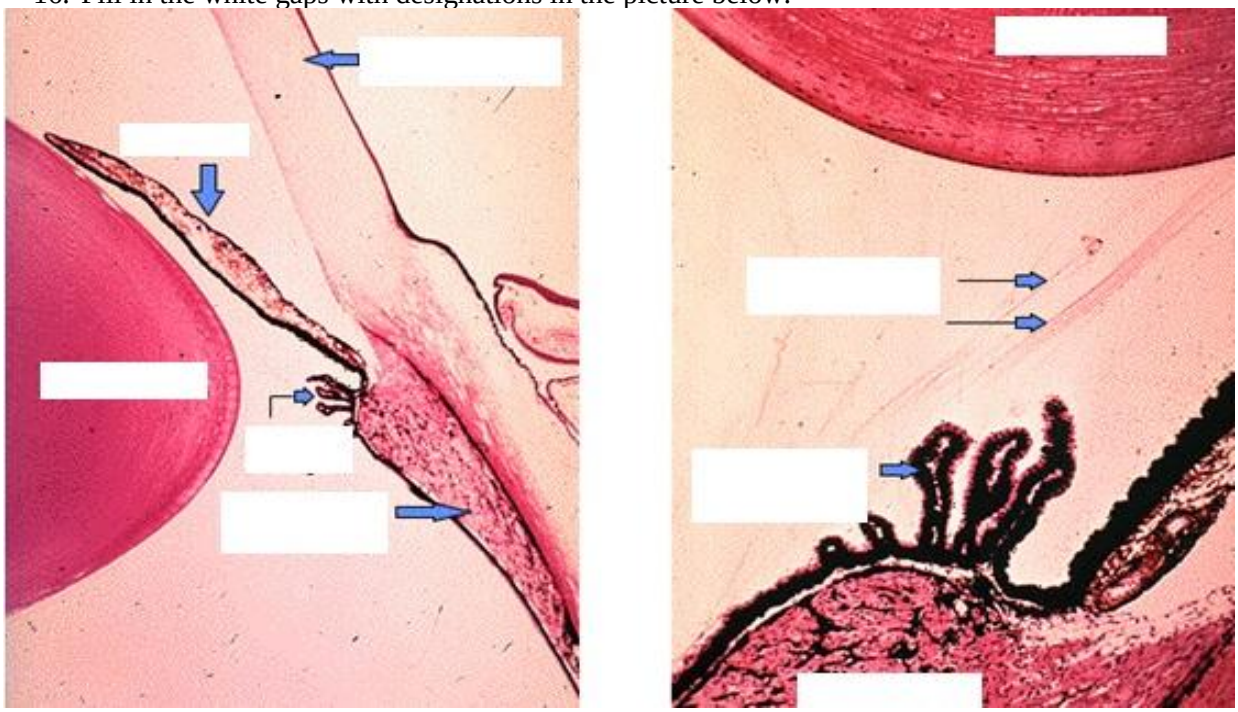
12. Identify the structure labeled 11.

13. Identify the structure labeled 12.

14. Identify the structure labeled 13.

15. Identify the structure labeled 14.

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



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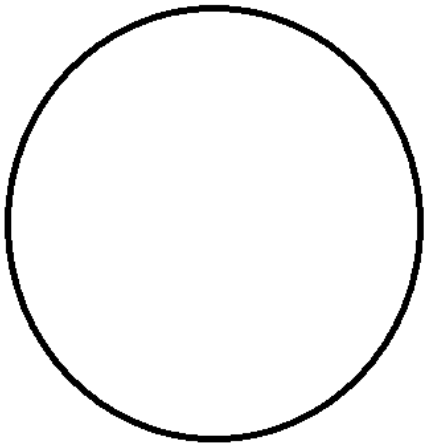
SLIDE 1

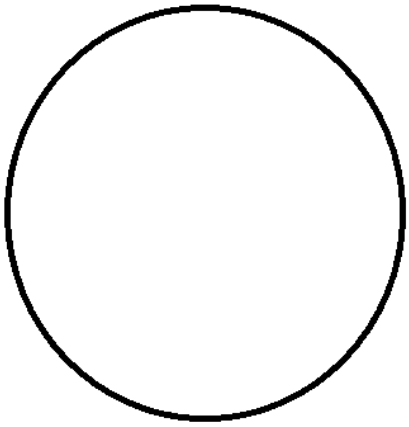


Cornea
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Epithelium
2. Bowman's membrane
3. Stroma
4. Descement's membrane
5. Endothelium
6. Fibroblasts

SLIDE 2



Posterior wall of the eye
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

A. Sclera
B. Vascular layer
C. Retina (the photosensitive region)
1. Pigment epithelium
2. Rods and cones layer
3. The outer limiting membrane
4. The outer nuclear layer
5. The outer plexiform layer
6. The inner nuclear layer
7. The inner plexiform layer
8. The ganglion cell layer
9. The layer of optic nerve fibers
10. The inner limiting membrane

TESTS OF THE "KROK-1" DATABASE

Neural origin cell is represented in the electron micrograph. Terminal part of the cell dendrite is cylindrically in shape and consists of 1000 membrane enclosed discs. What cell is shown in this microphotograph?
A. Rod cell
B. Cone cell
C. Spinal ganglion
D. Neuron of the spinal cord
E. Neuron of the cerebral cortex

An infectious disease caused contractive activity of muscles that contract and dilate eye pupil (paralytic state). What functional eye system was damaged?
A. *Accommodative
B. Dioptric
C. Ancillary
D. Photosensory
E. Lacrimal apparatus

A 14-year-old patient has twilight vision impairment. What vitamin deficiency takes place in the organism?
A. *A
B. B 1
C. B 6
D. C
E. B 12

During the examination the doctor found that the patient does not distinguish blue and green colors with normal perception of other colors. What structure is disordered?
A *Cones receptor cells
B Rod receptor cells
C Bipolar neurons
D Amacrine neurons
E Horizontal neurons

Deficiency of the vitamin A results in the impairment of twilight vision. Name the cells that have the above-mentioned photoreceptor function:
A *Rod receptor cell
B Horizontal neurons
C Cone receptor cells
D Bipolar neurons
E Ganglion neurons

An ophthalmologist has detected that patient has disorder of green color perception during examination. Which retina cells absence may cause this sight disorder?
A. *Cone receptor cells
B. Rod receptor cells
C. Epithelial pigmented cells
D. Bipolar neuron
E. Ganglionar nerve cell

An eyeball structure without blood vessels was detected in a histological specimen. What structure is characterized by this morphological sign?
A. *Cornea
B. Ciliary body
C. Choroid
D. Iris
E. Retina

Cells peripheral part of which consists of two segments were revealed in the electron microphotograph of the sense organ. The outer segment has membrane half discs and the inner one has ellipsoid. In what organ does this structure locate?
A. *In the organ of vision
B. In the organ of taste
C. In the organ of smell
D. In the vestibular organ
E. In the auditory organ

The increased intraocular tension is observed in the patient with glaucoma. Secretion of aqueous humor by the ciliary body is normal. Injury of what structure of the eyeball wall does the disorder of outflow from the anterior chamber cause?
A *Venous sinus
B Ciliary body
C Choroid
D Ciliary muscle
E Back epithelium of cornea

Damages of vascular membrane are detected in the histological specimen of a fetus eyeball. What embryonic material was probably damaged during the development of the eye?
A. *Mesenchyme
B. Ectoderm
C. Endoderm
D. Outer layer of the eyeball
E. Internal layer of the eyeball

In the electron microphotograph revealed cell of neural origin. Terminal part of the cell dendrite has cylindrical shape and consists of 1000 enclosed membrane discs. What cell is this?
A. *Rod cell
B. Ventral horn of the spinal cord
C. Sensory ganglia neuron
D. Cerebral cortex neuron
E. Cone cell

A lot of people with age have clouding of the lens (phacoscotasmus or cataract). It became opaque that leading to the partial blindness. What optical and chemical properties of the lens fibers protein will be disordered?
A. *Crystalline
B. Vitrein
C. Dinein
D. Rhodopsin
E. Iodopsin

In the histological specimen of the eyeball wall, structure which consists of three neurons chain is revealed. Bodies of these neurons form outer, inner nuclear and ganglion cell layers. Which eye component has this morphologic structure?
A. *Retina
B. Iris
C. Sclera
D. Choroid
E. Ciliary body

Underdeveloped epithelium of cornea is observed in the histological specimen of a fetus' eyeball. A part of what embryonal layer was probably affected in the process of embryogenesis?
A. *Ectoderm
B. Endoderm
C. Mesoderm
D. Outer layer of the eyeball
E. Inner layer of the eyeball

Patient with eye trauma consulted a doctor. During examination of corneal epithelium was revealed changes. What epithelium was damaged?
A. *Stratified squamous non keratinized
B. Simple pseudostratified
C. Stratified squamous keratinized
D. Stratified cuboidal
E. Stratified cylindrical

Transplantation of the cornea was done to the patient. Which peculiarities of the cornea structure give expectation to engraftment of it?
A. *Absence of blood and typical lymphatic vessels
B. Presence of stratified anterior epithelium
C. A huge innervations
D. Presence of connective tissue
E. Presence of simple squamous epithelium

Patient has appealed to the ophthalmologist with complaints about hurt in his eyes, which revealed itself after long presence of the patient in the field during dust storm. Doctor diagnosed superficial injuries of the external corneal epithelium. Which cells provide regeneration of the injured epithelium?
A. *Basal cells
B. Cells of stratum corneum
C. Cells of stratum granulosum
D. Cells of stratum spinosum
E. Cells of stratum lucidum

Ciliary body was damaged in the patient. Function of what eye apparatus will suffer in this case?
A. *Accommodative
B. Protective
C. Trophic
D. Photosensitive
E. Dioptric

An infectious disease caused contractive activity of muscles that contract and dilate eye pupil (paralytic state). What functional eye system was damaged?
A *Accommodative
B Dioptric
C Ancillary
D Photosensory
E Lacrimal apparatus

A 55-year-old man went to the doctor with complains about the significant increase in the distance that he has the ability to read without glasses. What part of the eye has undergone age-related changes that have led to this condition?
A. *Lens
B. Cornea
C. Sclera
D. Iris
E. Ciliary body

Nutrition of the cornea is carried out:
A. *By diffusion from the fluid of the anterior chamber of the eye
B. From its own blood vessels
C. By diffusion from the fluid of the posterior chamber of the eye
D. From the lymphatic vessels
E. Due to the secret of the lacrimal glands

As a result of petechial hemorrages to the retina, the patient lost the ability to see objects in the center of the view field. Where was bleeding in the retina?
A. *Macula lutea
B. Ciliary part of the retina
C. Blind spot
D. Choroid
E. -

A cell of the retina in which one of the processes has a segment with hemidiscs is visible in the electron microscope picture. What pigment is contained in the structure of the membrane of these hemidiscs?
A *Iodopsin
B Rodopsin
C Melanin
D Hemosiderin
E Lipofuscin

The patient attended the ophthalmologist with nyctalopia (night blindness). The doctor examined the retina and found degenerative changes in the photosensory layer of the rods of the retina. What vitamin will be prescribed by a doctor?
A *Vitamin A
B Vitamin C
C Vitamin D
D Vitamin B_1
E Vitamin B_{12}

Cells of the retina which have outer and inner segments in the dendrites are presented in the electron microscope picture. The outer segment contains hemidisc and inner segment contains lipid droplet surrounded by mitochondria. What do these cells?
A *Provide daylight and color vision
B Provide black and white vision
C Refract the light
D It is the source of regeneration of the photoreceptor neurons
E Form the efferent way – optic nerve

EAR

Checking your primary level of the knowledge:

1. Structure of the external ear.
2. Structure and functions of the middle ear.
3. Structure and functions of the auditory (Eustachian) tube.
4. General structure if the inner ear.
5. Structure of the vestibule of the bony labyrinth.
6. Structure of the semicircular canals of the bony labyrinth.
7. Structure of the cochlea of the bony labyrinth.
8. Membranous labyrinth components.
9. Specialized sensory cells location.
10. Specialized sensory cells functions.
11. Several important characteristics are common to hair cells.
12. Two hair cells types and associated nerve endings in the vestibular system.
13. Structure of cristae ampullaris of the membranous labyrinth.
14. Mechanism of nerve impulse generation in the cristae ampullaris.
15. Macula sacculi and macula utriculi of the membranous labyrinth.
16. Scalae of the cochlear canal.
17. The scala media structure.
18. Organ of Corti components.
19. Difference between inner and outer hair cells.
20. The phalangeal and pillar cells characteristics.

Standard answers for theoretical questions.

1. **Structure of the external ear**. The external ear is composed of an auricle and an external auditory meatus. Thin skin with hair follicles, sweat glands and sebaceous glands covers the auricle. The lateral part of the canal is lined by skin that contains hair follicles, sebaceous glands, and ceruminous glands.

2. **Structure of the middle ear**. The middle ear is an air-filled space that contains three small bones, the **ossicles**. The auditory ossicles (the malleus, the incus and the stapes) cross the space of the middle ear in series and connect the tympanic membrane to the oval window. **The tympanic membrane** (eardrum) separates the external auditory canal from the middle ear. One of the auditory ossicles, the malleus, is attached to the tympanic membrane. Ossicles help to convert sound waves (air vibrations) arriving from the external auditory meatus into mechanical vibrations that are transmitted to the inner ear. There are two openings in the medial wall of the middle ear, the **vestibular (oval) window** and the **cochlear (round) window.**

3. **Structure and functions of the auditory (Eustachian) tube.** It connects the middle ear to the nasopharynx. It is a narrow flattened channel lined with ciliated pseudostratified columnar epithelium. Eustachian tube equilibrates pressure in the middle ear with atmospheric pressure.

4. General structure if the inner ear. The inner ear consists of two labyrinthine compartments, one contained within the other. **The bony (osseous) labyrinth** is a complex system of interconnected cavities and canals. **The membranous labyrinth** lies within the bony labyrinth and also form continuous spaces enclosed within a wall of epithelium and connective tissue. There are three fluid-filled spaces in the inner ear. **Endolymphatic space** contained within the membranous labyrinth. **Perilymphatic space** lies between the wall of the bony labyrinth and the wall of the membranous labyrinth. **Cortilymphatic space** lies within the organ of Corti. The bony labyrinth consists of three connected space within the temporal bone: semicircular canals, vestibule and cochlea. The membranous labyrinth consists of membranous semicircular ducts, utricle and saccule, and membranous cochlea (cochlea duct).

5. **Structure of the vestibule of the bony labyrinth.** It is the central space that contains an elliptical and spherical recess. The semicircular canals extend from the vestibule posteriorly, and the cochlea extends from the vestibule anteriorly. The vestibular (oval) window lies in the lateral wall of the vestibule.

6. **Structure of the semicircular canals of the bony labyrinth.** They are bony walled tubes that lie in superior, posterior and horizontal planes. Each inner ear has three ampullae which are dilation of the lateral end of semicircular canal. The three canals open into the vestibule through five orifices.

7. **Structure of the cochlea of the bony labyrinth.** It is a conically shaped helix connected to the vestibule on the side opposite the semicircular canals. Between its base and the apex the cochlea makes

about 2,5 turns around a central bony core called **the modiolus**. One opening of the canal, the cochlear (round) window is covered by the secondary tympanic membrane.

8. Membranous labyrinth components. Membranous semicircular ducts lie within the bony semicircular canals and are continuous with the utricle. The **utricle** and **saccule** are contained in recesses in the vestibule and are connected by the membranous utriculosaccular duct. The **membranous cochlear duct** is contained within the bony cochlea and is continuous with the saccule. The membranous semicircular ducts, utricle and saccule are components of the vestibular system. The membranous cochlea is part of the auditory system.

9. Specialized sensory cells location. They are located in six regions in the wall of the membranous labyrinth. **Three cristae ampullaris** located in the ampullae of the semicircular ducts. **Two maculae**, one in the utricle (macula utriculi) and the other in the saccule (macula sacculi). **The organ of Corti** that project into the endolymph of the cochlear duct.

10. Specialized sensory cells functions. The three cristae ampullaris are sensitive to angular acceleration of the head (i.e., turning of the head). The maculae of utricle and saccule sense the position of the head (sensors of gravity) and linear movement. The organ of Corti functions as the sound receptor.

11. Several important characteristics are common to hair cells. All are epithelial cells. Each possesses numerous stereocilia, modified microvilli, called sensory "hairs". In the vestibular system, each hair cell possesses a single true cilium called a kinocilium. In the auditory system, hair cells have only a residual basal body. They are transducers, i.e., they convert mechanical energy to electrical energy. Function by the bending or flexing of their stereocilia which generates transmembrane potential changes in the receptor cell that are conveyed to the afferent nerve ending(s).

12. Two hair cells types and associated nerve endings in the vestibular system. Type I hair cells are piriform in shape with a rounded base and a thin neck. **Type II hair** cells are cylindrical in shape.

13. **Structure of cristae ampullaris of the membranous labyrinth.** Each of the three cristae ampullaris is the sensory region of one of the semicircular ducts in the semicircular canals and lies in the ampulla of the semicircular canal. Each crista consists of hair cells with stereocilia and supporting epithelial cells. A cupula is a gelatinous structure that is attached to the hair cells of each crista. The cupula projects into the lumen and is surrounded by endolymph. Mechanism of nerve impulse generation. During rotational movement of the head, the walls of the semicircular canal and the membranous semicircular ducts move. The endolymph contained within the ducts tends to lag behind because of inertia.

14. Mechanism of nerve impulse generation in the cristae ampullaris. The cupula, projecting into the endolymph, is swayed by the movement differential between the crista fixed to the wall of the duct and the endolymph. Bending of the stereocilia in the narrow space between the hair cells and the cupula leads to the generation of nerve impulses in the associated nerve endings.

15. Macula sacculi and macula utriculi of the membranous labyrinth. The maculae are innervated sensory thickenings of the epithelium facing the endolymph in the saccule and utricle of the vestibule. Each macula consists of hair cells of both types, supporting cells, and nerve endings associated with the hair cells. The maculae of the utricle and saccule are oriented at right angles to one another. When a person is standing, the macula utriculi is in a horizontal plane, and the macula sacculi is in vertical plane. The gelatinous material that overlies the maculae is called the otolithic membrane. It contains the otoliths (otoconia) on its outer surface. Otoliths consists of calcium carbonate. The otolithic membrane moves on the macula in a manner analogous to that by which the cupula moves on the crista.

16. Scalae of the cochlear canal. The cochlear duct divides the cochlear canal into three parallel compartments or scalae: scala media (the middle compartment in the cochlear canal), scala vestibuli and scala tympani. **The scala vestibuli and the scala tympani** are perilymph-containing spaces and communicate with each other at the apex of the cochlea through a small channel called the **helicotrema**. **The scala vestibuli** is described as beginning at **the oval window** and **scala tympani** is described as ending at **the round window**. **The cochlear duct**, itself, is the scala media. The scala vestibuli and scala tympani are the spaces above and below, respectively, the scala media. The scala media is an **endolymph-containing** space that is continuous with the lumen of the saccule and contains the organ of Corti, which rests on its lower wall.

17. The scala media structure. The scala media appears as a triangular space with its most acute angle attached to a bony extension of the modiolus, the osseous spiral lamina. **The upper wall** of the scala media, which separates it from the scala vestibuli, is the vestibular membrane. **The lateral or outer wall** of the scala media is **the stria vascularis**. It is lined with a pseudostratified epithelium that may be the site of synthesis of endolymph. **The lower wall** or floor of the scala media is **the basilar membrane**. **The organ of Corti** rests on the basilar membrane and is overlain by the tectorial membrane.

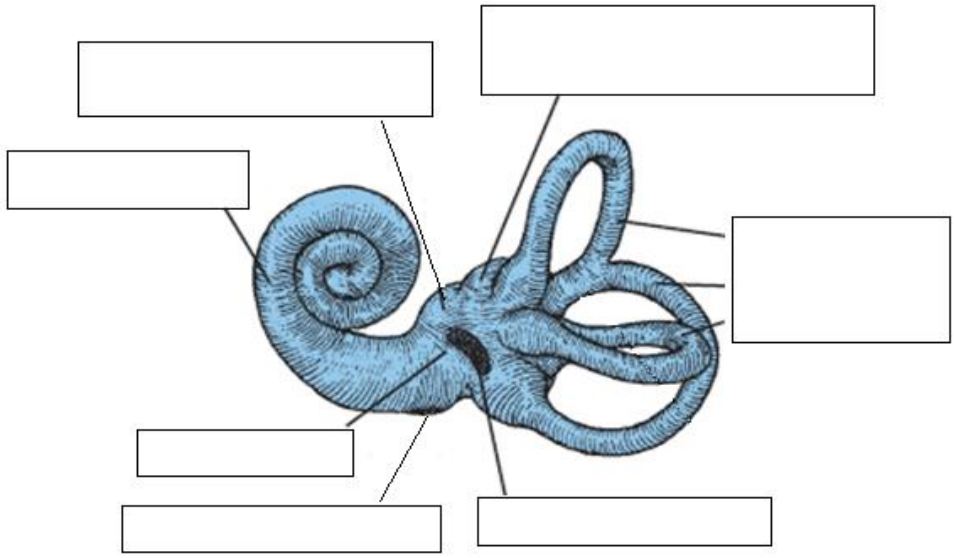
18. Organ of Corti components. The organ of Corti is a complex epithelial layer on the floor of the scala media. It is formed by inner (close to the spiral lamina) and outer (farther from the spiral lamina) hair cells, inner and outer phalangeal (supporting) cells, pillar cells and several other named cell types of unknown function are also presented in the organ of Corti. **The tectorial membrane** extends from the spiral limbus over the cells of the organ of Corti. Its lateral free edges attaches to the organ of Corti by the stereocilia of the hair cells.

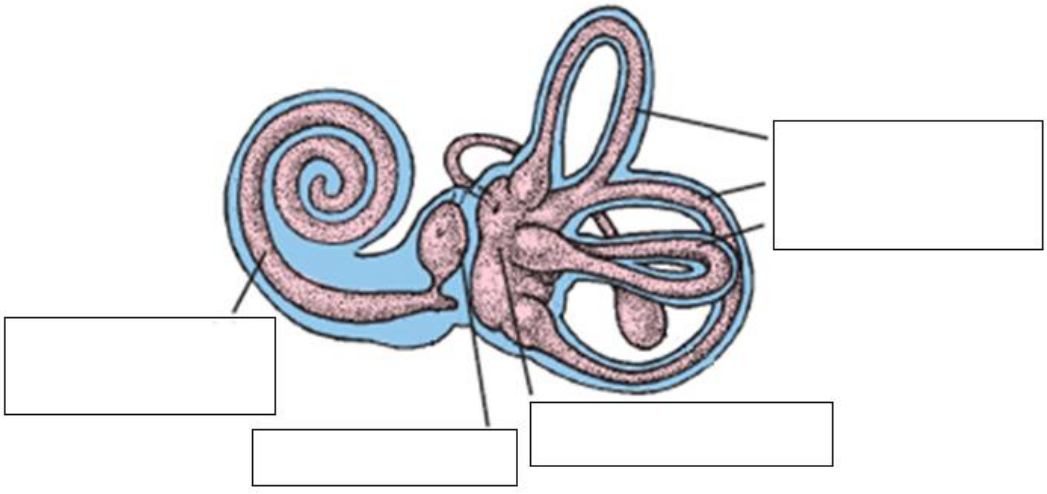
19. **Difference between inner and outer hair cells. Inner hair cells** are far less in number, approximately 3500, then **outer hair cells** which can number up to 20,000 in each ear. Both cells are innervated by the spiral ganglion which transmits signals to the auditory nerve and eventually to the auditory cortex in the brain. About 90% of dendrites originating from the spiral ganglion cells synapse with the inner hair cells; the remaining 10% of dendrites synapse with outer hair cells of the spiral ganglion of Corti. The inner hair cells form a single row of cells throughout all of the cochlear duct. Inner hair cells stereocilia form a straight line. Three ranks of outer hair cells are found in the basal part of the coil and five ranks of the cells at the apex of the cochlea. Outer hair cells stereocilia form a "V" pattern, with the wide part of the "V" facing the tunnel of Corti.

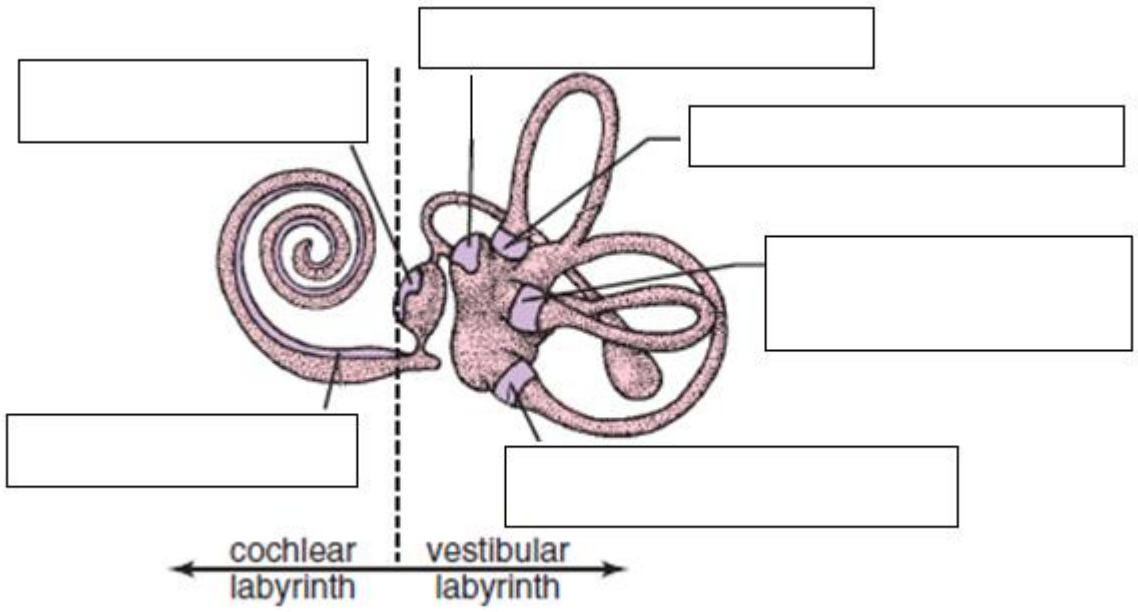
20. **The phalangeal and pillar cells characteristics.** They provide support for the hair cells. **The phalangeal cells** associated with the inner hair cells surround the cell completely. The phalangeal cells associated with outer hair cells surround only the basal portion of the hair cell completely and send apical processes toward the endolymphatic space. **Pillar cells** have broad apical and basal surfaces that form plates and a narrowed cytoplasm. The inner and outer pillar cells between them form a triangular shaped tunnel, the tunnel of Corti.

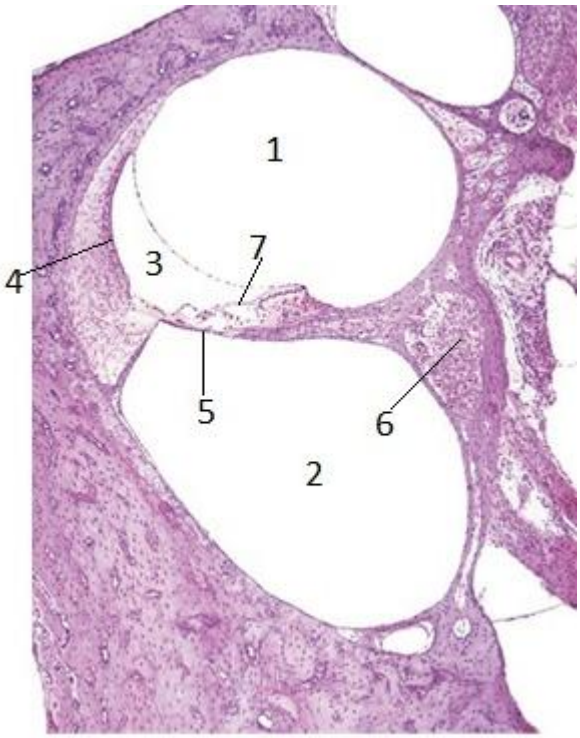
PRACTICAL QUESTIONS

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









2. In this picture identify the structure labeled 1.

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3. Identify the structure labeled 2.

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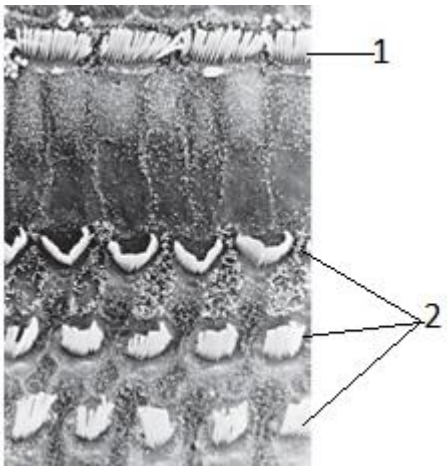

9. Give a name to this electron micrograph.

_____

10. In this electron micrograph identify the structure labeled 1.

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11. In this electron micrograph identify the structure labeled 2.

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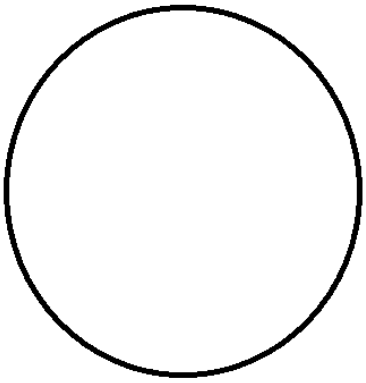
SLIDE 1

Cross section of the cochlea
Dye: hematoxylin-eosin



SLIDE'S DESIGNATION

1. Bone wall of the cochlea
2. Membranous canal of the cochlea
3. Spiral ligament
4. Stria vascularis
5. Vestibular membrane
6. Scala vestibuli
7. Tectorial membrane
8. Organ of Corti
9. Osseous spiral lamina
10. Spiral ganglion
11. Cochlear duct with basilar membrane
12. Scala tympani

TESTS OF THE "KROK-1" DATABASE

In an electronic micrograph of a sense organ hair cells are seen, on their apical part there are short microvilli – stereocilii and a polar located kinocilium. What sensory organ are such cells typical for?
A. *Vestibular organ
B. Vision organ
C. Olfactory organ
D. Hearing organ
E. Taste organ

A histological specimen represents a receptor zone of a sensoepithelial sense organ. Cells of this zone are placed upon the basal membrane and include the following types: external and internal receptor cells, external and internal phalangeal cell, stem cells, external limiting cells and external supporting cell. The described receptor zone belongs to the following sense organ:
A *Acoustic organ
B Visual organ
C Gustatory organ
D Equilibrium organ
E Olfactory organ

Cristae ampullaris have been damaged in a 32-year-old patient as a result of head trauma. What stimuli perception has been disordered?
A. *Angular movement
B. Vibration
C. Gravitation
D. Linear movement
E. Vibration and gravitation

A patient had taken high doses of streptomycin and consequently became deaf. The function of what cells of the inner ear was damaged in this case?
A. *Hair
B. Phalangeal
C. Pillar
D. Deiters'
E. Connective tissue

The patient lost the ability to hear loud bass sounds after suffering a viral illness. Which cells of the spiral organ are injured?
A. *Inner hair cells of the upper parts of the cochlear duct
B. Phalangeal cells
C. Outer hair cells of the lower parts of the cochlear duct
D. Inner hair cells of the lower parts of the cochlear duct
E. Pillar cells

The supporting cells, which are arranged in 3-4 rows, rest on the basement membrane close to the external columnar cells are visible in the electron microscope picture of the organ of Corti. Bowl-shaped recess presents in the upper third of these cells, which includes the basic of external sensory cells. What cells are these?
A *Outer phalangeal cells
B Outer border cells
C Outer supporting cells
D Inner phalangeal cells
E Inner pillar cells

The perception of the vibration oscillation was impaired in a patient with meningitis. What cells of the organ of hearing and balance are affected?

A *Hair sensory cells of the macula of spherical sacculi

B Hair sensory cells of the macula of elliptical saculi

C Supporting cells of the macula of spherical sacculi

D Supporting cells of the macula of elliptical sacculi

E Hair sensory cells of the cristae ampullaris

Sensory organs (taste, smell and touch)

Checking your primary level of the knowledge:

1. Taste buds location and general plan of structure.
2. Peculiarities of neuroepithelial sensory cells.
3. Peculiarities of the supporting cells of the taste buds.
4. Peculiarities of the basal cells of the taste buds.
5. Olfactory segment structure.
6. Peculiarities of olfactory receptor cells.
7. Peculiarities of supporting cells of the olfactory segment.
8. Peculiarities of Brush cells.
9. Peculiarities of the basal cells of the olfactory segment.
10. Olfactory glands structure and function.
11. The lamina propria of the olfactory mucosa.
12. Sensory nerve endings responsible as mechanoreceptors. Merkel's corpuscle.

Standard answers for theoretical questions.

1. **Taste buds location and general plan of structure.** Taste buds are present on fungiform, foliate, and circumvallate papillae of the dorsal surface of the tongue. In histologic sections, taste buds appear as oval, pale-staining bodies that extend through the thickness of the epithelium. A small opening onto the epithelial surface at the apex of the taste bud is called the **taste pore**. Three principal cell types are found in taste buds: neuroepithelial (sensory) cells, supporting cells and basal cells.

2. Peculiarities of neuroepithelial sensory cells. Neuroepithelial (sensory) cells are the most numerous cells in the taste bud. These elongated cells extend from the basal lamina of the epithelium to the taste pore, through which the tapered apical surface of each cell extends microvilli. Near their apical surface they are connected to neighboring neuroepithelial or supporting cells. At their base they form a synapse with the processes of afferent sensory neurons of the facial, glossopharyngeal, or vagus nerves. The turnover time of supporting cells is about 10 days.

3. **Peculiarities of the supporting cells of the taste buds.** Supporting cells are less numerous. They are also elongated cells that extend from the basal lamina to the taste pore. Like neuroepithelial cells, they contain microvilli on their apical surface and possess tight junctions, but they do not synapse with the nerve cells. The turnover time of supporting cells is also about 10 days.

4. **Peculiarities of the basal cells of the taste buds.** Basal cells are small cells located in the basal portion of the taste bud, near the basal lamina. They are the stem cells for the two other cell types.

5. **Olfactory segment structure.** The olfactory segment is lined with olfactory mucosa. The olfactory epithelium is composed of the following cell types. Olfactory cells are bipolar neurons. Supporting cells provide mechanical and metabolic support to the olfactory cells. Basal cells are stem cells from which new olfactory cells and supporting cells differentiate. Brush cells are involved in transduction of general sensory stimulation of the mucosa.

6. **Peculiarities of olfactory receptor cells.** The apical domain of each olfactory receptor cell has a single dendritic process that projects above the epithelial surface as a knoblike structure called the **olfactory vesicle**. A number of long, thin cilia (10 to 23) with typical basal bodies arise from the olfactory vesicle and extend radially in a plane parallel to the epithelial surface. The cilia are usually up to 200 μm long and may overlap with cilia of adjacent olfactory receptor cells. The cilia are regarded as nonmotile or may have limited motility. The basal domain of the cell gives rise to an unmyelinated axonal process. Collections of axons from olfactory receptor cells do not come together as a single nerve, but instead they are grouped into bundles which finally entering the olfactory bulb of the brain. The collections of axons from olfactory receptor cells form the olfactory nerve (cranial nerve I). The olfactory axons are very fragile, and can be harmed during traumatic head injury. They can be permanently severed, resulting in anosmia (loss of the sense of smell).

7. **Peculiarities of supporting cells of the olfactory segment**. Supporting cells are the most numerous cells in the olfactory epithelium. The nuclei of these tall columnar cells occupy a more apical position in the epithelium than do those of the other cell types. Numerous profiles of smooth endoplasmic reticulum and, to a more limited extent, rough endoplasmic reticulum are observed in the cytoplasm. They have numerous microvilli on their apical surface, and abundant mitochondria.

They also possess lipofuscin granules. Adhering junctions are present between these cells and the olfactory receptor cells. The supporting cells provide both metabolic and physical support to the olfactory receptor cells.

8. **Peculiarities of Brush cells.** Brush cells are columnar cells present in much smaller numbers in the olfactory epithelium. Brush cells exhibit large, blunt microvilli at their apical surface, a feature that gives them their name. The basal surface of a brush cell is in synaptic contact with nerve fibers that penetrate the basal lamina. The nerve fibers are terminal branches of the trigeminal nerve (cranial nerve V) that function in general sensation rather than olfaction. Brush cells appear to be involved in transduction of general sensory stimulation of the mucosa. In addition, presence of a microvillous border, vesicles near the apical cell membrane, and a well-defined Golgi apparatus suggest that brush cells might be involved in an absorptive as well as a secretory functions.

9. **Peculiarities of the basal cells of the olfactory segment.** Basal cells are progenitors of the other mature cell types. Basal cells are small, rounded cells located close to the basal lamina. Their nuclei are frequently invaginated and lie at a level below those of the olfactory receptor cell nuclei. The cytoplasm contains few organelles, a feature consistent with their role as a reserve or stem cell.

10. **Olfactory glands structure and function**. The olfactory glands (Bowman's glands), a characteristic feature of the olfactory mucosa, are branched tubuloalveolar serous glands that deliver their proteinaceous secretions via ducts onto the olfactory surface. Lipofuscin granules are prevalent in the gland cells, and in combination with the lipofuscin granules in the supporting cells of the olfactory epithelium, they give the mucosa its natural yellow-brown coloration. Short ducts composed of cuboidal cells lead from the glands and pass through the basal lamina into the olfactory epithelium, where they continue to the epithelial surface to discharge their contents. The serous secretion of the olfactory glands serves as a trap and solvent for odoriferous substances. Constant flow from the glands rids the mucosa of remnants of detected odoriferous substances so that new scents can be continuously detected as they arise. The identifying feature of the olfactory region of the nasal mucosa in a histologic preparation is the presence of the olfactory nerves in combination with olfactory glands in the lamina propria.

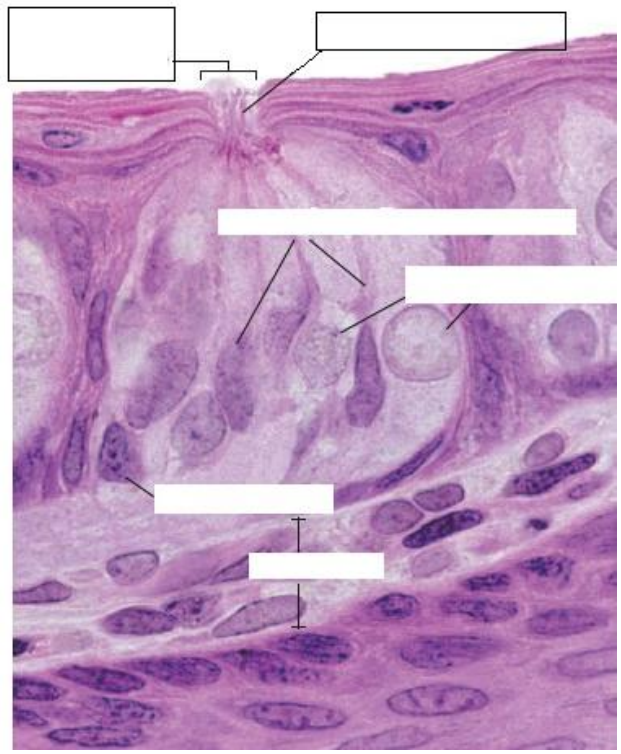
11. **The lamina propria of the olfactory mucosa**. The lamina propria of the olfactory mucosa is directly contiguous with the periosteum of the underlying bone.

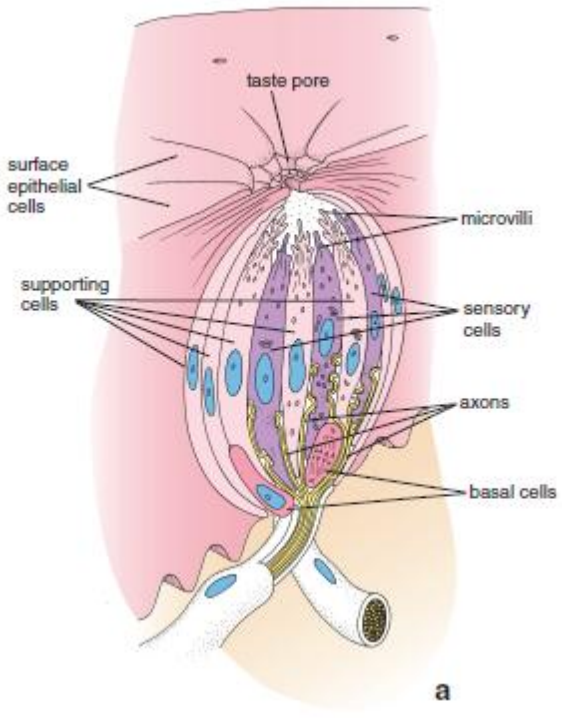
This connective tissue contains numerous blood and lymphatic vessels, unmyelinated olfactory nerves, myelinated nerves, and olfactory glands.

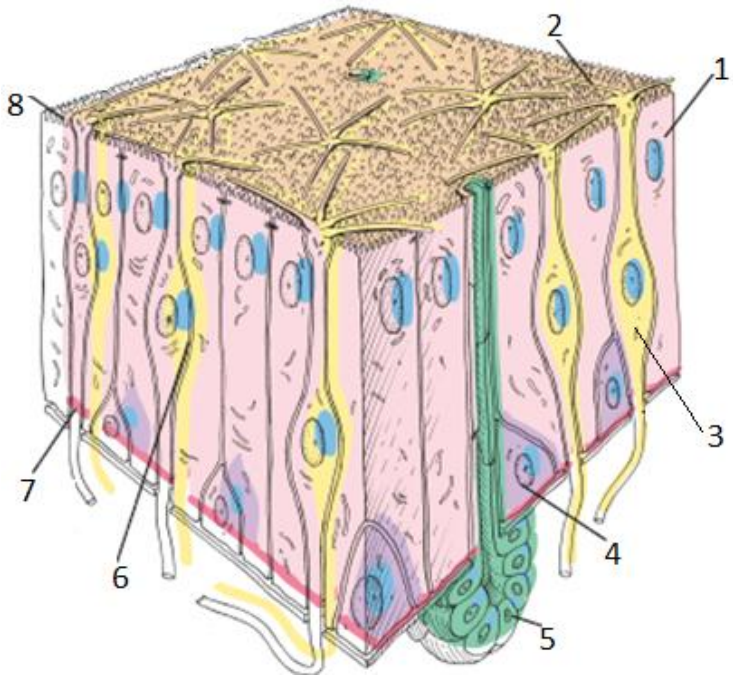
12. **Sensory nerve endings responsible as mechanoreceptors. Merkel's corpuscle.** You can read about this topic in peripheral nervous system chapter.

PRACTICAL QUESTIONS

1. Fill in the white gaps with designations in the pictures below. Use picture labeled "a" as a clue.







2. In this picture identify the structure labeled 1.

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7. Identify the structure labeled 6.

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8. Identify the structure labeled 7.

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9. Identify the structure labeled 8.

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TESTS OF THE "KROK-1" DATABASE

A 30-year-old man has damaged mucosal membrane which covers upper part of upper conchae as a result of trauma. What consequences did this lead to?
A. *Disorder of smell substances perception
B. Disorder of air moistening
C. Disorder of secretory activity of goblet cells
D. Disorder of air warming
E. Disorder of air moistening and warming

A boxer has disturbance in smell perception after a trauma of the nose. What cells damage may cause the loss of smell?
A. *Neurosensory
B. Supporting epithelial cells
C. Basal epithelial cells
D. Microvillous epithelial cells
E. Brush cells

On the electron microphotograph neural origin cell is presented. This cell constitutes part of mucosa membrane epithelium. Distal part of peripheral process of the cell has knob-like expansion from which arise 10-15 cilia. What cell is it?
A. *Olfactory cell
B. Bipolat neuron of spinal ganglion
C. Sensor epithelial cell of organ of taste
D. Rode cell
E. Cone cell

There are cells that perform a protective function in the epidermis. They are similar in morphology to the dendritic cells of the lymph nodes, spleen, and thymus and have a monocytic origin. What are these cells?
A. *Langerhans cells
B. Melanocytes
C. Keratinocytes of the basal layer
D. Keratinocytes of the spinosum layer
E. Keratinocytes of the granular layer

Five-month-old baby was admitted to the pediatric clinic with the changes of the skeletal system such as: softening of some flat bones of the skull, enlargement of the fontanels, characteristic swelling of ribs. The baby nutrition was normal but he rarely walked. The baby was diagnosed with rachitis. What function of the skin was violated in this case?
A. *Synthesis of vitamin D
B. Water-salt metabolism
C. Heat exchange and thermoregulation
D. Deposition of blood
E. Protection from environmental influences

One of the skin diseases is accompanied by the separation of the epidermis from the basement membrane and the formation of the bubble as a result of autoimmune reaction. Which structure of the epidermis is damaged in this reaction?
A *Hemidesmosomes
B Desmosomes
C Zonulae occludentes
D Gap junction
E Synapse

There are cells that form so-called Mongolian spot in people of the Mongoloid race in the dermis of coccygeal area of the skin. It is known that these cells originate from cells of the neural crest and synthesize melanin pigment. What are these cells?
A *Pigment cells
B Macrophages
C Fibroblasts
D Lipocytes
E Adventitial cells

Pemphigoid was diagnosed in the patient with damage of certain areas of the skin in the form of bubbles filled with fluid. This is an autoimmune disease which is accompanied with destruction of the basement membrane of the epidermis that causes its separation from the connective tissue. Which glycoproteins of the basement membrane perform the adhesive role under the normal condition?
A *Laminin and fibronectin
B Globin
C Actinin and vinculin
D Vimentin
E Tubulin

The palms and soles are covered with thick skin and other parts of the body covered with a thin skin. Which layer is missing in the thin skin?
A. *Stratum lucidum
B. Stratum basale
C. Stratum spinosum
D. Stratum granulosum
E. Stratum corneum

INTEGUMENTARY SYSTEM (SKIN)

Checking your primary level of the knowledge:

1. General knowledge of the skin.
2. Notion about thick and thin skin.
3. The three different layers of skin structure and function.
4. The stratum basale structure.
5. The stratum spinosum structure.
6. The stratum granulosum structure.
7. The stratum lucidum structure.
8. The stratum corneum structure.
9. Dermis structure.
10. The papillary layer of dermis.
11. The reticular layer of dermis.
12. Hypodermis structure.
13. Cells of the epidermis – keratinocyte.
14. Cells of the epidermis – melanocytes.
15. Cells of the epidermis – Langerhans Cell.
16. Cells of the epidermis – Merkel Cell.
17. Structure of the hair:
18. Sebaceous glands structure and function.
19. Eccrine sweat glands location, structure and functions.
20. Apocrine sweat glands location, structure and functions.
21. Structure of the nail.

Standard answers for theoretical questions.

1. **General knowledge of the skin.** The skin and its derivatives (hair follicles with hair, sweat (sudoriferous) glands, sebaceous glands, nails and mammary glands) constitute the **integumentary system**. The skin forms the external covering of the body and is its largest and heaviest organ. The skin consists of three main layers: epidermis, dermis and hypodermis.

2. **Notion about thick and thin skin.**

There are two types of the human skin: thick and thin. Thick skin, restricted to the palms of the hands and soles of the feet, lacks hairs and has abundant sweat glands. Thin skin, which has hairs, covers the rest of the body. Thick skin contains five cellular layers: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum and stratum corneum and thin skin contains only four types of cellular layers, there is no stratum lucidum in it.

3. **The three different layers of skin structure and function.**

The **epidermis** is a thin outer portion of the skin that composed of keratinized stratified squamous epithelium. It grows continuously but maintains its normal thickness by the process of desquamation. The epidermis is important for the protective function of skin. Epidermis is derived from ectoderm.

The **dermis** is a thicker inner portion. This is the dense connective tissue layer of skin. It is important for sensation, protection and thermoregulation. It also imparts strength and thickness of the skin. It contains nerves, the blood supply, fibroblasts, etc, as well as sweat glands, which open out onto the surface of the skin, and in some regions, hair. The apical layers of the dermis are folded, to form dermal papillae, which are particularly prominent in thick skin. Dermis is derived from mesoderm.

The **hypodermis** lies underneath the dermis, and merges with it. It is subcutaneous connective tissue, a looser connective tissue than the dermis. It mainly contains adipose tissue and sweat glands. The adipose tissue has metabolic functions: it is responsible for production of vitamin D, and triglycerides.

4. The **stratum basale** is represented by a single layer of cells that rests on the basal lamina. It contains the **stem cells** from which new cells, the **keratinocytes**, arise by mitotic division. Migration process terminates when the cell becomes a mature keratinized cell, which is eventually sloughed off at the skin surface. The cells are small and cuboidal to low columnar. The basal cells also contain various amounts of melanin in their cytoplasm that is transferred from neighboring melanocytes interspersed in this layer. Basal cells exhibit extensive cell junctions; they are connected to each other and to keratinocytes by desmosomes.

5. The **stratum spinosum** is at least several cells thick. **Keratinocytes** in this layer are larger than those of the stratum basale. They exhibit numerous **cytoplasmic processes** or spines, which gives this layer its name. As the cells mature and move to the surface, they increase in size and become flattened in a plane

parallel to the surface. This arrangement is particularly notable in the most superficial spinous cells, where the nuclei also become elongate instead of ovoid, matching the acquired squamous shape of the cells.

6. The **stratum granulosum** is the most superficial layer of the nonkeratinized portion of the epidermis. This layer varies from one to three cells thick. **Keratinocytes** in this layer contain numerous **keratohyalin granules**, hence the name of the layer.

7. The **stratum lucidum** is normally only well seen in thick skin. This highly refractile layer contains eosinophilic cells in which the process of keratinization is well advanced. The nucleus and cytoplasmic organelles become disrupted and disappear as the cell gradually fills with keratin.

8. The **stratum corneum** consists of anucleate squamous cells largely filled with keratin filaments. Usually, an abrupt transition occurs between the nucleated cells of the stratum granulosum and the flattened, desiccated, anucleate cells of the **stratum corneum**. The cells in the stratum corneum are the most differentiated cells in the skin. They lose their nucleus and cytoplasmic organelles and become filled almost entirely with **keratin filaments**. The thick plasma membrane of these cornified, keratinized cells is coated from the outside, in the deeper portion of this layer, with an extracellular layer of lipids that form the major constituent of the **water barrier** in the epidermis. The stratum corneum is the layer that varies most in thickness, being thickest in thick skin. The thickness of this layer constitutes the principal difference between the epidermis of thick and thin skin.

9. **Dermis structure**. The dermis is a connective tissue layer that contains collagen and elastin fibres, and fibroblasts, macrophages and adipocytes, as well as nerves, glands and hair follicles. Sections of skin cut perpendicular to the surface reveal numerous fingerlike connective tissue protrusions, **dermal papillae**, that project into the undersurface of the epidermis. The papillae are complemented by what appear to be similar epidermal protrusions, called **epidermal ridges**, that project into the dermis. There are two layers in the dermis: papillary and reticular layer.

10. The **papillary layer**, the more superficial layer, consists of loose connective tissue immediately beneath the epidermis. The papillary layer is relatively thin and includes the substance of the dermal papillae and dermal ridges. It contains blood vessels that serve but do not enter the epidermis. It also contains nerve processes that either terminate in the dermis or penetrate the basal lamina to enter the epithelial compartment. This layer is responsible for fingerprints.

11. The **reticular layer** lies deep to the papillary layer. This layer consists of dense irregular connective tissue. Although its thickness varies in different parts of the body, it is always considerably thicker and less cellular than the papillary layer. It is characterized by thick, irregular bundles of mostly type I collagen and by coarser elastic fibers.

12. **Hypodermis structure.** Deep to the reticular layer is a **layer of adipose tissue**, the **panniculus adiposus**. This layer serves as a major energy storage site and also provides insulation. This layer and its associated loose connective tissue constitute the **hypodermis** or **subcutaneous fascia**. It is a major energy storage site and an important insulating layer. Individual smooth muscle cells or small bundles of smooth muscle cells that originate in this layer form the **arrector pili muscles** that connect the deep part of hair follicles to the more superficial dermis. Contraction of these muscles in humans produces the erection of hairs and puckering of skin called “goose flesh.”

13. **Cells of the epidermis – keratinocyte.**

The keratinocyte is predominate cell type of the epidermis. It has next functions: production of keratin and creation of an extracellular water barrier. The keratinocytes in the basal layer contain numerous free ribosomes, most of which are engaged in the synthesis of intermediate filaments. The intermediate filaments, more commonly called tonofilaments in the case of the keratinocytes, represent the essential protein in keratin production. As the cells enter and are moved through the stratum spinosum, the synthesis of tonofilaments continues, and the filaments become grouped into bundles. These bundles are called tonofibrils. In the upper part of the stratum spinosum the keratinocytes begin to synthesize keratohyaline granules and lamellar bodies (membrane-coating granules). As the number of granules increases, they become the most distinctive feature of the cells that constitute the stratum granulosum. Keratinization, i.e., the conversion of granular cells to cornified cells, this process also involves the breakdown of the nucleus and other organelles and the thickening of the plasma membrane. Finally, there is a regular desquamation of these keratinized cells.

14. **Cells of the epidermis – melanocytes**

Melanocytes are pigment-producing cells. The epidermal melanocyte is a dendritic cell found among the basal cells of the stratum basale. The ratio of melanocyte to keratinocyte in the basal layer ranges from 1:4 to 1:10 in different parts of the body. They are called dendritic cells because the rounded cell body resides in

the basal layer and extends long processes between the keratinocytes of the stratum spinosum. Melanocytes have developing and mature melanin granules in the cytoplasm.

15. **Cells of the epidermis – Langerhans Cell**

The Langerhans cell plays a role in the immune response by presenting antigens to t cells. In common with macrophages, the Langerhans cell possesses surface receptors. At sites of allergic contact, lymphocytes are seen in close apposition to the Langerhans cell membrane shortly after antigenic challenge. As an antigen-presenting cell, the Langerhans cell is involved in the initiation of cutaneous contact hypersensitivity reactions, i.e., contact allergic dermatitis, and in other cell-mediated immune responses in the skin.

16. **Cells of the epidermis – Merkel Cell**

Merkel's cells are modified epidermal cells that are located in the stratum basale. The combination of the neuron and epidermal cell, called a Merkel's corpuscle, is a very sensitive mechanoreceptor.

17. **Structure of the hair.**

Hairs are composed of keratinized cells that develop from hair follicles. The hair follicle is responsible for the production and growth of a hair. The growing follicle expands on its base to form the ***bulb***. The bulb consists of **matrix cells.** The outermost part of the hair follicle is the ***external (outer) root sheath***. The dividing cells in the germinative layer of the matrix are the **internal root sheath**. The hair consists of a **medulla, cortex,** and **cuticle**.

The internal root sheath consists of a **cuticle, Huxley's layer,** and **Henle's layer**. Keratinization of the hair and internal root sheath occurs in a region called the **keratogenous zone** shortly after the cells leave the matrix. By the time the hair emerges from the follicle, it is entirely keratinized as **hard keratin.** The internal root sheath consists of the **soft keratin**. The follicle is surrounded by a connective tissue sheath to which the **arrector pili muscle** is attached.

18. **Sebaceous glands structure and function.**

Sebaceous gland is simple, branched and acinar, with holocrine type of secretion. It produces **sebum**. Sebaceous glands secretes into the **pilosebaceous canal**. New cells are produced by mitosis of the basal cells at the periphery of the gland. The basal cells of the sebaceous gland contain smooth (sER) and few lipid droplets. As the cells move away from the basal layer and begin to produce the lipid secretory product, the amount of sER increases, reflecting the role of the sER in lipid synthesis and secretion. The cells gradually become filled with numerous lipid droplets separated by thin strands of cytoplasm. Sebaceous glands secrete sebum that coats the hair and skin surface.

19. **Eccrine sweat glands location, structure and functions.**

Eccrine sweat glands are distributed over the entire body surface except for the lips and part of the external genitalia.

Eccrine sweat glands are arranged as simple coiled tubular glands with merocrine type of secretion. Secretory segment has clear, dark and myoepithelial cells. Clear cells produce the watery component of sweat. They are characterized by abundant glycogen and numerous mitochondria. Dark cells secrete glycoprotein. They are characterized by abundant rER, secretory granules and relatively large Golgi complex. Myoepithelial cells are responsible due their contraction for the expression of sweat from the gland. The epithelium of the duct is stratified cuboidal, consisting of a basal cell layer and luminal cell layer.

Eccrine sweat glands are regulating body temperature and serves as an excretory organ (for sodium chloride, urea, uric acid, and ammonia).

20. **Apocrine sweat glands location, structure and functions.**

Apocrine sweat glands, limited to the axilla, areola, and nipple of the mammary gland, circumanal region, and the external genitalia.

Apocrine glands are coiled tubular glands with apocrine type of secretion. They are associated with hair follicles. The apocrine glands store their secretory product in the lumen, which is very wide. The secretory portion of the gland is composed of simple epithelium. The apical cytoplasm contains numerous small granules, the secretory component within the cells and also includes lysosomes and lipofuscin pigment granules. The duct epithelium is stratified cuboidal. Secretory segment contains secretory and myoepithelial cells

Apocrine sweat glands secrete protein, carbohydrate, ammonia, lipid, and certain organic compounds. When secreted, the fluid is odorless, but through bacterial action on the skin surface it develops an acrid odor.

21. **Structure of the nail.**

Nails are plates of keratinized cells containing hard keratin. The **nail plate** rests on the **nail bed**. The proximal part of the nail is the **nail root**. It covers the cells of the germinative zone, the **matrix**. The

crescent-shaped white area near the root of the nail is the **lunula**. The edge of the skin fold covering the root of the nail is the **eponychium** or cuticle. A thickened epidermal layer, the **hyponychium**, secures the free edge of the nail plate at the fingertip.

PRACTICAL QUESTIONS

In this picture:

1. Identify the structure labeled by the arrow.

_____

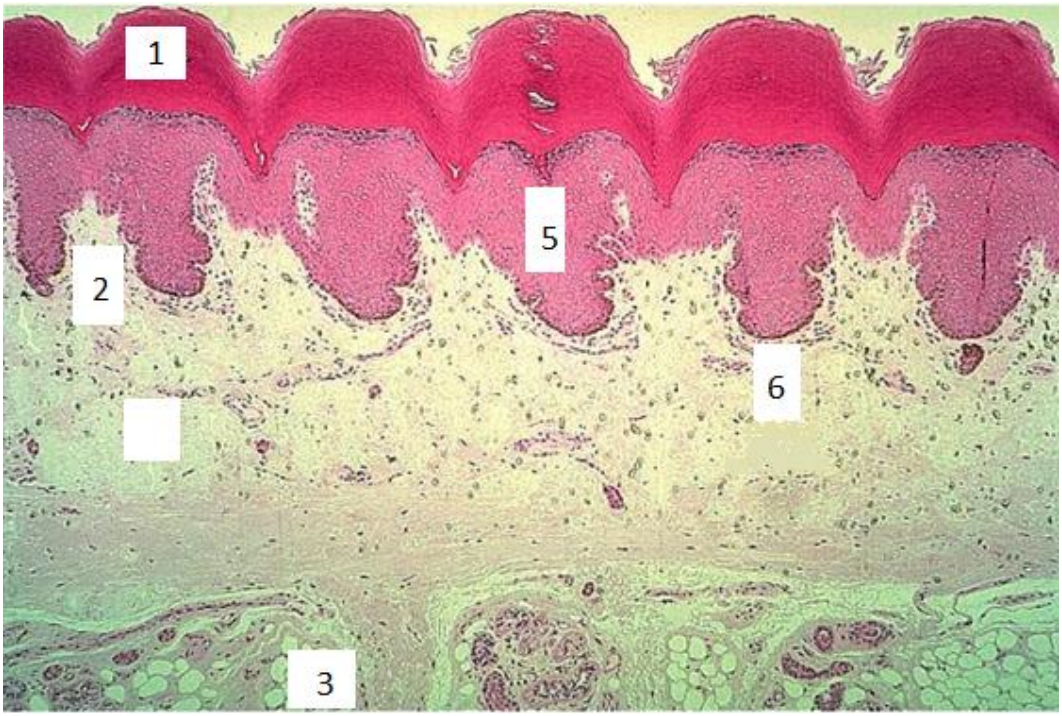
2. What is the function of this structure?

_____

3. What mode of secretion does this gland have?

_____

In the picture below:



4. Identify the layer labeled 1.

_____

5. What type of tissue is found here?

_____

6. What protein is found in abundance in this layer?

_____

7. What place in the body could this slide be from?

_____

8. Identify the layer labeled 2.

9. What structure is this label 2 within?

_____

10. What is the function of this structure?

_____

11. What type of tissue is predominant in this layer?

_____

12. Identify the layer labeled 3.

_____

13. What type of tissue is predominant in this layer?

_____

a. Identify the layer labeled 4.

_____

b. What type of tissue is predominant in this layer?

_____

c. What layer is just above label 5?

_____

d. What layer is the majority of the label 5 within?

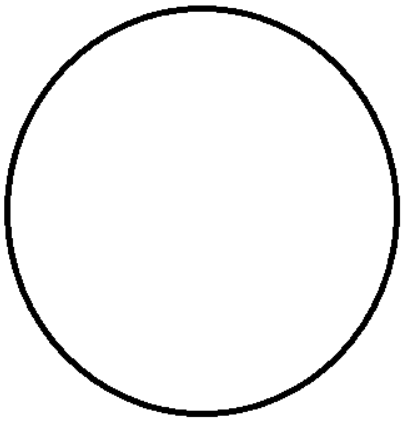
_____

e. What layer is indicated by label 6?

_____

f. Why is this layer so important?

_____



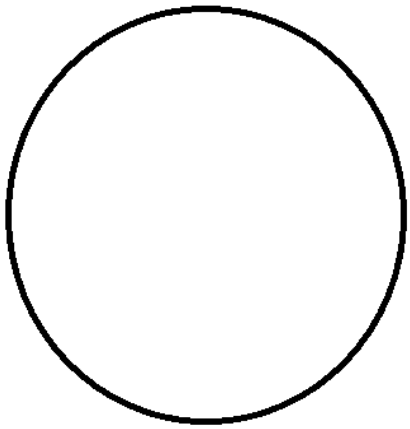
SLIDE 1 Finger skin

Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Epidermis
   a. Stratum basale
   b. Stratum spinosum
   c. Stratum granulosum
   d. Stratum lucidum
   e. Stratum corneum
2. Derma
   a. Papillary layer
   b. Reticular layer
3. Hypodermis
4. End portion of the sweat gland
5. Excretory ducts of the sweat glands
6. Blood vessels

SLIDE 2 **Skin with hair**



Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Epidermis
2. Derma
3. Hypodermis
4. Hair root
5. Internal root sheath
6. External root sheath
7. Hair bulb
8. Hair follicle
9. Hair papilla
10. Sebaceous gland
11. Hair erector muscle

TESTS OF THE "KROK-1" DATABASE
SKIN MORPHOLOGY

The method of dactylography is used extensively in the forensic medical expertise. This method is based on the strictly individual picture of the skin surface made by the papillary layer of the derma. What tissue is forming this layer of the derma?
A * Loose connective tissue
B Dense irregular fibrous tissue
C Dense regular fibrous tissue
D Reticular tissue
E Adipose tissue

A 12-year-old patient has white non-pigmented spots on the skin. The spots appeared after the patient became 10-year-old, and they constantly grow. This spots appeared due to the lack of the following skin cells:
A. *Melanocytes
B. Adipocytes
C. Fibrocytes
D. Plasmocytes
E. Labrocytes

Cells with processes and dark brown granules in the cytoplasm were revealed in the skin epidermis of the biopsy material. What are these cells?
A. *Melanocytes
B. Intraepidermal macrophages
C. Keratinocytes
D. Merkel cells
E. Lymphocytes

Trauma of skin reticular layer was happened. At the expense of what cells differon activity regeneration of this layer will happen?
A. *Fibroblastic
B. Macrophagic
C. Lymphoblastic
D. Neuroblastic
E. -

Under the radiation influence epidermal cells of the stratum basale were damaged. What function of the epidermis will be weakening or depressed first of all?
A. *Regenerative
B. Protective
C. Absorptive
D. Barrier
E. Dielectric

With age human skin undergoes changes, which may declare themselves by reduction of skin elasticity. What structures of the connective tissue provide skin elasticity most of all?
A. *Collagen and elastic fibers
B. Ground substance
C. Epidermis cells
D. Connective tissue cells
E. Reticular fiber

In the course of experiment on a frog embryo the external embryonic layer – ectoderm – has been destroyed. Which of the following morphological structures has not been developed henceforth?
A. *Epidermis
B. Somites
C. Nephrotome
D. Splanchnotome
E. Sclerotome

One of the surgery rules is performing sections along the so-called Langers' lines (lines of skin tension). Which from mentioned below tissues form papillary layer (the strongest layer in the derma)?
A. *Dense irregular connective tissue
B. Reticular connective tissue
C. Loose connective tissue
D. Epithelial tissue
E. Dense regular connective tissue

In an electron micrograph of skin epidermis among the cells of cuboidal form dendritic cells are detected. In their cytoplasm Golgi apparatus is well-developed; there are a lot of ribosomes and melanosomes. Name these cells.
A. *Melanocytes
B. Keratinocytes
C. Cells of Langerhans
D. Merkel's cells
E. Mast cells

Study of fingerprints (dactylography) is used by criminalists for personal identification as well as for diagnostics of genetic abnormalities, particularly Dawn's disease. What layer of skin determines individuality of fingerprints?
A *Dermopapillary
B Horny
C Reticular
D Clear (stratum lucidum)
E Basal

A child has abraded skin of the palm when falling down. What epithelium was damaged?
A. *Stratified squamous keratinized
B. Stratified squamous non-keratinized
C. Simple low columnar
D. Transitional
E. Simple squamous

Method of dactyloscopy is largely used in forensic medicine. This method is based on strictly individual print of the skin surface which determines papillary layer of derma. Which tissue forms this layer of the derma?
A. *Loose irregular connective tissue
B. Reticular connective tissue
C. Dense irregular connective tissue
D. Adipose tissue
E. Dense regular connective tissue

There is histological specimen of the skin epidermis biopsy sample taken from the healthy adult. Cells division can be seen in the stratum basale. What process does provide these cells?
A. *Physiologic regeneration
B. Differentiation
C. Adaptation
D. Reparation
E. Apoptosis

Some layers are absent on a limited area of epidermis after a trauma. Only germinative layer is preserved. Name the cells, which will become the main source of its regeneration.
A. *Layer of basal cells
B. Layer of spinosum cells
C. Layer of granulosum cells
D. Layer of spinous and granular cells of undisturbed area
E. Cells of lucidum layer of undisturbed area

The central part of epiblast cells (ectoderm) sags and neurulation process begins during the third week of embryogenesis. In which direction will the remaining ectodermal cells differentiate?
A. *Skin
B. Somites
C. Gut
D. Chord
E. Yolk sac

Stratified structure organ which covered with stratified squamous keratinized epithelium is represented on the histological specimen. There is loose connective tissue which forms convexity in the form of papilla located under epithelial basal membrane. Dense irregular connective tissue located under it and form reticular layer. What organ has these morphological peculiarities?
A. *Skin
B. Tongue
C. Esophagus
D. Tonsil
E. Cervix of the uterus

There are next layers in the skin histological specimen: stratum basale, spinosum, granulosum, lucidum and corneum. Which part of the human body does this epithelium belong to?
A. *Palm skin
B. Face skin
C. Hairy part of the head skin
D. Shoulder skin
E. Thigh skin

Skin malignant tumor was revealed at 30-years old patient. What epidermis cells take place in the immune response?
A. *T-lymphocytes
B. Keratinocytes
C. Keratinocytes and Merkel cells
D. Merkel cells
E. Stratum spinosum cells

Trauma of derma reticular layer was happened. At the expense of what cell differon activity regeneration of this layer will happen?
A. *Fibroblasts
B. Macrophages
C. Lymphoblasts
D. Mast cells
E. Plasma cells

Process of the dorsal mesoderm segmentation and somites formation was disordered in the embryo. In what part of the skin is disorder development possible?
A. *Derma
B. Hair
C. Sebaceous glands
D. Epidermis
E. Sweat glands

There are cells that perform a protective function in the epidermis. They are similar in morphology to the dendritic cells of the lymph nodes, spleen, thymus and have a monocytic origin. What are these cells?
A. *Langerhans cells
B. Melanocytes
C. Keratinocytes of the basal layer
D. Keratinocytes of the spinosum layer
E. Keratinocytes of the granular layer

Five-month-old baby was admitted to the pediatric clinic with the changes of the skeletal system such as: softening of some flat bones of the skull, enlargement of the fontanels, characteristic swelling of ribs. The baby nutrition was normal but he rarely walked. The baby was diagnosed with rachitis. What function of the skin was violated in this case?
F. *Synthesis of vitamin D
G. Water-salt metabolism
H. Heat exchange and thermoregulation
I. Deposition of blood
J. Protection from environmental influences

One of the skin diseases is accompanied by the separation of the epidermis from the basement membrane and the formation of the bubble as a result of autoimmune reaction. Which structure of the epidermis is damaged in this reaction?
A *Hemidesmosomes
B Desmosomes
C Zonulae occludentes
D Gap junction
E Synapse

There are cells that form so-called Mongolian spot in people of the Mongoloid race in the dermis of coccygeal area of the skin. It is known that these cells originate from cells of the neural crest and synthesize melanin pigment. What are these cells?
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C Fibroblasts
D Lipocytes
E Adventitial cells

Pemphigoid was diagnosed in the patient with damage of certain areas of the skin in the form of bubbles filled with fluid. This is an autoimmune disease which is accompanied with destruction of the basement membrane of the epidermis that causes its separation from the connective tissue. Which glycoproteins of the basement membrane perform the adhesive role under the normal condition?
A *Laminin and fibronectin
B Globin
C Actinin and vinculin
D Vimentin
E Tubulin

The palms and soles are covered with thick skin and other parts of the body covered with a thin skin. Which layer is missing in the thin skin?
A. *Stratum lucidum
B. Stratum basale
C. Stratum spinosum
D. Stratum granulosum
E. Stratum corneum

A patient complains about dryness of head skin, itching, fragility and loss of hair. He was diagnosed with seborrhea after examination. Disturbed activity of which cells caused this condition?
A *Cells of sebaceous glands
B Cells of sudoriferous glands
C Epithelial cells
D Adipocytes
E Melanocytes

A man was admitted to the traumatological department with burns of the scalp. All epidermal cells of all layers down to the basement membrane died as a result of it. What structures will provide the epithelization of the affected areas?
A *Cells of the hair follicles
B Cells of the papillary layer of dermis
C Cells of the reticular layer of dermis
D Cells of the hair bags
E Cells of the hair papilla

The hair shaft of long hair has been destroyed as a result of injury of the victim. What structures will the renewal of hair provide?
A *Hair bulb
B Dermal papila
C External root sheath
D Internal root sheath
E Cuticle of the hair

A part of the nail plate was removed in patient as a result of trauma. What structures will provide the renewal of it?
A *Nail matrix
B Nail cushion
C Eponychium
D Nail fold (groove)
E Nail root

CARDIOVASCULAR SYSTEM

Checking your primary level of the knowledge:

1. The interrelationships and functions of the different parts of the cardiovascular system.
2. The common structural plan seen in most components of the cardiovascular system.
3. Classifications of the arteries.
4. Elastic arteries location in the body
5. Elastic arteries structure.
6. Muscular arteries location in the body.
7. Muscular arteries structure. Difference between elastic arteries and muscular arteries.
8. Difference between small arteries and arterioles.
9. Arterioles function.
10. Two types of the arterio-venous connections.
11. Capillaries structure and functions.
12. Continuous (somatic) capillaries location and structure.
13. Fenestrated (visceral) capillaries location and structure.
14. Discontinuous (sinusoidal) capillaries location and structure.
15. Capillaries functions.
16. Arteriovenous anastomosis (shunts).
17. Classifications of veins.
18. Muscular and non muscular veins.
19. Venules structure.
20. Medium veins structure.
21. Large veins structure.
22. Difference between veins and arteries.
23. Lymphatic vessels types and structure.
24. Difference between lymph and blood capillaries
25. General plan of heart structure.
26. Epicardium structure.
27. Difference between cardiac and skeletal muscle. Myocardium structure.
28. Intercalated discs of myocardium.
29. Smooth endoplasmic reticulum and the T System.
30. Endocardium structure.
31. Spontaneous contraction versus neural control
32. Intrinsic regulation of heart rate.

Standard answers for theoretical questions.

1. **The interrelationships and functions of the different parts of the cardiovascular system.** The cardiovascular system is a transport system that carries blood and lymph to and from the tissues of the body. The cardiovascular system includes the heart, blood vessels, and lymphatic vessels. Blood vessels provide the route by which blood circulates to and from all parts of the body. The heart pumps the blood. Lymphatic vessels carry tissue derived fluid, called lymph, back to the blood vascular system.

The vessels that deliver blood to the capillaries are the arteries. The smallest arteries, called arterioles, are functionally associated with net works of capillaries into which they deliver blood. Together, the arterioles, associated capillary network, and post capillary venules form a functional unit referred to as the **microcirculatory** or **microvascular bed** of that tissue. Veins collect blood from the microvascular bed and carry it toward the heart.

2. **The common structural plan seen in most components of the cardiovascular system.** The walls of arteries and veins are composed of three layers called tunics. The three layers of the vascular wall, from the lumen outward, are tunica intima, the innermost layer that includes the endothelial lining; tunica media, the muscular middle layer and tunica adventitia, the outermost connective tissue layer.

In addition to the three tunics, large arteries and veins may have a system of vessels, called **vasa vasorum**, to supply the vessels themselves and a network of autonomic nerves, called **nervi vascularis**, to control contraction of the smooth muscle in the walls of the vessels.

3. **Classification of the arteries.** Traditionally, arteries are classified into three types on the basis of size and characteristics of the tunica media. There are large or elastic arteries, medium or muscular arteries and small arteries and arterioles. In Ukraine there is another classification. The last one is based on diameter

of the vessel and features of the wall structure. There are muscular arteries (medium and small diameter), mixed or muscular-elastic arteries (medium diameter) and elastic arteries (large diameter).

4. **Elastic arteries location in the body.** There are the largest of elastic arteries such as aorta and pulmonary arteries and their main branches, the brachiocephalic, common carotid, subclavian and common iliac arteries. Their main function is to transport blood away from the heart. These arteries also serve to smooth out the large fluctuations in pressure created by the heartbeat.

5. **Elastic arteries structure.** The **tunica intima** of elastic arteries is relatively thick and consists of an endothelial lining with its basal lamina, a subendothelial layer of connective tissue and the internal elastic membrane (lamina). In elastic arteries, the **internal elastic membrane** is not conspicuous, because it is one of many elastic layers in the wall of the vessel. The main cell type of this layer is the smooth muscle cell.

The **tunica media** is the thickest of the three layers of elastic arteries and consists of elastin in the form of fenestrated sheets or lamellae between the muscle layers, smooth muscle cells arranged in layers and collagen fibers and ground substance. The elastic lamellae are arranged in concentric layers.

In elastic arteries, the **tunica adventitia** is a relatively thin connective tissue layer that is usually less than half the thickness of the tunica media. It consists of collagen fibers, elastic fibers, fibroblasts and macrophages. The tunica adventitia contains blood vessels (vasa vasorum) and nerves (nervi vascularis).

6. **Muscular arteries location in the body.** The muscular arteries are the brachial, radial, ulnar, femoral and tibial arteries.

7. **Muscular arteries structure. Difference between elastic arteries and muscular arteries.**

Muscular arteries have same structure as elastic arteries. However there are some differences between them. Muscular arteries have more smooth muscle and less elastin in the tunica media than do elastic arteries. Prominent internal and external elastic membranes help to distinguish muscular arteries from elastic arteries. Adipose cells are present in tunica adventitia of muscular arteries instead macrophages. Compared with elastic arteries the tunica adventitia of muscularis arteries is relatively about the same thickness as the tunica media. Collagen fibers are principal extra cellular component.

8. **Difference between small arteries and arterioles.** Small arteries and arterioles are distinguished from one another by the number of smooth muscle layers in the tunica media. Arterioles have only one or two layers of smooth muscle in the tunica media, a small artery may have up to about eight layers. Typically, the tunica intima of a small artery has an internal elastic membrane, whereas this layer may or may not be present in the arteriole. The tunica adventitia is a thin, sheath of connective tissue that blends with the connective tissue in which these vessels travel.

9. **Arterioles function.** The arterioles have two important functions such as maintaining the blood pressure inside the arterial system and controlling blood flow to the capillary networks.

10. **Two types of the arterio-venous connections.** The arterio-venous connections are classified into two main types. There are blood capillaries and the vessels regulating their blood flow and arterio-venous anastomosis (A-V shunts).

11. **Capillaries structure and functions.** Capillaries are the smallest diameter blood vessels, often smaller than diameter of an erythrocyte. Capillaries form blood vessel networks that allow fluids containing gases, waste products to move through their thin wall. They consist of a single layer of endothelial cells and their basal lamina. The endothelial cells form a tube just large enough to allow the passage of red blood cells one a time.

12. **Continuous (somatic) capillaries location and structure.** They found in muscle, lung, skin, connective tissue and central nervous system (CNS). They are continuous in the sense that the endothelial cells and basal lamina provide an uninterrupted lining, and they only allow smaller molecules, such as water and ions to pass through their intercellular clefts. In certain continuous capillaries, pericytes may be found in association with the endothelium. Numerous pinocytotic vesicles underlie both the luminal and basal plasma surfaces of the capillaries.

13. **Fenestrated (visceral) capillaries location and structure.** They found in endocrine glands and in the gallbladder and intestinal tract. Fenestrated capillaries are characterized by the presence of fenestrae in the walls of endothelial cells. That provides channels across the capillary wall. A continuous basal lamina is present. Fenestrated capillaries also have pinocytotic vesicles and pericytes.

14. **Discontinuous (sinusoidal) capillaries location and structure.** They found in the liver, spleen and bone marrow. They are larger and more irregularly shaped than other capillaries. They have unusually wide gaps (fenestrae) between endothelial cells, as in the liver and spleen; partial of total absence of basal lamina underlying the endothelium and presence of specialized cells, such as the stellate sinusoidal macrophages (Kupffer cells) and vitamin A storage cells (of Ito) in the liver, among the lining endothelial cells.

15. **Capillaries functions**. **Selective permeability**. The movement of large molecules from the blood to the tissues and from the tissues to the blood is related to the size and charge of the molecules. **Synthetic and metabolic activities**. Endothelial cells are involved in a number of synthetic activities, such as production of prostacyclin, plasminogen activator and others. **Antithrombogenic function**. Endothelial cells produce anticoagulants and antithrombogenic agents.

16. **Arteriovenous anastomosis (shunts).** They allow blood to bypass capillaries by providing direct routes between arteries and veins. The shunt vessel may be straight or coiled, possesses a thick muscular coat, and is under the influence of sympathetic nervous system. Shunts of **simple structure** are found in the skin of nose, lips, fingertips and external ear. They are also common in the in the erectile tissue of the penis and clitoris. Contrary to the ordinary precapillary sphincter, contraction of the arteriole smooth muscle of the AV shunt sends blood to a capillary bed; relaxation of the smooth muscle sends blood to a venule, bypassing the capillary bed. AV shunts serve in thermoregulation at the body surface. Closing an AV shunt in the skin causes blood flow through the capillary bed, enhancing heat loss. Opening an AV shunt in the skin reduces the blood flow to the skin capillaries, thereby conserving body heat. In erectile tissue such as the penis, closing the AV shunt directs blood flow into the corpora cavernosa, initiating the erectile response.

In addition, preferential thoroughfares, the proximal segment of which is called a **metarteriole** (modified capillaries), also exist that allow some blood to pass more directly from arterioles and venules. Instead of a continuous tunica media, they have individual smooth muscle cells placed a short distance apart, each forming a **precapillary sphincter** that encircles the entrance to that capillary bed. Constriction of these sphincters reduces or shuts off blood flow through their respective capillary beds. These sphincters control the amount of blood passing through the capillary bed.

17. **Classification of veins.** Traditionally, veins are divided into three types on the basis of size. There are small veins or venules, further subclassified as postcapillary and muscular venules, medium veins and large veins. In Ukraine there is another classification. The last one is based on smooth muscle content, which development depends on veins location (hemodynamic condition) not diameter. There are two types of veins: muscular and non muscular veins.

18. **Muscular and non muscular veins.** Muscular veins don't have tunica media. They are represented by veins of retina, bones, spleen, placenta, dura and pia mater. Non muscular veins are subdivided into veins with strong and week development of muscle cells. Veins with strong development of muscle cells locate in the lower half of the body and lower limbs; veins with week development of smooth muscle cells locate in the upper half of the body and upper limbs.

19. **Venules structure.** Muscular venules are distinguished from postcapillary venules by the presence of a tunica media. Postcapillary venules receive blood from capillaries and possess an endothelial lining with its basal lamina and pericytes. Muscular venules are located distal to the postcapillary venules in the returning venous network. Whereas postcapillary venules have no true tunica media, the muscular venules have one or two layers of smooth muscle that constitute a tunica media and have a thin tunica adventitia.

20. **Medium veins structure.** The tunica intima consists of an endothelium with its basal lamina, a thin subendothelial layer with some smooth muscle cells, scattered among connective tissue elements, and, in some cases, a thin internal elastic membrane. The tunica media of medium sized veins contains circularly arranged smooth muscle cells and collagen fibers. The tunica adventitia is usually thicker than the tunica media and consists of longitudinally oriented bundles of smooth muscle cells, collagen fibers, and networks of elastic fibers.

21. **Large veins structure**. They have identical to medium veins structure. One exception is that the three tunics of the venous wall are most evident in medium-sized veins compared to the large veins.

22. **Difference between veins and arteries**

- Typically, veins have thinner walls than their accompanying arteries.
- The lumen of the vein is usually larger than that of the artery.
- The lumen of the vein is often collapsed, whereas the lumen of the artery is often patent.
- Many veins have valves.
- Adventitia is the thickest tunica in the veins and media in the arteries.
- The veins have more collagen fibers than elastic.
- Shape of the wall in the vein is irregular and in the artery is regular.

23. **Lymphatic vessels types and structure.** There is a set of vessels that circulates fluid, called **lymph**, through certain parts of the body. The lymphatic vessels are unidirectional, conveying fluid only from tissues to the bloodstream. The smallest lymphatic vessels are called **lymphatic capillaries**. Lymphatic capillaries converge into increasingly larger vessels, called **lymphatic vessels** that ultimately unite to form two main channels that empty into the blood vascular system by draining into the large

veins in the base of the neck. The largest lymphatic vessel, draining most of the body and emptying into the veins on the left side, is the **thoracic duct**. Other main channel is the **right lymphatic duct.** As lymphatic vessels become larger, the wall becomes thicker. The increasing thickness is due to connective tissue and bundles of smooth muscle. Lymphatic vessels possess valves that prevent backflow of the lymph, thus aiding unidirectional flow. Before lymph is returned to the blood, it passes through **lymph nodes**, where it is exposed to the cells of the immune system.

24.**Difference between lymph and blood capillaries**

Lymph capillaries	Blood capillaries
Wider irregular lumen.	Narrower regular lumen.
Blind ended, i.e. it begins by a blind end.	Has arterial and venous ends.
The endothelium is not fenestrated.	The endothelium may be fenestrated.
It lacks a well-developed basement membrane.	It has a well-developed basement membrane.
Lacks pericytes.	Has pericytes.
The outer surface of the endothelium is attached to the surrounding C.T. by anchoring fibers	No anchoring fibers.
Greater permeability which have to remove protein-rich fluid from the intercellular spaces	Smaller permeability

25. **General plan of the heart structure.** The heart is a pump with four chambers with valves that maintain a one-way flow of blood. The heart contains 4 chambers (two atria and two ventricles) through which blood is pump. Valves guard the exits of chambers, preventing the backflow of blood. An interatrial septum and an interventricular septum separate the right and left sides of the heart. The wall of the heart consists of three layers: epicardium, myocardium and endocardium. The heart is surrounded by the pericardium, which is often covered by highly variable amounts of adipose tissue. The pericardium has two layers: a tough external fibrous layer called the **fibrous pericardium** and a parietal layer of **serous pericardium** that lines its inner surface.

26. **Epicardium structure.** It consists of a layer of mesothelial cells on the outer surface of the heart and its underlying connective tissue. The blood vessels and nerves that supply the heart lie in epicardium and are surrounded by adipose tissue that cushions the heart in the pericardial cavity.

27. **Difference between cardiac and skeletal muscle. Myocardium**, the cardiac muscle, is the principal component of the heart.

Cardiac muscle	Skeletal muscle
formed by individual cardiac muscle cells	formed by muscle fiber
mononucleated	multinucleated
location of the nucleus in the center	location of nuclei under the plasma membrane (sarcolemma)
presence of intercalated disks (attachment between neighboring muscle cells)	absence of intercalated disks
presence of diad (T tubule and terminal cisternae)	presence of triad (T tubule and two terminal cisternae)
presence of juxtanuclear mitochondria	absence of juxtanuclear mitochondria
presence of cardiac conducting cells (Purkinje cells)	absence of cardiac conducting cells (Purkinje cells)

28. **Intercalated discs of myocardium.** The intercalated discs (densely staining cross-bands) represent the major site of attachment between cardiac muscle cells. The step-like appearance of the intercalated discs appears to be due to the presence of a **transverse component** that crosses the fibers at a right angle to the myofibrils and a **lateral component** that runs parallel to the myofibrils.

29. **Smooth endoplasmic reticulum and the T System.** The smooth endoplasmic reticulum (sER) of cardiac muscle is not as well organized as that of skeletal muscle. The smooth endoplasmic reticulum in cardiac muscle is organized into a single network per sarcomere, extending from Z disc to Z disc. The T tubules in cardiac muscle penetrate into the myofilament bundles at the level of the Z disc, between the ends the sER network. Thus, there is only one T tubule per sarcomere in cardiac muscle. The small terminal cisternae of the sER at the level of the Z disc interact with the T tubules to form a **diad**.

30. **Endocardium structure.** It consists of an inner layer of endothelium and subendothelial connective tissue, a middle layer of connective tissue and smooth muscle cells, and a deeper layer, also called the subendocardial layer of connective tissue that is continuous with the connective tissue of the myocardium. The impulse-conducting system of the heart is located in the subendothelial layer of the endocardium.

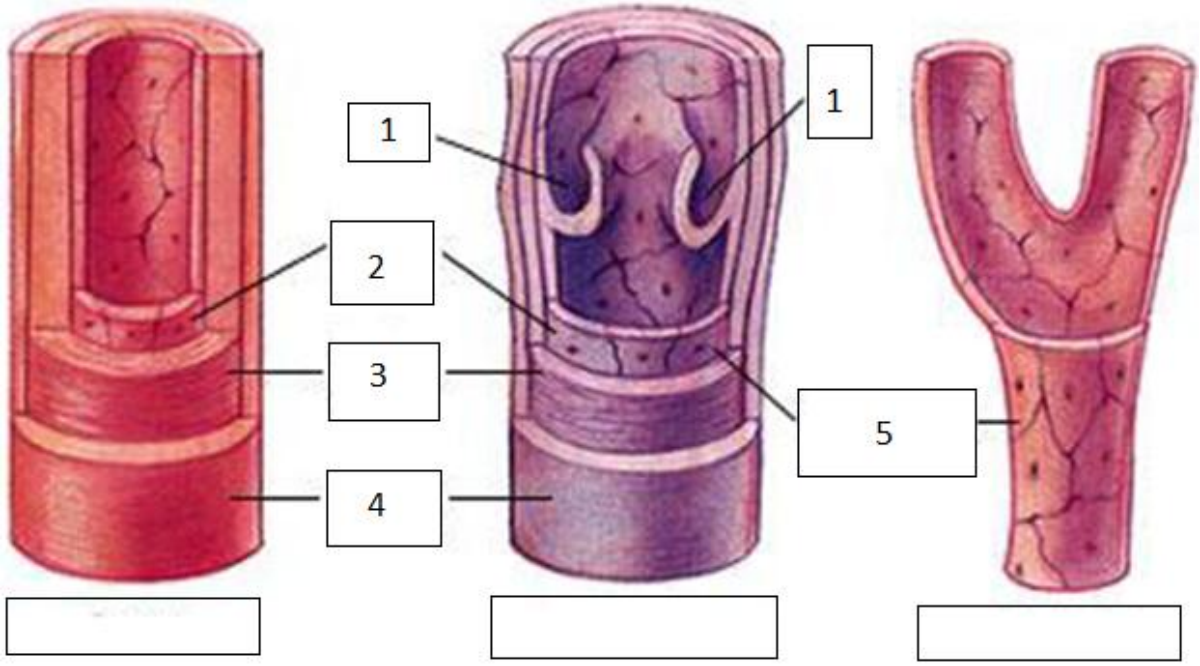
31. **Spontaneous contraction versus neural control.** Cardiac muscle cells exhibit a spontaneous rhythmic contraction or beat. In the heart, this beat is initiated, locally regulated, and coordinated by specialized, modified cardiac muscle cells that are organized into nodes and bundles to transmit the contractile impulse to various parts of the myocardium in a precise sequence. These cells, called **cardiac conducting cells (Purkinje cells),** and their functions.

32. **Intrinsic regulation of heart rate.** Cardiac muscle is capable of contracting in a rhythmic manner without any direct stimulates from the nervous system.

- The base of this beating action is initiated at the **sinoatrial (SA) node**, a group of specialized cardiac muscle cells located near the junction of the superior vena cava and the right atrium. The SA node is referred to as the **pacemaker**. The SA node initiates an impulse that spreads along the cardiac muscle fibers of the atria and along internodal tracts composed of modified cardiac muscle fibers.
- The impulse is then picked up at the **atrioventricular (AV) node** and conducted across the fibrous skeleton to the ventricles by the **AV bundle** (of His).
- The bundle divides into smaller right and left bundle branches and then into **Purkinje fibers.**
- The AV bundle, the bundle branches, and the Purkinje fibers are modified cardiac muscle cells that are specialized to conduct impulses.

PRACTICAL QUESTIONS

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



2. In the picture above identify the structure labeled 1.

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3. Identify the structure labeled 2.

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4. Identify the structure labeled 3.

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5. Identify the structure labeled 4.

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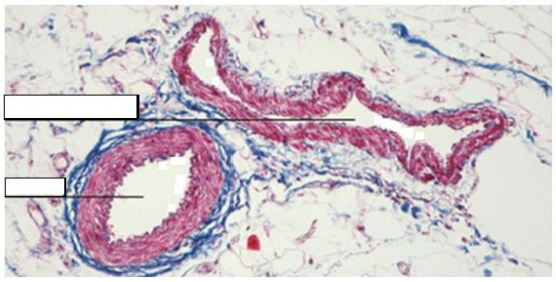
6. Identify the structure labeled 5.

_____

7. Fill in the white gaps with designations in the pictures below.



8. What differences between these two vessels in the picture above do you know?

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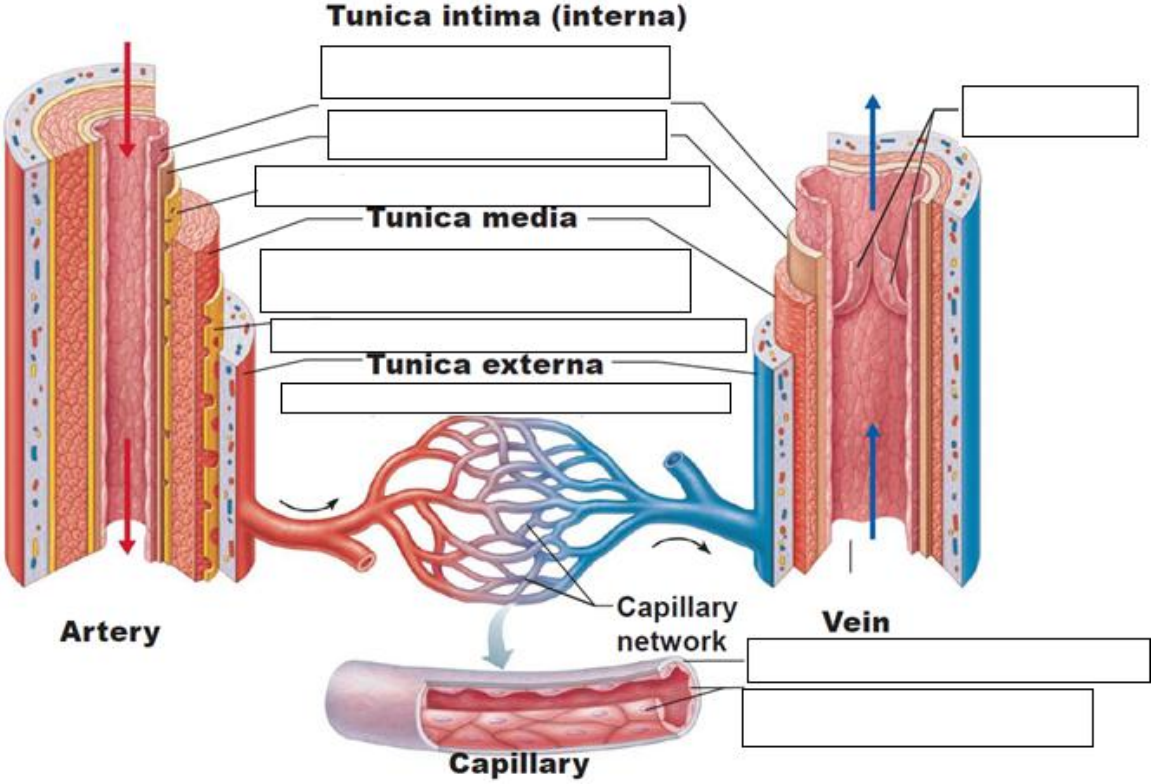
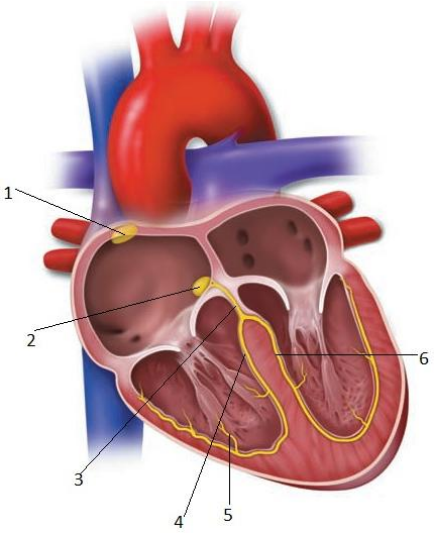
9. Fill in the white gaps with designations in the pictures below.





10. In this picture identify the structure labeled 1.

_____

11. Identify the structure labeled 2.

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12. Identify the structure labeled 3.

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13. Identify the structure labeled 4.

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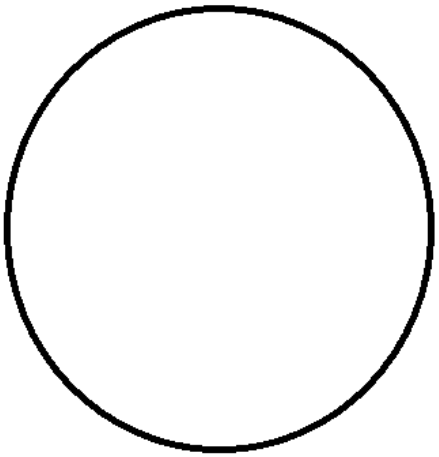
14. Identify the structure labeled 5.

_____

15. Identify the structure labeled 6.

_____

SLIDE 1

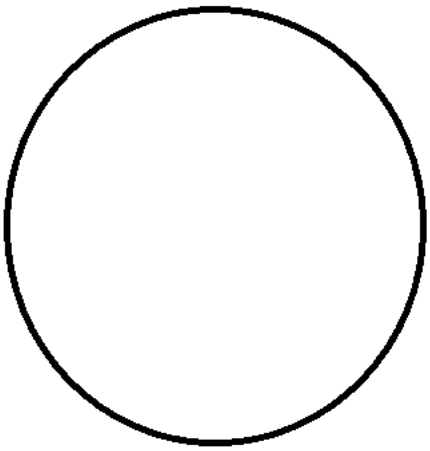


Microvascular bed
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Arteriole
2. Venule
3. Capillary

SLIDE 2

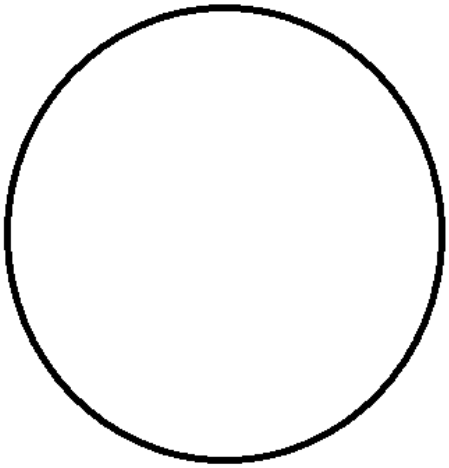


Aorta
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Tunica intima
   a. Endothelial layer
   b. Subendothelial layer
2. Tunica media
3. Tunica adventitia
4. Vasa vasorum

SLIDE 3

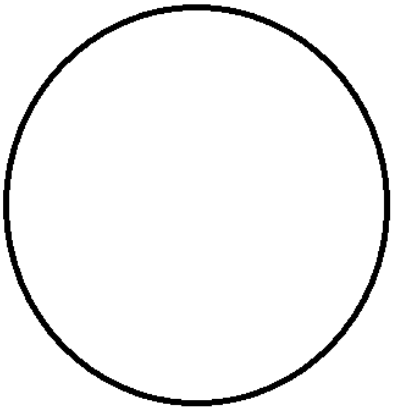


Vein
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Tunica intima
   a. Endothelial layer
   b. Subendothelial layer
2. Tunica media
3. Tunica adventitia
4. Smooth muscle cells
5. Vasa vasorum

SLIDE 4



Wall of the heart

Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Endocardium
   a. Endothelial layer
   b. Subendothelial layer
2. Myocardium
   c. Individual cardiac muscle cells
   d. Purkinje cell
   e. Intercalated disks

TESTS OF THE "KROK-1" DATABASE

Tunica media consists of 1-2 layers of smooth muscle cells which have spiral orientation in the slide of the vessel of microvascular bed. Tunica adventitia is a thin, sheath of loose connective tissue. What vessel is it?
A. *Arteriole
B. Venule
C. Capillary
D. Postcapillary
E. Arterio-venous shunt

A histological specimen represents an artery. One of the membranes of its wall has flat cells lying on the basal membrane. What type of cells is it?
A *Endothelium
B Mesothelium
C Smooth myocytes
D Fibroblasts
E Macrophages

Large arteries during systole stretch out and return in previous condition during diastole providing stability of bloodstream. What elements of vessel wall will explain this?
A. *Elastic fibers
B. Muscle fibers
C. Reticular fibers
D. Collagen fibers
E. Large amount of fibroblasts

Wall of the vessels often have huge morphological difference in the structure of the tunica media. What is the reason of appearance such specific peculiarities in the structure of this tunica in different vessels?
A. *Hemodynamic condition
B. Influence of endocrine system organs
C. Regulation from central nervous system
D. Inductive influence of vegetative ganglion neurons
E. Large content of catecholamines in the blood

A histological specimen shows a blood vessel. Its inner coat is composed by endothelium, subendothelium and internal elastic membrane. The middle coat is enriched with smooth myocytes. Such morphological characteristics are typical for the following vessel:
A *Muscular-type artery
B Elastic-type artery
C Capillary
D Non-muscular vein
E Muscular-type vein

Fenestrae between endothelial cells and partial or total absence of basal lamina underlying the endothelium are revealed in the electron micrograph of a capillary. What type of capillary is it?
A. *Sinusoidal
B. Somatic
C. Visceral
D. Atypical
E. Shunt

Multiple capillaries with penetrated through their walls mature blood cells were revealed in the microspecimen of the red bone marrow. What type of capillaries is it?
A *Sinusoidal
B Fenestrated
C Somatic
D Visceral
E Lymphatic

The artery is presented in the histological specimen. Squamous cells that lying on the basement membrane are defined in one of the layer of its wall. Name this type of cells.
A *Endothelium
B Mesothelium
C Smooth muscle cells
D Fibroblasts
E Macrophages

About 50 thick membranes have been detected in a histological specimen of tubular organ dyed with orcein. They have wiggly appearance and formed tunica media of this organ. Name this organ.
A. *Aorta
B. Muscular artery
C. Esophagus
D. Trachea
E. Heart wall

Vessels which have thick layer of smooth muscle cells in the tunica media were revealed during investigation of skin bioptat in the derma. What is the name of these vessels?
A. *Muscular artery
B. Capillaries
C. Arterioles
D. Venules
E. Arterio-venous shunts

In the vessel slide one found prominent internal and external elastic membranes and a lot of smooth muscle cells in the tunica media. What type of vessel is it?
A. *Muscular artery
B. Small artery (mixed)
C. Large vein (muscular)
D. Elastic artery
E. Extraorganic lymphatic system

Fragment cells which rests on the basal membrane and connected with each other by means of desmosomes and zonulae occludentes revealed in an electron micrograph of a tunica intima. Name these cells.
A. *Endothelium
B. Mesothelium
C. Epidermis
D. Epithelioreticular cells
E. Macrophages

Tunica intima of a vessel is lined with epithelium from within. What epithelium is this?
A. *Endothelium
B. Mesothelium
C. Epidermis
D. Transitional epithelium
E. Pseudostratified epithelium

Wall blood clot was revealed in the blood vessel in the patient during an X-ray isotope scanning. Damaging of what epithelium leads to the clotting formation?
A. *Endothelium
B. Mesothelium
C. Simple cuboidal epithelium
D. Simple columnar epithelium
E. Stratified squamous epithelium

A 45-year-old patient had a heart attack, which was accompanied by intensive squeezing retrosternal pain that lasted more than 30 minutes, radiated to the lower jaw, left arm under the left shoulder scapula and did not pass after taking nitroglycerin during physical activity. Subendocardial myocardial infarction was diagnosed in the clinic. Which structures have undergone specific changes in the first place in this case?
A. *Endothelium
B. Fibroblasts
C. Myocytes
D. Fibrocytes
E. Macrophages

The endothelial cell is presented in the electron micrographs. There are pores that are bridged by a diaphragm in the cytoplasm of this cell. Which vessel has such endothelial cell?
A. *Fenestrated capillaries
B. Somatic capillaries
C. Sinusoidal capillaries
D. Artery
E. Vein

Preparation of the aorta was investigated in the corpse of 74-year-old man. What age-related changes can be detected in the aortic wall?
A. *The growth of the collagen fibers in the tunica intima and tunica media
B. The growth of elastic fibers in the tunica media
C. Proliferation of smooth muscle cells in the tunica media
D. Hypertrophy of smooth muscle cells in the tunica media
E. Proliferation of endothelial cells

A piece of the soft tissue of the thigh was investigated in the experiment of the animal in two weeks after incision through the skin and muscles. Newly formed blood vessels were revealed. Which structures of the vascular wall provide the formation of capillaries in the area of injury?
A. *Proliferation of endothelial cells
B. Proliferation of pericytes
C. Proliferation of adventitial cells
D. Hypertrophy of fibroblasts
E. Proliferation of smooth muscle cells

Which vessels have the highest total surface area that creates optimal conditions for bilateral exchange of substances between tissues and blood?
A. *Capillaries
B. Arteries
C. Veins
D. Arterioles
E. Venules

The patient has aortic aneurysm. Which of the following structures of the aortic wall wil be damaged?
A. *Elastic membranes
B. Endothelium
C. Subendothelial layer
D. Smooth muscle cells
E. Tunica adventitia

Short capillary-type vessels that connected arterioles and venules are visible in a histological specimen. What is the name of these anastomoses?
A. *Hemishunts
B. Genuine simple shunt
C. Genuine anastomoses secured the contractile structures
D. Genuine simple epitheliod-type
E. Genuine complex epitheliod-type anastomoses

Ultrasound examination of the patient revealed the damage of the wall of arteries of elastic type. Which function of the vessels may be violated?
A *Transportation of blood
B Participation in the formation of tissue fluid
C Regulation of blood supply to organs
D Ensuring nutrition of organs and tissues
E Drainage function

There is a capillary in electron micrographs of the organ. There are numerous thinning of the cytoplasm in the endothelium of this capillary. The basement membrane is continuous. Which organ has this capillary?
A *Hypophysis
B Cerebral cortex
C Liver
D Spleen
E Skeletal muscle

The histological specimen of the vessel with dominating elastic fibers which form fenestrated membranes in the middle layer was presented for medical examination. Obliquely oriented myocytes are well expressed between the elastic membranes. Name the vessel from which it was prepared the histological specimen.
A. *Pulmonary artery
B. Renal artery
C. Capillary
D. Femoral vein
E. Vena cava inferior

One of the malformations of the cardiovascular system - cleft arterial duct (patent ductus arteriosus) was revealed in a one-year-old child. Name the place of its localization.
A. *The vessel connecting the pulmonary artery and aorta
B. Interatrial septum
C. Interventricular septum
D. The vessel connecting the umbilical cord and the vena cava inferior
E. The vessel connecting the portal vein and vena cava inferior

One can see that the structure of the wall of arteries significantly differs from the structure of the wall of veins during the study of histological specimen of blood vessels. What cause these differences?
A. *Different hemodynamic conditions
B. The different in diameter
C. The different in length
D. Different functions
E. Different distance from the heart

What type of capillaries is characteristic for the microvascular bed of the hematopoietic organs?
A. *Discontinuous capillaries
B. Fenestrated capillaries
C. Somatic capillaries
D. Continuous capillaries
E. Lacunes

The inner surface of the blood vessels is covered with an epithelium that synthesizes substances that prevent the blood clotting in vessels. What kind of epithelium is this?
A *Simple squamous epithelium (endothelium)
B Stratified squamous nonkeratinized epithelium
C Stratified squamous keratinized epithelium
D Simple squamous epithelium (mesothelium)
E Simple pseudostratified columnar epithelium

The contraction of smooth muscle cells of arterioles occurs upon admission into the blood of epinephrine from the adrenal medulla. What features of the structure have these cells?
A * Presence of perforations in the basement membrane and inner elastic membrane
B A single location of smooth muscle cells
C Presence of effector endings on pericytes
D Presence of contacts between endothelium and pericytes
E Presence of narrowing in the place of origin of capillary from arterioles due to the circularly arranged smooth muscle cells

During the systole aorta is stretched out and returns to its original state during diastole, thus providing stability to the blood stream. What structural elements of the vessel wall provide it?
A *Elastic membranes
B Muscle fibers
C Reticular fibers
D Collagen fibers
E A large number of fibroblasts

A large number of elastic fibers in all layers and fenestrated elastic membranes in the tunica media are detected in the wall of the blood vessel. What factors contribute to these structural features of blood vessels?
A *High blood pressure
B Low blood pressure
C High speed of blood flows
D Low speed of blood flows
E Osmotic pressure

I.M. Sechenov called arterioles “taps” of the cardiovascular system. What structural elements provide this function of arterioles?
A *Circular oriented muscle cells
B Longitudinal oriented muscle cells
C Elastic fibers
D Longitudinal oriented muscle fibers
E Collagen fibers

Cells with uneven wavy edges were revealed as a result of impregnation with silver salts of tunica intima of blood vessel. Name these cells.
A *Endothelial cells
B Stellate cells
C Myocytes
D Fibroblasts
E Adipocytes

The venom of spiders and snakes that contained hyaluronidase easily penetrates through the wall of capillaries. What structural component is associated with permeability of capillary walls?
A *Basement membrane
B Fenestrae
C A layer of glycoproteins which covered endothelial cells
D Pericytes
E Adventitial cells

The patient with hypertension has increase in pressure up to 180/100 mm Hg. What receptors in the wall of the vessel are embraced this change?
A *Mechanoreceptors
B Osmoreceptors.
C Chemoreceptors.
D Thermoreceptors.
E Photoreceptors.

Arterioles play an important role in the blood supply of the organs functional units. Which of these structures perform this function?
A *Myocytes
B External elastic membrane
C Internal elastic membrane
D Special connective tissue cells
E Endothelial

From 40 to 60 fenestrated elastic membranes were found at the histological preparations stained by the orcein. Name this vessel.
A *Artery of elastic type
B Artery of muscular type
C Artery of mixed type
D Vein of muscular type
E Vein of unmuscular type

The contraction of the smooth muscle cells of arterioles occurs after the adrenalin releasing from the adrenal medulla into the blood. What are the features of these vessels structure?
A * Availability of perforations in the endothelium basement membrane and the internal elastic membrane
B Single position of the smooth muscle cells
C Presence of the effector endings on the pericytes
D Presence of the contacts between the pericytes
E Availability of precapillary sphincters

Obliterating atherosclerosis causes changes in the vessels of the lower extremities. A histological specimen of such vessel evidently presents both internal and external elastic membranes; middle membrane contains a lot of smooth muscle cells. What vessel is affected in case of this disease?
A *Artery of muscular type
B Artery of elastic type
C Artery of mixed type
D Vein with strongly developed muscles
E Lymph node

Intralobular capillaries of a liver specimen have wide irregular lumen. Basal membrane is absent in the major part of the capillary. What type of capillaries is it?
A *Sinusoidal
B Visceral
C Somatic
D Precapillaries
E Postcapillaries

A histological specimen shows a blood vessel. Its inner coat is composed by endothelium, subendothelium and internal elastic membrane. The middle coat is enriched with smooth myocytes. Such morphological characteristics are typical for the following vessel:
A *Muscular-type artery
B Elastic-type artery
C Capillary
D Non-muscular vein
E Muscular-type vein

An organ, the wall of which is formed by three tunics is determined in a histological specimen. The tunica intima consists of endothelium and a thin subendothelial layer. Tunica externa is the thickest. Which organ is represented in a histological specimen?
A. *****Vein
B. Artery
C. Urethra
D. Heart
E. Uterus

Blind ended vessels which have shape of oblate tubes are present in the histological slide. They don't have basal membrane and pericytes. The outer surface of the endothelium is attached to the surrounding connective tissue by anchoring fibers. What type of vessel is it?
A. *Lymph capillary
B. Blood capillary
C. Arterioles
D. Venules
E. Arterio-venous shunts

A histological specimen of spleen shows a vessel with a wall consisting of endothelium and subendothelial layer, tunica media is absent, and tunica adventitia attached to the layers of spleen connective tissue. What vessel is it?
A *Vein of non-muscular type
B Vein of muscular type
C Artery of muscular type
D Arteriole
E Capillary

Histological specimen presents a vessel the wall of which consists of endothelium, basal membrane and loose connective tissue. What type of vessel is it?
A *Vein of non-muscular type
B Artery
C Vein of muscular type
D Hemocapillary
E Lymphocapillary

A specimen of pia mater includes a vessel whose wall doesn't have the tunica media, the tunica externa is adherent to the surrounding tissues, the intima is composed of a basement membrane and endothelium. What vessel is it?
A *Nonmuscular vein
B Muscular vein with underdeveloped muscular elements
C Muscular artery
D Arteriole
E Artery of mixed type

A specimen of the pia mater shows a vessel without tunica media in its wall, its tunica adventitia adheres to the surrounding tissues, and the tunica intima is made up of the basal membrane and endothelium. Specify this vessel:
A *Fibrous vein
B Muscular vein with weakly developed muscular elements
C Muscular artery
D Arteriola
E Mixed artery

Morphological examination revealed in histological specimen of biopsy material an irregular-shaped vessel. Its middle layer is formed by bundles of smooth myocytes and layers of connective tissue. What type of vessel is it?
A *Vein of muscular type
B Artery of muscular type
C Lymphatic vessel
D Venule
E Arteriole

The medical examiner found the venous sinuses that are adherent to the surrounding tissues during the study of meninges of the brain. What type of veins is this?
A *Fibrous type of vein
B Veins with weak development of muscle elements
C Veins with middle development of muscle elements
D Veins with high development of muscle elements
E Venules

Thrombophlebitis of deep veins of the shin was revealed in a 63-year-old man. Which layer of these vessels is damaged?
A * Endothelial layer
B Subendothelial layer
C Layer of elastic fibers
D Layer of smooth muscle cells
E Connective tissue layer

The varicose veins of the lower extremities often develop in people who are forced to work standing for a long time. What caused changes in the structure of the walls of veins?
A *Weak development of elastic elements of the walls
B Weak development of striated muscle tissue
C Weak development of collagen fibers
D The thinning of the endothelial layer
E Weak development of reticular fibers

A histological specimen shows a blood vessel. Its inner coat is composed by endothelium and subendothelial layer. The middle coat consists of smooth muscle cells bundles. Tunica adventitia well developed and consists of loose connective tissue and some smooth muscle cells. Such morphological characteristics are typical for which vessel?
A *Muscular vein (large vein)
B Muscular artery
C Non-muscular vein
D Mixed artery (small artery)
E Elastic artery

During morphological investigation in a histological specimen one can see irregularly shaped vessel tunica media of which formed by bundles of smooth muscle cells and layer of connective tissue. What type of vessel is it?
A *Large vein (muscular type)
B Muscular artery
C Lymphatic vessel
D Venule
E Arteriole

The epithelial tumor of pericardium was diagnosed at a 53-year-old patient. What kind of epithelium was the source of this tumor?
A *Simple squamous
B Simple pseudostratified
C Transitory
D Stratified keratinizing
E Stratified non-keratinizing

Large cells with light cytoplasm and eccentrically located nucleus are revealed in the histological specimen of the heart wall between endocardium and myocardium. What kind of the heart cells have following morphologic signs?
A. *Purkinje cells
B. Pacemaker cells
C. Cardiac muscle cells
D. Endocrine cells
E. Adipose cells

Concentration of calcium is increased in sarcoplasma of cardiac muscle cells during myocardium contraction. Which structure participate in calcium storage
A. *L systems
B. Lysosomes
C. Ribosomes
D. T-systems
E. Nucleolus

As a result of thrombosis of left coronary artery the group of contractive cardiac muscle cells have been destroyed. At the expense of which cells reparation in the area of damage will occur?
A. *Fibroblasts
B. Cardiac muscle cells
C. Myosymplast
D. Myosatelitocytes
E. Smooth muscle cells

There are detected cells of squared shape, 80-120 micrometers in size, with a centrically positioned nucleus and well-developed myofibrils connected with the help of intercalated discs in a heart specimen. What function is connected with these cells?
A. *Heart contraction
B. Nerve impulses conduction
C. Endocrine
D. Protective
E. Regenerative

In a slide revealed organ of cardio-vascular system. One of it coats is build by fibers which formed anastomosis between each other. They formed by cells which connected with the help of intercalated disks. Name this organ of cardio-vascular system.
A. *Heart
B. Large vein (muscle type)
C. Muscle artery
D. Elastic artery
E. Arteriole

In a histological specimen is represented heart wall. In one of its layers are found contractive, conducting and secretory muscle cells, endomysium and blood vessels. Which layer of the heart is it?
A. *Myocardium of the atrium
B. Endocardium of the ventricles
C. Epicardium
D. Adventitia
E. Pericardium

Morphological structure of the heart wall was restored after myocardial infarction. At the expense of which tissue did regeneration occur?
A. *Connective
B. Smooth muscle
C. Striated muscle
D. Epithelial
E. Nervous

A 40 year-old patient had myocardial infarction of left ventricle. What morphological components of the heart wall will replace this damage?
A. *Proliferation of connective tissue cells
B. Intracellular regeneration of contractive cardiac muscle cells
C. Proliferation of contractive cardiac muscle cells
D. Proliferation of conducting cells
E. Proliferation of contractive cardiac muscle cells and conducting cells

A 55-year-old patient consults a cardiologist with complaints about abnormal heart rhythm. What structures of the heart are damaged in this case?
A. *Cardiac conducting cells
B. Contractile cardiomyocytes
C. Coronary vessels
D. Heart valves
E. -

The myocardium does not receive arterial blood during the systole. Which inclusions of cardiomyocytes provide delivery of oxygen to them?
A. *Pigment.
B. Trophic.
C. Excretory.
D. Secretory.
E. Incretors.

A 45-year-old patient consults a doctor with complaints about leg swelling and pain. Varicose veins and redness of the skin were observed during the examination. What structures of the subcutaneous veins have changed most likely?
A. *Valves
B. Endothelium
C. Smooth muscle cells
D. Vasa vasorum
E. Collagen fibers

Impaired development of the myocardium of the ventricle was diagnosed in a newborn child. What embryonic source have impaired development in this pathology?
A. *Myoepicardial plate.
B. Parietal splanchnopleura
C. Entoderm
D. Ectoderm
E. Mesenchyma

Portion of the heart muscle was injured as a result of myocardial infarction. It was accompanied by massive loss of cardiomyocytes. What cells will provide the substitution of the formed defect in the structure of the myocardium?
A. * Fibroblasts
B. Cardiomyocytes
C. Satellite cells
D. Epithelial cells
E. Smooth muscle cells

There are several layers in the wall of blood vessels and the heart wall. Which of the layers of the heart is similar to the wall of blood vessels in histogenesis and tissue structure?
A. *Endocardium
B. Myocardium
C. Pericardium
D. Epicardium
E. Epicardium and myocardium

Accumulation of fluid in the pericardium is observed in the patient with pericarditis. Which cells of the pericardium have violated activity?
A. *Mesothelium cells
B. Endothelial cells
C. Smooth muscle cells
D. Fibroblasts
E. Macrophages

One of walls of the heart is similar in the histogenesis and tissue structure to the blood vessel walls. What is its source of development?
A. *Mesenchyma
B. Splanchnotom
C. Entoderm
D. Ectoderm
E. Somites

Changes in cardiomyocytes were revealed during microscopic examination of the heart of a dead fetus. Development disorder of what source leads to this changes?
A. * Myoepicardial plate
B. Myotom
C. Entoderm
D. Ectoderm
E. Mesenchyma

One distinguishes star-shaped cardiomyocytes with a centrally located nucleus, developed rough endoplasmic reticulum, Golgi apparatus and specific granules in a histological specimen of the

heart. What function is provided by these cells?
A. *Endocrine function
B. Contraction
C. Conduction of impulses
D. Protective function
E. Regenerative function

One of the organs of the cardiovascular system is built of cells that are connected to each other by intercalated discs. Name this organ.
A *Heart
B Muscular type of vein
C Mixed type of artery
D Muscle type of artery
E Aorta

Branched cells containing few organelles but well developed rough endoplasmic reticulum and secretory granules are visible in electron micrographs of the myocardium. Name these cells.
A *Secretory cardiomyocetes.
B Ventricular cardiomyocytes.
C Pacemaker cells.
D Transitional atypical cells.
E Cells of the AV bundle (of His).

One can see elongated cells with a small number of randomly located organelles and myofibrils and peripherally positioned nucleus in a histological specimen of the heart wall under the endocardium. Name these cells.
A. *Striated muscle cells
B. Contractile cardiomyocytes
C. Secretory cardiomyocytes
D. Smooth muscle cells
E. Cardiac conducting cells

Cardiomyocytes form the main part of the myocardium in a histological specimen of the heart wall. They form muscle fibers due to intercalated discs. What type of junction provides electrical connection of neighboring cells?

A. *Gap junction.
B. Desmosomes.
C. Hemidesmosomes.
D. Zonula occludens.
E. Simple contact.

There are atrial cardiomyocytes that produce natriuretic factor, which relax smooth muscle cells of the wall of blood vessels and inhibit the secretion of aldosterone and vasopressin among various types of cardiomyocytes. What type of cardiomyocytes is this?
A *Secretory cardiomyocytes
B Atypical cardiomyocytes
C Typical cardiomyocytes
D Fibrous cardiomyocytes
E -

It is known that the contractile cardiomyocytes are interconnected with intercalated disks in the formation of which involved the junctions of three types. Indicate the correct answer.
A *Desmosomes, gap junction, zonula adherens
B Adherent junction, desmosome
C Synapse, desmosome, zonula occludens
D Synapse, desmosome, gap junction
E Zonula occludens, gap junction, zonula adherens

In a 45-year-old patient a doctor by EKG identified a violation of the synchronism of the cardiac cycle phases, the rapid conduction of excitation through myocardium. Which of the following structures that provide electrical connections between cardiomyocytes are damaged?
A. *Gap junction.
B. Hemidesmosomes.
C. Places of interweave of myofiblils in sarcolema.
D. Intercalated disk.
E. Simple adherent junction.

A distinguish feature of the structure of Pacemaker cells of the cardiac conducting system is:
A. *Presence of a large amount of free calcium in the cytoplasm of cells
B. Presence of T-systems
C. Presence of a large number of myofibrils
D. Compact arrangement of myofilaments in the structure of myofibrils
E. Presence of a large number of mitochondria

Cells which are arranged in the form of light bands have a small number of myofibrils and inclusions of glycogen are determined In a histological specimen of the heart. These cells belong to:
A. *AV bundle (of His)
B. Pacemaker cells
C. Conduction transitional cells
D. Endocrine cells
E. Contractile cells

Myocardiodystrophy is accompanied by a violation of the metabolism of cardiomyocytes. What source of development is damaged in this pathology?
A. *Myoepicardial plate

B. Myotom
C. Entoderm
D. Ectoderm
E. Mesenchyma

Myoepicardial plate was damaged in embryo. What tissue will undergo the impaired development?
A. *Cardiac muscle tissue
B. Connective tissue
C. Smooth muscle tissue
D. Skeletal muscle tissue
E. Epithelial tissue

The disorder of heart rhythm (the rhythm is not sinus) on the electrocardiogram was revealed in 32-year-old woman after suffering from myocarditis. What cardiomyocytes have impaired function?
A. *Pacemaker cells
B. Contractile cardiomyocytes
C. Conducting transitional cardiomyocytes
D. Cardiac conducting cells of AV bundle
E. -

A 54-year-old patient has a disorder of heart rhythm. What cells of the heart are affected?
A. *Pacemaker cells
B. Conducting transitional cells
C. Purkinje fibers
D. Typical cardiomyocytes
E. Secretory cardiomyocytes

Intensive therapy was performed to the patient with myocardial infarction in the intensive care unit. Prognosis to the future myocardial function is poor. What can be the reason?
A. *Violation of the structure of smooth myocytes of the myocardium
B. Violation of the structure of contractile cardiomyocytes
C. Violation of the structure of myofibroblasts of the myocardium connective tissue
D. Violation of the structure of myosimplast of the myocardium
E. Changes in the structure of connective tissue of the myocardium

Impaired development of the ventricle myocardium was diagnosed to a newborn child. What source of embryonic development is violated in this pathology?
A. *Visceral splanchnopleura
B. Parietal splanchnopleura
C. Entoderm
D. Ectoderm
E. Mesenchyma

The pathology of the valvular apparatus of the inner lining of the heart is revealing in the patient with endocarditis. What tissues form the valves of the heart?
A. *Dense connective tissue, endothelium
B. Loose connective tissue, endothelium
C. Cardiac muscle tissue, endothelium
D. Hyaline cartilage, endothelium
E. Elastic cartilage, endothelium

The heart block occurred as a result of myocardial infarction. Atria and ventricles contracted asynchronously. What structures were damaged?
A. *Cells of AV bundle (of His)
B. Pacemaker cells of sinus-atrial node
C. Contractile myocytes of ventricles
D. Nerve fibers of nervus vagi
E. Sympathetic nerve fibers

A 45-year-old patient had a heart attack, which was accompanied by intensive squeezing retrosternal pain that lasted more than 30 minutes, radiated to the lower jaw, left arm under the left shoulder blade and did not pass after taking nitroglycerin, during physical activity. Subendocardial infarction was diagnosed. What structures have undergone specific changes in the first place in this case?
A *Endothelium
B Fibroblast
C Myocytes
D Fibrocytes
E Macrophages

The death of the group of contractile cardiomyocytes (myocardial infarction) occurred as a result of thrombosis of the left coronary artery. What mechanism will ensure the regeneration in the damaged area?
A. *Proliferation and secretory activity of fibroblasts
B. Proliferation of surviving cardiomyocytes
C. Proliferation of myosymplast
D. Proliferation and secretory activity of myosatellitocytes
E. Proliferation of smooth muscle cells

The total weight of the myocardium differs in several times in children and in adults. What is the basic process that provides an increase of the weight of myocardium with age?
A. *Polyploidy of cardiomyocytes
B. Division of cardiomyocytes
C. Activation of macrophages
D. Proliferation of fibroblasts
E. Proliferation of smooth muscle cells

The fibers of the myocardium composed of cells which in places of connections form intercalated discs. What tissue forms this layer?
A * Cardiac muscle tissue
B Skeletal muscle tissue
C Smooth muscle tissue
D Loose connective tissue
E Dense irregular connective tissue

A 56-year-old patient consulted a doctor with complaints about shortness of breath, palpitations, swelling of hands and feet. She was diagnosed with congestive heart failure as a result of violation of trophism of cardiac muscle. What intercellular structures provide storage of trophic material in physiological conditions?
A *Glycogen, lipids
B Smooth endoplasmic reticulum
C Rough endoplasmic reticulum
D Pynocytosic vesicles
E T -system

Atrioventricular block associated with a violation of conducting electrical impulses to the working cardiomyocytes of the ventricle was revealed in the patient during ECG-examination. What structural components of cardiac muscle tissue provide a consistent contraction in the working cardiomyocytes of atria and ventricles?
A *Cardiac conducting cells
B Pacemaker cells
C Nerve fibers
D Collagen fibers
E Contractile cardiomyocytes

The patient was admitted to the hospital with tangential gunshot wound of the pericardium. What kind of epithelium is damaged as a result of injury?
A *Simple squamous epithelium
B Simple columnar epithelium
C Simple cuboidal epithelium
D Stratified squamous keratinized epithelium
E Stratified squamous nonkeratinized epithelium

Visceral layers of mesoderm adjacent to the mesenchyme tube were destroyed in the experiment the animal embryo. What structures of the heart will undergo impaired development?
A *Myocardium and epicardium
B Myocardium and endocardium
C Epicardium and endocardium
D Endothelium of the endocardium
E Mesothelium of the epicardium

A 56-year-old patient consulted a doctor with complaints about shortness of breath, palpitations, swelling of hands and feet. She was diagnosed with congestive heart failure as a result of violation of trophism of cardiac muscle. What intercellular structures provide storage of trophic material in physiological conditions?
A *Glycogen, lipids
B Smooth endoplasmic reticulum
C Rough endoplasmic reticulum
D Pynocytosic vesicles
E T-system

LYMPHATIC TISSUES AND ORGANS

Checking your primary level of the knowledge:

1. Classification of hematopoietic and immune defense organs.
2. Thymus development, age and accidental involution of the thymus.
3. General architecture of the thymus.
4. Thymic cortex structure.
5. Epithelioreticular cell functions in the cortex.
6. Thymic medulla structure.
7. Epithelioreticular cell functions in the medulla.
8. Blood–thymus barrier structure and function.
9. The thymus and T-cell education.
10. Structure and functions of the red bone marrow.
11. How does red bone marrow transform with age?
12. Diffuse lymphatic tissue and lymphatic nodules.
13. Lymph node structure.
14. Cells of the reticular meshwork.
15. General architecture of the cortex and paracortex.
16. General structure of the medulla.
17. Lymph sinuses.
18. Functions of the lymph node.
19. General structure of the spleen.
20. White pulp structure.
21. Red pulp structure.
22. Blood supply of the spleen.
23. Functions of the spleen.
24. Nonspecific (innate) and specific (adaptive) defenses.
25. Notion about antigen, antibody, cell mediated and humoral immunity; primary and secondary immune response and active and passive immunity.

Standard answers for theoretical questions

1. Classification of hematopoietic and immune defense organs. The lymphatic system consists of groups of cells, tissues, and organs that monitor body surfaces and internal fluid compartments and react to the presence of potentially harmful substances. Included in this system are the **diffuse lymphatic tissue**, **lymphatic nodules**, **lymph nodes**, **spleen**, **bone marrow**, and **thymus**. The various lymphatic organs and lymphatic tissues are often collectively referred to as the **immune system**. **Central organs** of hematopoiesis and immune defense are thymus and red bone marrow. **Peripheral organs** of hematopoiesis and immune defense are spleen, lymph nodes and solitary lymphatic nodules.

2. Thymus development. The thymus is a bilobed organ located in the superior mediastinum, anterior to the heart and great vessels. It develops bilaterally from the third (and sometimes also the fourth) branchial pouch. The thymus is fully formed and functional at birth. It persists as a large organ until about the time of puberty when T-cell differentiation and proliferation are reduced and most of the lymphatic tissue is replaced by adipose and connective tissue (**age involution**). Hassall's corpuscles last longer. There is also **accidental involution** of the thymus. In case of infections, intoxications, famine and trauma mass damage of lymphocytes are happened under action of the corticosteroid, and also amount and size of Hassall's corpuscles is increased.

3. General architecture of the thymus. The thymus possesses a thin connective tissue **capsule** from which **trabeculae** extend into the parenchyma of the organ. The capsule and trabeculae contain blood vessels, efferent lymphatic vessels, and nerves. In addition to collagen fibers and fibroblasts, the connective tissue of the thymus contains variable numbers of plasma cells, granulocytes, lymphocytes, mast cells, adipose cells, and macrophages. The structural and functional unit of the thymus is **thymic lobule**. Each of thymic lobule contains cortex and medulla. A connective tissue capsule surrounds the cortex and extends trabeculae to the margin of the cortex and medulla to form domains.

4. Thymic cortex structure. The outer portion of the parenchyma, the **thymic cortex**, is markedly basophilic because of the closely packed developing T lymphocytes with their intensely staining nuclei. These T lymphocytes, also called **thymocytes**, occupy spaces within an extensive meshwork of **epithelioreticular cells**. Epithelioreticular cells have features of both epithelial and reticular cells. They provide a framework for the developing T cells; thus, they correspond to the reticular cells and their

associated reticular fibers in other lymphatic tissues and organs. Epithelioreticular cells exhibit certain features characteristic of epithelium. **Macrophages** also reside within the thymic cortex and are responsible for phagocytosis of T cells that do not fulfill thymic education requirements. These T cells are programmed to die before leaving the cortex. Approximately 98% of the T cells undergo this apoptosis and are then phagocytosed by the macrophages. These cells have numerous large lysosomes.

5. **Epithelioreticular cell functions in the cortex.**

- Epithelioreticular cells isolates developing T cells from the connective tissue of the organ – that is, capsule, trabeculae, and perivascular connective tissue.
- They involved in thymic cell education.
- They create a functional barrier between the cortex and medulla.

6. **Thymic medulla structure.** The thymic medulla, the inner portion of the parenchyma, contains a large number of epithelioreticular cells and loosely packed T cells. The medulla stains less intensely than the cortex because, it contains mostly large lymphocytes. These lymphocytes have pale-staining nuclei than small lymphocytes. **Thymic** or **Hassall's corpuscles** are a distinctive feature of the thymic medulla.

7. **Epithelioreticular cell functions in the medulla.**

- They create the barrier between the cortex and medulla.
- Processes of adjacent epithelioreticular cells provide the cellular framework of the medulla and compartmentalize groups of lymphocytes.
- They form the **thymic (Hassall's) corpuscles**. Thymic corpuscles are isolated masses of closely packed, concentrically arranged epithelioreticular cells that contain **keratohyalin granules**, bundles of cytoplasmic intermediate filaments, and lipid droplets. Thymic corpuscles are unique, antigenically distinct, and functionally active multicellular components of the medulla. It is thought that thymic corpuscles produce interleukins that function in thymic differentiation and education of T lymphocytes.

8. **Blood–thymus barrier structure and function.** Lymphocytes reaching the thymic cortex are prevented from contact with antigen by a physical barrier called the **blood–thymus barrier**. The following components constitute the blood–thymus barrier between the T cells and the lumen of cortical blood vessels, from the lumen outward:

The continuous **endothelium** lining the capillary wall is **the first layer** of blood-thymus barrier. The underlying **basal lamina** of endothelial cells and occasional **pericytes** are **second layer** of this barrier. **Macrophages** residing in the surrounding **perivascular connective tissue** constitute **third layer** of this barrier. **Basal lamina** of the epithelioreticular cells is the fourth layer and finally **epithelioreticular cells** with their occluding junctions provide the last structural component of the blood–thymus barrier.

The blood thymic barrier forms a shield that prevents the contact between the high concentrations of antigens circulating in the blood and the developing immature lymphocytes in the thymic cortex.

9. **The thymus and T-cell education.** During fetal life, the thymus is populated by multipotential lymphoid stem cells that originate from the bone marrow and are destined to develop into immunocompetent T cells. Stem cell maturation and differentiation into immunocompetent T cells is called **thymic cell education**. The transformation of primitive or immature lymphocytes into T lymphocytes is promoted by a thymic humoral factor called thymosin. The thymic epithelioreticular cells produce this factor.

10. **Red bone marrow structure.** Red bone marrow lies entirely within the spaces of bone, medullary cavity of young long bones, and spaces of spongy bone. Bone marrow consists of specialized units of blood vessels called **sinusoids**, and a spongelike network of hemopoietic cells. The hemopoietic cells lie in "cords" between sinusoids or between sinusoids and bone. The sinusoid wall consists of an endothelial lining, a basal lamina, and an incomplete covering of adventitial cells. The **adventitial cell**, also called a **reticular cell**, sends sheetlike extensions into the substance of the hemopoietic cords, which provide some support for the developing blood cells. In addition, adventitial cells produce reticular fibers. In active **red bone marrow**, the cords of hemopoietic cells contain predominately developing blood cells and megakaryocytes. The cords also contain macrophages, mast cells, and some adipose cells. Clusters of developing erythrocytes surround and receive iron from macrophages in groupings called **erythroblastic islands**.

11. **How does red bone marrow transform with age?** Inactive bone marrow is called **yellow bone marrow**. In the bones of adult the red bone marrow has been replaced mostly completely by adipose tissue. The yellow bone marrow retains its hemopoietic potential, however, and when necessary, as after severe loss of blood, it can revert to red bone marrow, both by extension of the hemopoietic tissue into the yellow bone marrow and by repopulation of the yellow bone marrow by circulating stem cells.

12. **Diffuse lymphatic tissue and lymphatic nodules.** Diffuse lymphatic tissue and lymphatic nodules guard the body against pathogenic substances and are the site of the initial immune response. The alimentary canal, respiratory passages, and genitourinary tract are guarded by accumulations of lymphatic tissue that are

not enclosed by a capsule. Lymphocytes and other free cells of this tissue are found in the **lamina propria** of these tracts. This form of lymphatic tissue is called **diffuse lymphatic tissue** or **mucosa-associated lymphatic tissue (MALT)** because of its association with mucous membranes.

In addition to diffuse lymphatic tissue, localized concentrations of lymphocytes are commonly found in the walls of the alimentary canal, respiratory passages, and genitourinary tract. These concentrations, called **lymphatic nodules** or **lymphatic follicles**, are sharply defined but not encapsulated. A lymphatic nodule consisting chiefly of small lymphocytes is called a **primary nodule**. However, most nodules are **secondary nodules** and have distinctive features that include the following:

A **germinal center** is located in the central region of the nodule and develops when a lymphocyte that has recognized an antigen undergoes proliferation. So, the germinal center is a reaction center that forms in response to antigen exposure. A **mantle zone** or **corona** is present that represents an outer ring of small lymphocytes that encircles the germinal center.

Diffuse lymphatic tissue and lymphatic nodules are named according to the region or organ in which they appear. In the alimentary canal, they are collectively referred to as **gut-associated lymphatic tissue (GALT)**; in the bronchial tree, they are known as **bronchus-associated lymphatic tissue (BALT)**. The term **mucosa-associated lymphatic tissue (MALT)** includes GALT and BALT.

13. **Lymph node structure.** Lymph nodes are small, bean-shaped, encapsulated lymphatic organs. They range in size from about 1 mm to about 1 to 2 cm in their longest dimension. Lymph nodes are located along lymphatic vessels and serve as filters through which lymph percolates on its way to the blood vascular system.

Two types of lymphatic vessels serve the lymph node:

• **Afferent lymphatic vessels** convey lymph toward the node and enter it at various points on the convex surface of the capsule

• **Efferent lymphatic vessels** convey lymph away from the node and leave at the hilum, a depression on the concave surface of the node that also serves as the entrance and exit for blood vessels and nerves.

Note that activated lymphocytes, which remain in the lymph node to proliferate and differentiate, are carried to the node primarily by blood vessels.

The supporting elements of the **lymph node** are: **capsule**, composed of dense connective tissue that surrounds the node; **trabeculae**, also composed of dense connective tissue, which extend from the capsule into the substance of the node, forming a gross framework; and **reticular tissue** composed of reticular cells and reticular fibers that form a fine supporting meshwork throughout the remainder of the organ. The **parenchyma of the lymph node** is divided into a cortex and medulla.

14. Cells of the reticular meshwork.

- **Reticular cells** synthesize and secrete type III collagen (reticular fibers) and the associated ground substance that forms the stroma. Besides their supporting role, they express surface molecules and produce substances that attract T cells, B cells, and dendritic cells.
- **Dendritic cells (DCs)** are unique bone marrow–derived antigen presenting cells. DCs monitor the local environment for foreign substances that they then process and present to antigen specific T cells. In the lymph node, DCs are usually localized in T lymphocyte–rich areas.
- **Macrophages** are both phagocytic and antigen-presenting cells. Instead, they have an immense capacity for endocytosis and digestion of internalized materials.
- **Follicular dendritic cells (FDCs)** have multiple, thin branching cytoplasmic processes that interdigitate between B lymphocytes in the germinal centers. Antigen–antibody complexes adhere to the dendritic cytoplasmic processes and the cell can retain antigen on its surface for weeks, months, or years.

15. General architecture of the cortex and paracortex. The **cortex** forms the outer portion of the node except at the hilum. It consists of a dense mass of lymphatic tissue (reticular framework, dendritic cells, follicular dendritic cells, lymphocytes, macrophages, and plasma cells) and lymphatic sinuses, the lymph channels. The lymphatic nodules of the cortex are designated **primary nodules** if they consist chiefly of small lymphocytes and **secondary nodules** if they possess a germinal center.

The portion between the medulla and cortex is free of nodules; it is called the **paracortex**. This region contains most of the T cells in the lymph node. On the basis of this observation, it is also called the **thymus dependent cortex**.

16. General structure of the medulla. The **medulla**, the inner part of the lymph node, consists of cords of lymphatic tissue separated by lymphatic sinuses called **medullary sinuses**. A network of reticular cells and fibers traverses the medullary cords and medullary sinuses and serves as the framework of the parenchyma. In addition to reticular cells, the **medullary cords** contain lymphocytes (mostly B

lymphocytes), macrophages, dendritic, and plasma cells. The medullary sinuses converge near the hilum, where they drain into efferent lymphatic vessels.

17. **Lymph sinuses**. There are three types of **lymphatic channels** called sinuses in the lymph node. Just beneath the capsule of the lymph node is a sinus interposed between the capsule and the cortical lymphocytes called the **subcapsular sinus**. Afferent lymphatic vessels drain lymph into this sinus. **Cortical sinuses (other name trabecular sinuses)** that originate from the subcapsular sinuses extend through the cortex along the trabeculae and drain into **medullary sinuses**. Lymphocytes and macrophages or their processes readily pass back and forth between the lymphatic sinuses and the parenchyma of the node. The sinuses have a lining of endothelium.

18. **Functions of the lymph node.**

- **Filtration of lymph:** Lymph gets into the lymph node through its afferent lymphatics. It percolates through the subcapsular, cortical and lastly the medullary lymph sinuses. It gets out of the lymph node through its efferent lymphatics. As lymph flows through the sinuses, 99% or more of the antigens and other debris it carries are removed, by the phagocytic activity of macrophages that span the sinuses.
- **Antibodies production:** About 1% of the antigens carried into the lymph node by the lymph pass through the cortical nodules. These antigens stimulate the B-lymphocytes to become active. Activated B-lymphocytes proliferate in the germinal centers of the cortical nodules. Some of the daughter cells are preserved as memory cells. The other cells change to plasma cells which migrate to the medulla and secrete the specific antibodies.
- **Site of proliferation of lymphocytes:** Activated lymphocytes pass into the nodal parenchyma where they proliferate. Daughter cells get out of the node through the efferent lymphatics to be finally poured back, to the circulation.

19. General structure of the spleen. The spleen is the largest lymphatic organ. The spleen is enclosed by a dense connective tissue **capsule** from which **trabeculae** extend into the parenchyma of the organ. The connective tissue of the capsule and trabeculae contains **myofibroblasts**. The human spleen normally retains relatively little blood, but it has the capacity for contraction by means of the contractile cells in the capsule and trabeculae.

The **hilum**, located on the medial surface of the spleen, is the site for the passage of the splenic artery and vein, nerves, and lymphatic vessels. The lymphatic vessels originate in the white pulp near the trabeculae and constitute a route for lymphocytes leaving the spleen. Most of the spleen consists of splenic pulp. Splenic pulp, in turn, is divided into two functionally and morphologically different regions: **white pulp** and **red pulp**, based on the color of fresh sections. White pulp appears as circular or elongated whitish gray areas surrounded by red pulp.

20. White pulp structure. The **white pulp** consists of lymphatic tissue, mostly lymphocytes. Within the white pulp, the branch of the splenic artery is called the **central artery**. Lymphocytes that aggregate around the central artery constitute the **periarterial lymphatic sheath (PALS)**. In cross sections, the PALS may resemble a **lymphatic nodule**. The presence of the central artery, however, distinguishes the lymphatic nodules of the spleen from typical lymphatic nodules found in other sites.

The nodules are the territory of B lymphocytes; other lymphocytes of the PALS are chiefly T lymphocytes that surround the nodules. The nodules usually contain **germinal centers**, **mantle zone** and **marginal zone**.

Germinal centers develop as B cells proliferate after their activation. These enlarged nodules are called **splenic nodules** or Malpighian corpuscles. The **mantle zone** is an outer ring of small, dark lymphocytes surrounding a germinal center. The **marginal zone** that the area that separates white pulp and red pulp. It contains few lymphocytes, but many actively phagocytic macrophages **(dendritic cells)** with branching processes. Marginal zone acts as a filter to pull foreign antigens out of blood.

21. **Red pulp structure.** Essentially, red pulp consists of splenic sinuses separated by splenic cords (cords of Billroth). **Splenic cords** consist of the loose meshwork of reticular cells and reticular fibers that contain large numbers of erythrocytes, macrophages, lymphocytes, dendritic cells, plasma cells, and granulocytes. Splenic macrophages phagocytose damaged red blood cells.

The **splenic sinuses** are special sinusoidal vessels lined by rod-shaped endothelial cells. Processes of macrophages extend between the endothelial cells and into the lumen of the sinuses to monitor the passing blood for foreign antigens. The sinuses do not possess a continuous basal lamina.

22. Blood supply of the spleen. Branches of the splenic artery enter the white pulp from the trabeculae. The **central artery** sends branches to the white pulp itself and to the sinuses at the perimeter of the white pulp called **marginal sinuses**. The central artery continues into the red pulp, where it branches into several relatively straight arterioles called **penicillar arterioles**. The penicillar arterioles then continue as arterial

capillaries. Some arterial capillaries are surrounded by aggregations of macrophages and are thus called **sheathed capillaries**. Sheathed capillaries then empty directly into the reticular meshwork of the splenic cords rather than connecting to the endothelium-lined splenic sinuses. Blood entering the red pulp in this manner percolates through the cords and is exposed to the macrophages of the cords before returning to the circulation by squeezing through the walls of the splenic sinuses. The blood collected in the sinuses drains to tributaries of the trabecular veins that converge into larger veins and eventually leaves the spleen by the splenic vein. The splenic vein in turn joins the drainage from the intestine in the hepatic portal vein. **Circulation within red pulp allows macrophages to screen antigens in the blood.**

23. Spleen functions.

Immune system functions of the spleen	**Hemopoietic functions of the spleen**
Antigen presentation by APCs (mostly dendritic cells and macrophages) and initiation of immune response;	Removal and destruction of aged, damaged, and abnormal erythrocytes and platelets;
Activation and proliferation of B and T lymphocytes	Retrieval of iron from erythrocyte hemoglobin and storage of it as ferritin or hemosiderin for future recycling
Production of antibodies against antigen present in circulating blood	Broken down of the heme portion of the molecule to bilirubin, which is conjugated and secreted into the bile
Removal of macromolecular antigens from the blood	Formation of erythrocytes during early fetal life;
Activation and proliferation of T cells and differentiation of B cells and plasma cells, as well as secretion of antibodies, occur in the white pulp of the spleen; in this regard, the white pulp is the equivalent of other lymphatic organs	Storage of blood, especially red blood cells, in some species.

24. Nonspecific (innate) and specific (adaptive) defenses.

The immune responses can be divided into nonspecific (innate) and specific (adaptive) defenses.

In **nonspecific (innate) immunity**, preexisting nonspecific defenses constitute the innate immune response. In all living organisms, the innate immunity represents the first line of defense against microbial aggression. It consists of (1) physical barriers (e.g., the skin and mucous membranes) that prevent foreign organisms from invading the tissues, (2) chemical defenses (e.g., low pH) that destroy many invading microorganisms, (3) various secretory substances (e.g., lysozymes, interferons and complement in serum) that neutralize foreign cells, and (4) phagocytic cells (e.g., macrophages, neutrophils, and monocytes) and natural killer (NK) cells swallow up and destroy pathogens that penetrate epithelial barriers.

With **specific (adaptive) immunity**, if nonspecific defenses fail, the immune system provides specific, or adaptive, defenses that target specific invaders. Immunity, composed of mechanisms whereby lymphocytes recognize and destroy specific pathogens. The initial contact with a specific antigen or foreign agent initiates a chain of reactions that involve effector cells of the immune system and frequently leads to a state of immune "**memory**."

25. Notion about antigen, antibody, cell mediated and humoral immunity; primary and secondary immune response and active and passive immunity.

Antigens (Ag) are large, complex molecules (or parts of them) recognized as foreign by the body. Foreign proteins are the strongest antigens. **An antibody (Ab),** or **immunoglobulin**, is a gamma globulin. **Immunoglobulins** (antibodies) fit foreign antigens like a lock and key. Their variety is so extensive that they can be produced to match all possible microorganisms in our environment.

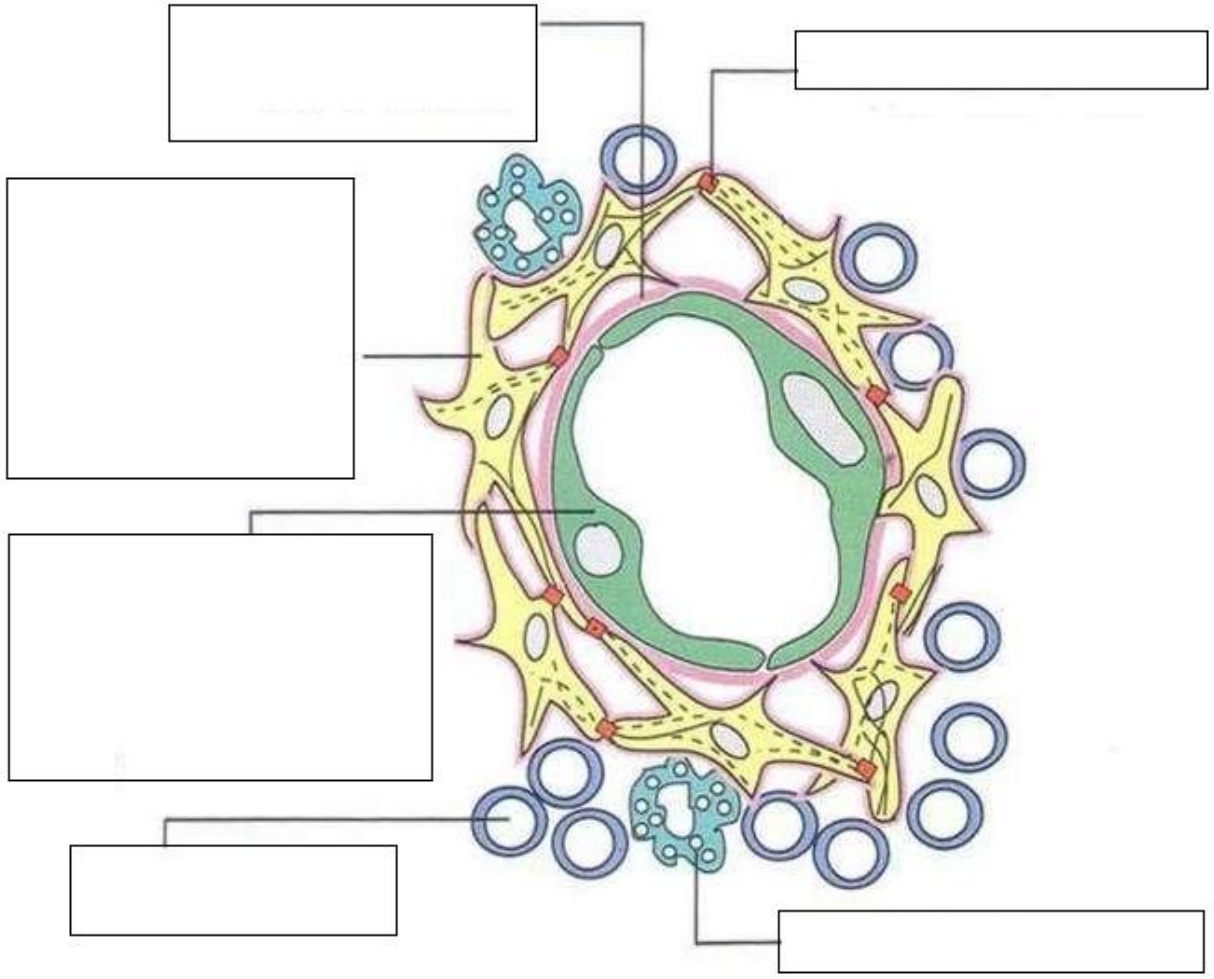
Humoral immunity is also known as antibody-mediated immunity. It is mediated by antibody molecules secreted by the B- lymphocyte cells (plasma cells) that can neutralize specific pathogens outside the cells. The essential stages in humoral immunity are recognition, attack, and memory. **Cell mediated immunity** is mediated by T-cell antigen receptors made by thymus-derived T-cells.

Primary immune response occurs when antigens bind for the first time to B-cells receptors, causing them to proliferate. Most clone members become **plasma cells**, which secrete antibodies. Other clone members become **memory B cells**, capable of mounting a rapid attack against the same antigen in subsequent meetings (**secondary immune responses**). These memory cells provide immunological

"memory." **Active humoral immunity** is acquired during an infection or via vaccination and provides immunological memory. **Passive immunity** is conferred when a donor's antibodies are injected into the bloodstream, or when the mother's antibodies cross the placenta. It does not provide immunological memory.

PRACTICAL QUESTIONS

1. Fill in the white gaps with designations in the pictures below (the blood-thymus barrier).



2. In the picture below (smaller magnification of the lymph node) identify the structure labeled 1.

3. Identify the structure labeled 2.

4. Identify the structure labeled 3.

5. Identify the structure labeled 4.

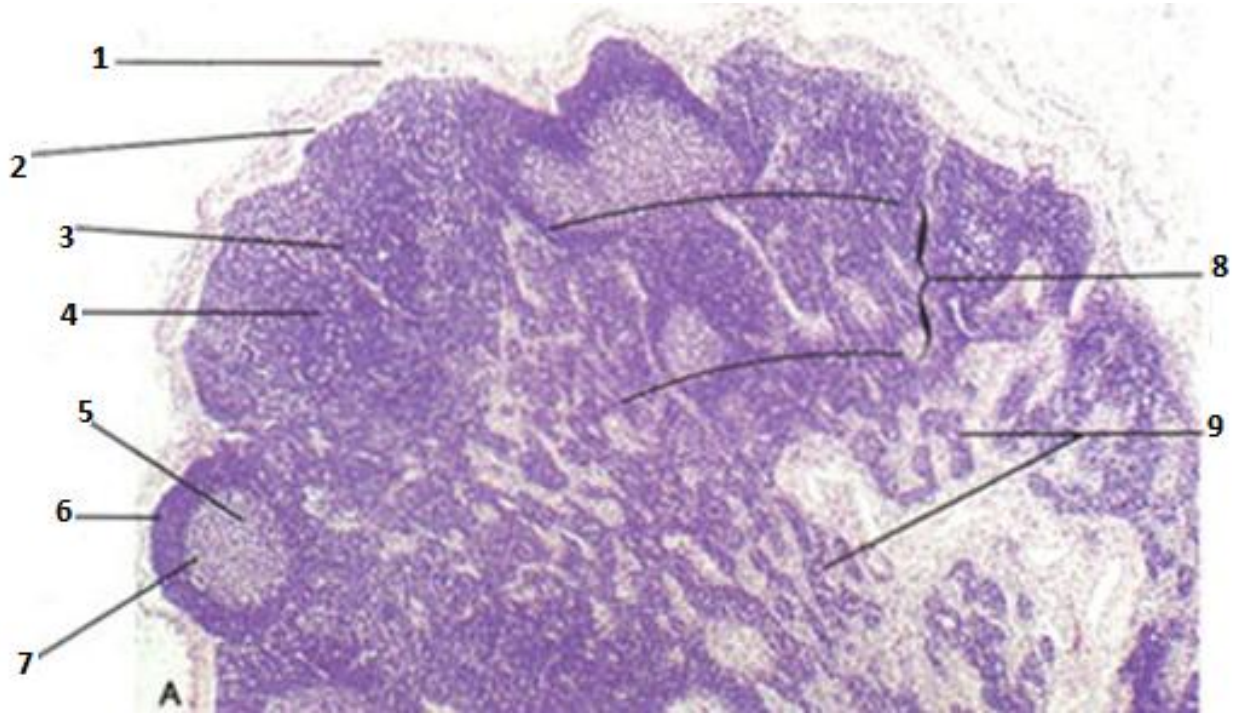
6. Identify the structure labeled 5.

7. Identify the structure labeled 6.

8. Identify the structure labeled 7.

9. Identify the structure labeled 8.

10. Identify the structure labeled 9.



11. In the picture below (larger magnification of the lymph node) identify the structure labeled 1.

12. Identify the structure labeled 2.

13. Identify the structure labeled 3.

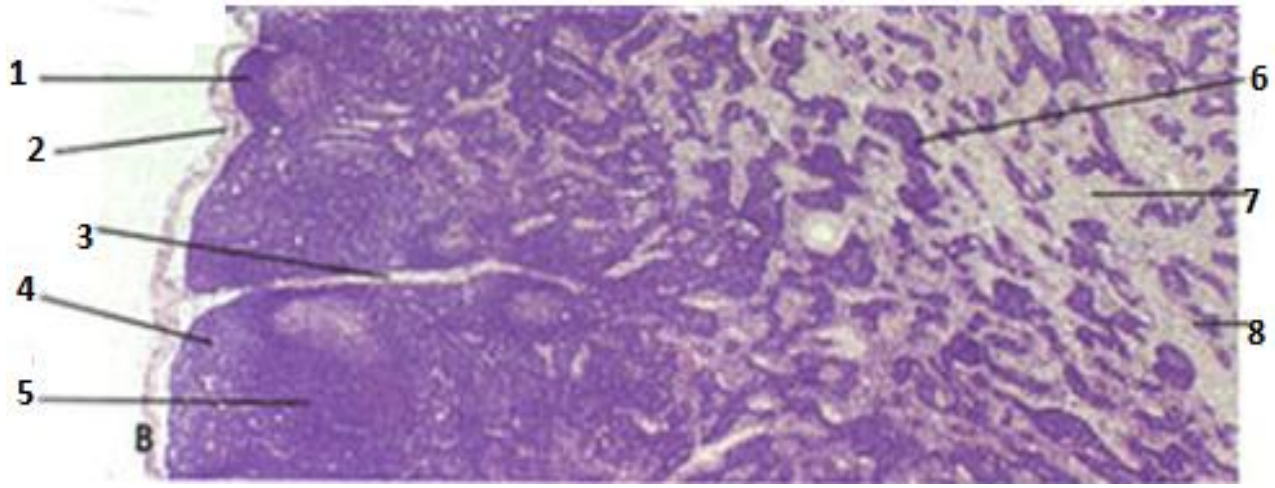
14. Identify the structure labeled 4.

15. Identify the structure labeled 5.

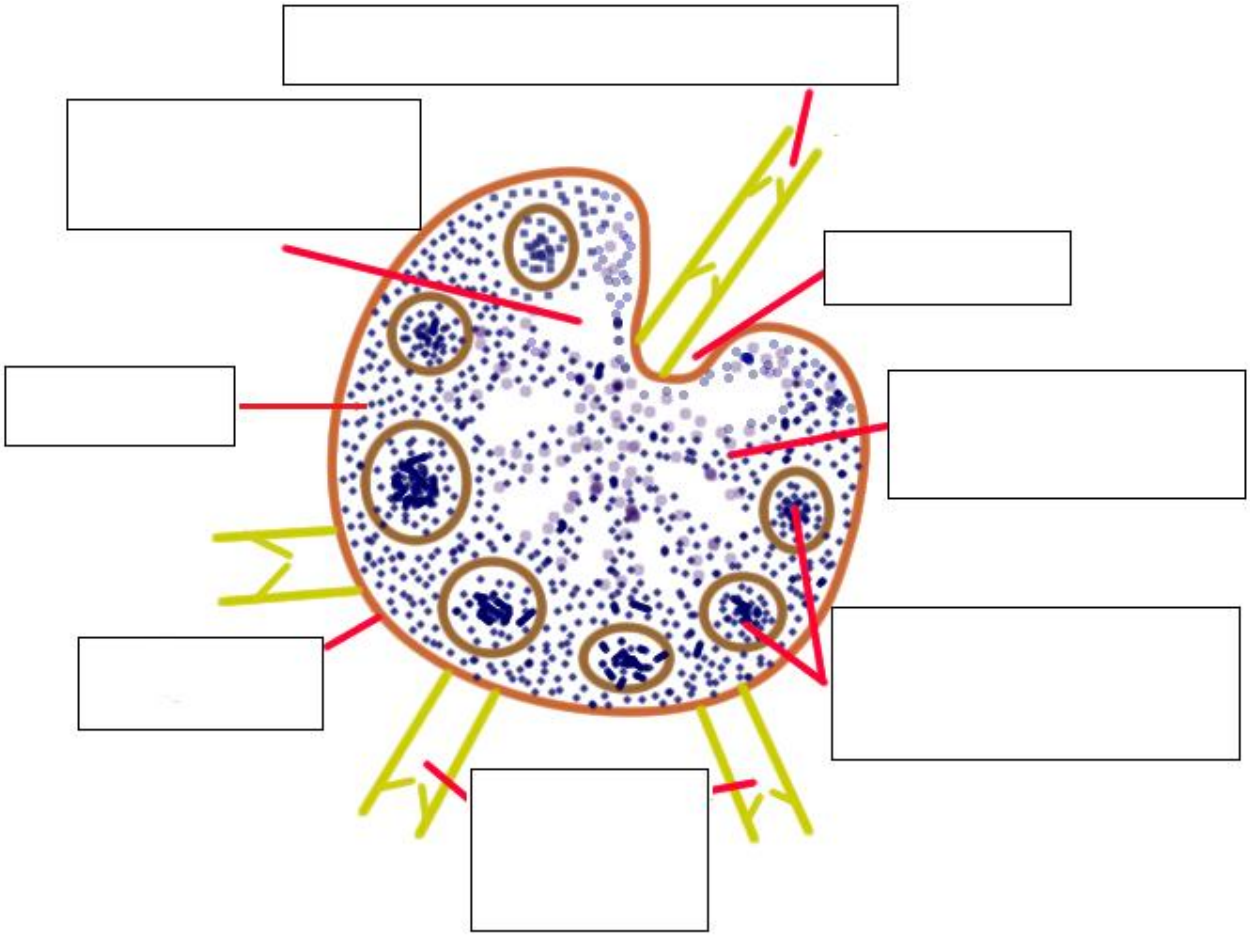
16. Identify the structure labeled 6.

17. Identify the structure labeled 7.

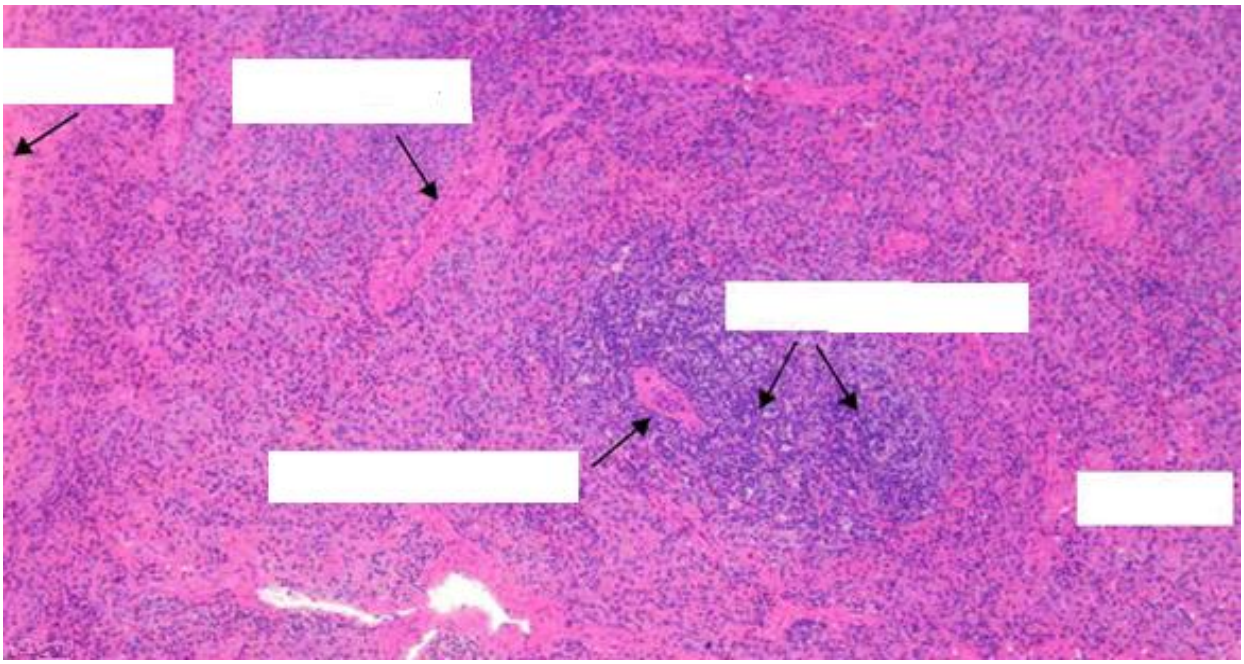
18. Identify the structure labeled 8.



19. Fill in the white gaps with designations in the pictures below (lymph node).



20. Fill in the white gaps with designations in the pictures below (spleen).

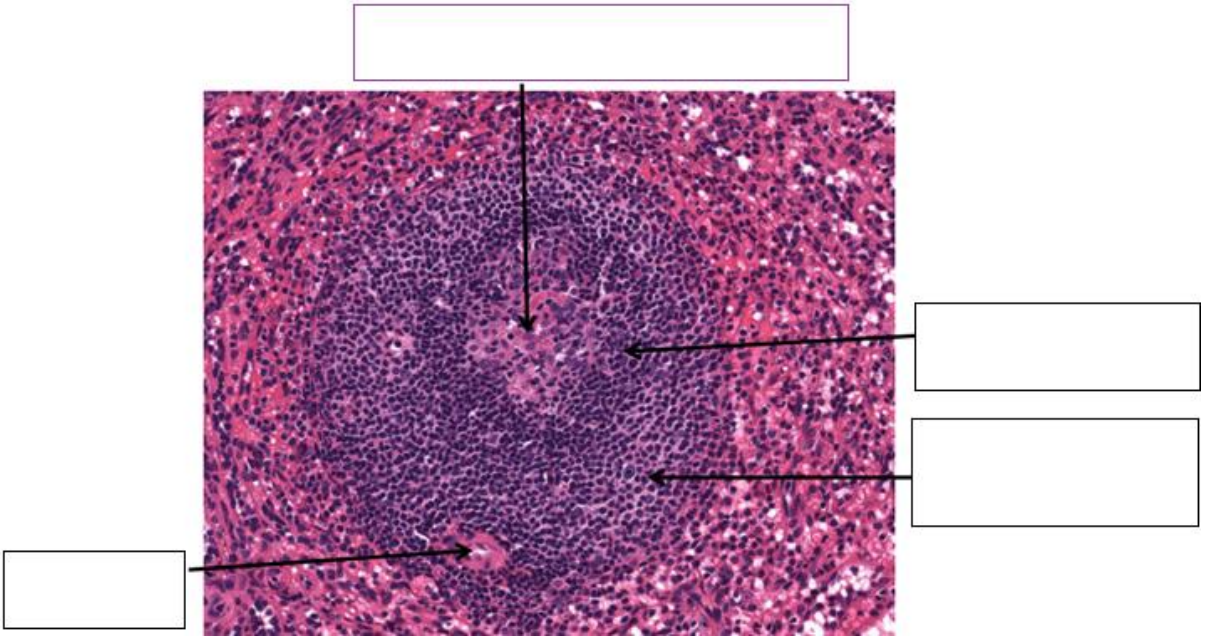


21. How one can differentiate nodule of the spleen from nodule of the lymph node?

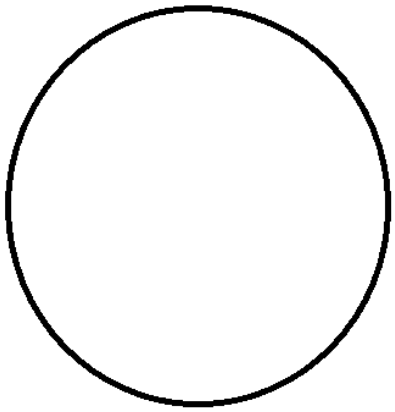
_____

_____

22. Fill in the white gaps with designations in the pictures below (nodule of the spleen white pulp).



SLIDE 1

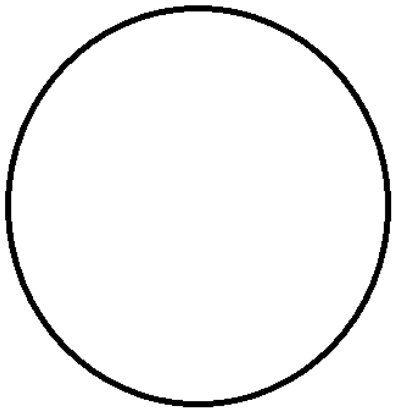


Thymus
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Capsule
2. Interlobular trabeculae
3. Lobules
4. Cortex
5. Medulla
6. Hassall's corpuscle
7. Lymphocytes
8. Epithelioreticular cells

SLIDE 2

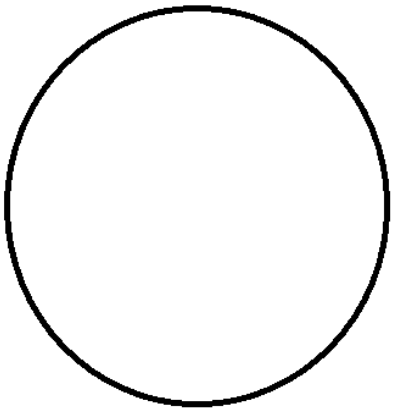


Lymph node
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Afferent vessel
2. Capsule
3. Trabeculae
4. Lymphoid nodules
5. Subcapsular sinus
6. Reticular tissue
7. Hilum of the lymph node
8. Efferent vessel

SLIDE 3



Spleen
Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Capsule
2. Trabeculae
3. Red pulp
4. White pulp
5. Germinal center
6. Central artery
7. The penicillar arterioles

TESTS OF THE "KROK-1" DATABASE

Reduction of the gland mass to 3.0 g was revealed in a 5-year-old child who died from acute destructive staphylococcal pneumonia during the study of the thymus. Histological examination of the thymus showed a decrease in the number of lobules of the gland, a significant decrease in the number of lymphocytes with the collapse of the stroma of lobules, inversion of layers, cyst-like enlargement of Hassall's corpuscles. Which of the following diagnoses is most likely?
A. *Accidental involution of thymus
B. Thymus hypoplasia
C. Thymomegaly
D. Thymus dysplasia
E. Thymus agenesis

During autopsy of a 9-month-old girl's body, which died due to severe pneumonia complicated with sepsis, lack of thymus is observed. In the lymph nodes the lymphoid follicles and cortical substance are absent; follicles of spleen are reduced in size with no light zones and plasma cells. What is the cause of such structural changes?
A. *Thymus aging
B. Accidental involution of thymus
C. Thymus hypoplasia
D. Thymus atrophy
E. Thymus aplasia

A child received a hit to the retrosternal region during a game. As a result of this trauma an organ located behind the restrosternal was damaged. Name this organ:
A. *Thymus
B. Thyroid gland
C. Heart
D. Pericardium
E. Larynx

Histological examination of a 40 y.o. mans' thymus revealed decreased share of parenchymatous gland elements, increased share of adipose and loose connective tissue, and its enrichment with thymus bodies. The organs mass was unchanged. What phenomenon is it?
A *Age involution
B Accidental involution
C Hypotrophy
D Dystrophy
E Atrophy

An electron microphotograph shows a macrophagic cell with erythrocytes at different stages of differentiation located along its processes. This is the cell of the following organ:
A *Red bone marrow
B Thymus
C Spleen
D Tonsil
E Lymph node

Amount of epithelioreticular cells and Hassall's corpuscles are increased and area of medulla became larger in the lobules of thymus during infections and intoxication. Give name of these changes in the thymus.
A. *Accidental involution
B. B immunodeficiency
C. Thymico-lymphatic condition
D. Age involution
E. T immunodeficiency

The specimen represents sections of hemopoietic and immunogenetic organ. Organ has lymph tissue forming different structures (lymph nodes, lobules, bars). In what organ does antigen-independent proliferation and differentiation take place?
A *Thymus
B Lymphatic nodes
C Spleen
D Hemolymph nodes
E Tonsil

An organ which is made up of lobules is presented in a histological specimen. Each lobule has a cortex and medulla. Parenchyma of lobules is formed of lymphoid tissue, which contains T-lymphocytes at different stages of proliferation and differentiation. Microenvironment is presented by epithelioreticular cells. The Hassall's corpuscles are found in the medulla. What organ of the human body has such morphological structure?
A * Thymus
B Red bone marrow
C Lymph node
D Adrenal gland
E Spleen

A teenager was irradiated with high radiation dose that resulted in serious damages of lymphoid system, lysis of many lymphocytes. Restoration of normal hemogram is possible due to the functioning of the following gland:
A *Thymus
B Thyroid
C Liver
D Pancreas
E Adrenal

One can find star shaped cells with oxyphilic cytoplasm which contacts with each other by means of their processes in the slide of the human red bone marrow smear between myeloid row of cells and adipose cells. Name these cells.
A. *Reticular
B. Fibroblasts
C. Macrophages
D. Dendrite cells
E. Osteocytes

Slide of hematopoietic organ is under investigation. This organ consists of differently shaped lobules. In each of the lobule presents cortex and medulla. What organ possesses these morphological characteristics?
A. *Thymus
B. Lymph node
C. Spleen
D. Tonsils
E. Appendix

An organ of hematopoiesis and immune response is presented in a histological specimen. This organ is made up of lobules that are surrounded by layers of connective tissue; in the periphery of lobules the number of cells is much higher than in the center. Lymphatic nodules are absent. What organ of the body is represented?
A * Thymus
B Red bone marrow
C Lymph node
D Spleen
E Tonsil

A newborn baby has underdevelopment of the thymus. What line of hematopoiesis will be violated? A*Lymphopoiesis
B Monocytopoiesis
C Erythropoiesis
D Granulopoiesis
E Platelet formation

Antibodies against thymosin were revealed in the patient. What cells have impaired differentiation in the first place?
A * T-lymphocytes
B B-lymphocytes
C Monocytes
D Macrophages
E –

Antibody against thymus hormones was injected under condition of experiment into the body of investigated animal. Which cells differentiation will be affected first of all?
A. *T lymphocytes
B. Monocytes
C. Plasma cells
D. Macrophages
E. B lymphocytes

A parenchyma of the hematopoietic organ in which was found megakaryocytes was taken in a sick person with diagnostic purpose. Name this organ.
A *Red bone marrow
B Spleen
C Thymus
D Lymph node
E Tonsil

The child was born with immunodeficiency. Cell mediated immunity has been affected that has caused often viral infections. What organ has been damaged?
A. *Thymus
B. Red bone marrow
C. Lymph node
D. Spleen
E. Tonsil

The student was given specimens of two smears. Red blood cells cover the entire field of view in the first specimen. Blood cells of different maturity are seen in the second specimen. What are the kinds of smears?
A *Human blood and red bone marrow
B Blood and lymph
C Blood of frog and human blood
D Blood and smear of yellow bone marrow
E Smears of red and yellow bone marrow

Antigen independent proliferation and differentiation of T-lymphocytes was studied in the child with impaired immune reactivity. What organ was investigated?
A * Thymus
B Spleen
C Lymph node
D Red bone marrow
E Palatine tonsils

Medullary substance of a hemopoietic organ lobule is lighter colored and contains epithelial bodies in a histological specimen. What organ are these morphological properties typical for?
A *Thymus
B Lymph node
C Spleen
D Liver
E Kidney

The cell with processes is visible in electron micrographs. There are lymphocytes at the stage of differentiation in recesses of the plasmolemma of this cell. What organ of the human body has such structure?
A * Thymus
B Red bone marrow
C Spleen
D Tonsil
E Liver

Developing cells are located in the form of islets in the red bone marrow. Some islets are associated with macrophages. What blood cells develop in these islets?
A *Erythrocytes.
B Precusors of T- and B-lymphocytes
C Monocytes
D Platelets
E Basophilic granulocytes

Decreasing of the thymus parenchyma, increasing of adipose and loose connective tissue, enriching of Hassall's corpuscles, with remaining the same weight of the organ was revealed in a 40-year-old man's' thymus during histological investigation. What is the name of this phenomenon?
A. *Age involution of the thymus
B. Accidental involution of the thymus
C. Thymus hypotrophy
D. Thymus dystrophy
E. Thymus atrophy

Decreased number of erythrocytes in one liter of the blood has been found in a patient as a result of massive bleeding. After a short period of time the level of red blood cells became physiological. What additional sources of hematopoiesis provided restoration of normal level of red blood cells?
A. *Foci of hematopoiesis of the yellow bone marrow of long bone diaphysis
B. Red bone marrow of long bones diaphysis
C. Red bone marrow of flat bones
D. Foci of hematopoiesis of the yellow bone marrow of long bone epiphysis
E. Red bone marrow of long bone epiphysis

The patient has symptoms of autoimmune damage of organs that may be the results of a violation of the structure and function of the blood thymic barrier. What structures are involved in its formation?
A Endothelial cells and basement membrane
B Macrophages
C Hassall's corpuscles
D Postcapillary venules of medulla
E Connective tissue trabeculae

A 46-year-old patient was admitted to the hematological department. It was found that he had disorder of granulocytopoesis and thrombocytogenesis processes. In what organ does this pathological process take place?
A *Red bone marrow
B Thymus
C Spleen
D Lymphatic ganglion
E Palatine tonsil

In the red bone marrow the blood cells, which develop, are located by the islands. Some of the islands associated with macrophages. What blood cells are developed in these islands?
A * Erythrocytes
B Precursors of T- and B-lymphocytes
C Monocytes
D Platelets
E Basophilic granulocytes

Patient has disordered processes of erythropoiesis, granulocytopoiesis, monocytopoiesis and thrombocytopoiesis. Which hematopoietic organ had been affected?
A. *Red bone marrow
B. Thymus
C. Spleen
D. Lymph node
E. Tonsil

One can see macrophage with erythrocytes at different stages of differentiation situated along processes its processes in the electron microphotograph. What organ is it?
A. *Red bone marrow
B. Thymus
C. Spleen
D. Tonsil
E. Lymph node

One can see the organ stroma of which consists of reticular tissue, adipose cells, macrophages and osteogenic cells in the slide. What organ is represented in the slide?
A. *Red bone marrow
B. Spleen
C. Thymus
D. Lymph node
E. Tonsil

One can see an organ which consists of lobules and stroma includes epitheliocytes with processes in the specimen. What organ is represented in the slide?
A. *Thymus
B. Red bone marrow
C. Spleen
D. Tonsil
E. Lymph node

In a microscopic specimen is a bean-shaped organ which has cortical and medullar substance. Cortical substance is represented by separate spherical nodules 0,5-1 mm in diameter, medullar substance – by medullary cords. What organ is this?
A. *Lymph node
B. Kidney
C. Thymus
D. Adrenal gland
E. Spleen

One has done histological section through lymph node. In the slide one can see enlargement of it paracortex. Proliferation of what cells of lymph node have caused this process?
A. *T lymphocytes
B. Dendritic cells
C. Plasma cells
D. Macrophages
E. Reticular cells

Student got 2 histological specimens. They both have lymphatic nodules. First slide has only follicles but second one has follicles with eccentrically positioned vessel. Determine these slides.
A. *First-lymph node, second-spleen
B. First-red bone marrow, second -spleen
C. First thymus, second- spleen
D. First liver, second -lymph node
E. First-liver, second -spleen

In a histological specimen parenchyma of an organ is represented by lymphoid tissue that forms lymph nodes; the latter are arranged in a diffuse manner and enclose a central artery. What anatomic formation has such morphological structure?
A *Spleen
B Tonsil
C Lymph node
D Thymus
E Red bone marrow

The increase in the amount of lymphoid tissue, which may indicate the activation of immune response, is determined in histological specimens of spleen and lymph node. Name the place where the antigen-dependent proliferation and differentiation of B-lymphocytes (B-zone) are performed in these organs.
A * Germinal center of lymphatic nodules
B Mantle zone
C Paracortical zone
D Medullary sinuses
E Peryarterial zone

A specimen shows an organ covered with the connective tissue capsule with trabeculae radiating inward the organ. There is also cortex containing some lymph nodules, and medullar cords made of lymphoid cells. What organ is under study?
A *Lymph node
B Thymus
C Spleen
D Red bone marrow
E Tonsils

Morphological investigation of the spleen revealed activation of immune reactions in the organism. In which structures of this organ do antigen depended proliferation of T lymphocytes begin?
A. *Periarterial sheath of white pulp
B. Central zone of white pulp
C. Germinal center
D. Marginal zone of white pulp
E. Red pulp

Focuses of increased formation of plasma cells were revealed in the biopsy sample of the lymph node. Antigen depended stimulation of which immune cells have caused their formation?
A. *B lymphocytes
B. T lymphocytes
C. Macrophages
D. Dendrite cells
E. Interdigital cells

Vital dye to the afferent vessel of the lymph node was injected the animal in the experiment. Which cells of the lymph node will contain particles of the dye?
A *Macrophages
B Reticular endothelial cells
C B-lymphocytes
D Plasma cells
E T-lymphocytes

The patient has an enlarged spleen and a reduced level of erythrocytes in peripheral blood. Which cells of spleen have enhanced activity in this case?
A *Macrophages
B Lymphocytes
C Dendritic cells
D Plasma cells
E Reticular cells

In a histological specimen parenchyma of an organ is represented by lymphoid tissue that forms lymph nodes; the latter are arranged in a diffuse manner and enclose a central artery. What anatomic formation has such morphological structure?
A *Spleen
B Tonsil
C Lymph node
D Thymus
E Red bone marrow

A histological specimen represents an organ that has both cortical and medullary substance. Cortical substance consists of an external zone that contains lymph nodules as well as of a paracortical zone. Medullary substance contains medullary cords, sinuses and trabeculae. What organ possesses these morphological signs?
A *Lymph node
B Spleen
C Kidney
D Thymus
E Adrenal glands

One can see an organ where lymphocytes formed 3 types of lymphoid structures such as lymphatic nodules, medullary cords and sinuses in the specimen. What organ is it?
A. *Lymph node
B. Spleen
C. Thymus
D. Tonsil
E. Red bone marrow

In the specimen revealed an organ in the reticular stroma of which situated blood formed elements and seen lymphoid formation. What organ is this?
A. *Spleen
B. Lymph node
C. Tonsil
D. Thymus
E. Red bone marrow

In a specimen revealed roundish formation of the lymphocytes with a central artery in the center. What organ is it?
A *Spleen
B kidney
C Lymph node
D Thymus
E Red bone marrow

A doctor noted an enlarged spleen during the examination of a 20-year-old patient. The level of erythrocytes was $3,2x10^{12}$ /L in the analysis of the blood. What cells of the spleen have enhanced function that caused such changes?
A. *Macrophages
B. Endothelial cells
C. Dendritic cells
D. Microphages
E. Follicular dendritic cells

Examination of a patient who was exposed to the ionizing radiation revealed damage of white pulp. What cells of white pulp undergo pathological changes?
A *Lymphocytes
B Neutrophilic leukocytes
C Basophilic leukocytes
D Monocytes
E Tissue basophils

There are cells that produce substances stimulating the proliferation of T-lymphocytes and have lost ability to phagocytosis in a histological specimen of the lymph node on the border of cortex and medulla. Name these cells.
A *Follicular dendritic cells
B T – lymphocytes
C B – lymphocytes
D Macrophages
E Plasma cells

The spleen is not a vital organ but its rupture in trauma can cause the death of a person. It is associated with such its function as:
A. *Deposition of blood
B. Deposition of iron
C. Elimination of red blood cells and platelets
D. Formation of B-lymphocytes
E. Synthesis of splenin

In the slide which was made from the spleen one can see white and red pulp in the base of which is rest special tissue which formed their stroma. What tissue is it?
A. *Reticular connective tissue
B. Dense connective tissue
C. Adipose tissue
D. Muscle tissue
E. Nervous tissue

In the histological cross section of the lymph node in the experimental animal after antigen stimulation in the medullary cords one can find huge amount of cells with intensively basophilic cytoplasm, eccentrically positioned nucleus with chromatin giving the illusion of the spokes of the wheel and light area of cytoplasm near it. Name these cells.
A. *Plasma cells
B. Macrophages
C. Fibroblasts
D. Adipose cells
E. Mast cells

15-year-old patient has enlarged tonsils because of the tonsillitis. Which histological structures of these organs take place in immune protection of the body at a response of streptococcus invasion?
A. *Lymphatic nodules
B. Stratified squamous keratinized epithelium
C. Stratified squamous non keratinized epithelium
D. Loose connective tissue
E. Crypt

The patient consulted an immunologist with complaints about diarrhea, weight loss within a few months, low-grade fever, and swollen lymph nodes. The doctor suggested that the patient has HIV infection. Which cells have to be examined in the first place?
A. T-helpers
B. T-suppressors
C. B-lymphocytes
D. Monocytes
E. Plasma cells

Rejection of transplant developed in the patient after transplantation of heterogenous kidney. Name main effector cells, which take place in this immune reaction?
A. *T killer
B. B lymphocytes
C. T suppressor
D. T helper
E. Plasma cells

Donor skin transplantation was performed to a patient with extensive burns. On the 8-th day the graft became swollen and changed colour; on the 11-th day graft rejection started. What cells take part in this process?
A *T-lymphocytes
B Erythrocytes
C Basophils
D Eosinophils
E B-lymphocytes

In a patient with clinical signs of immunodeficiency the number and functional activity of T and B lymphocytes are not changed. Defect with dysfunction of antigen-presentation to the immunocompetent cells was found during investigation on the molecule level. Defect of what cells is the most probable?
A *Macrophages, monocytes
B T-lymphocytes, B-lymphocytes
C NK-cells
D Fibroblasts, T-lymphocytes, B-lymphocytes
E 0-lymphocytes

A female patient underwent liver transplantation. Her condition became worse because of reaction of transplant rejection 1,5 month after it. What factor of immune system plays the leading part in this reaction?
A *T-killers
B Interleukin-1
C Natural killers
D B-lymphocytes
E T-helpers

Humoral immune response developed in response of the introduction of foreign antigens during vaccination of the child. Specify the main spleen cells involved in the immune response.
A * Macrophages, T-helpers, B-lymphocytes
B T-killers, T-helpers
C B-lymphocytes
D T-suppressors and T-helpers, macrophages
E B-lymphocytes

Rejection of transplant was revealed during heterotransplantation of an organ. What blood cells will ensure this process?
A. *T killer
B. T helper
C. T suppressor
D. T 0 lymphocytes
E. T memory cells

Fabrician's bag was removed from the chicken embryo. What disorder of immunity will occur in this case?
A *The lack of humoral responses
B Deficiency of T-killers
C Deficiency of T-helpers
D Hyper production of T-suppressors
E The lack of T- and B-lymphocytes

The same antigen was injected twice after a certain period of time to the animal in the experiment. In this case secondary immune response developed faster and was more intense. What cells provide this rapid response?
A Memory cells T- and B- types and immunoblasts
B Plasma cells
C NK-cells
D T-killers
E T-suppressors

The patient was diagnosed with AIDS after a positive reaction enzyme immunoassay. What cells of the peripheral blood are affected in first place?
A *T-helpers
B T-suppressors
C T-killers
D T-memory cells
E Macrophages

There are mutations of somatic cells in the body by the impact of unfavorable factors. What cells participate in the destruction of genetically modified cells?
A * NK-cells
B T-helpers
C Plasma cells
D Monocytes
E B-lymphocytes

Cells having the receptors of T cells (TCR+), enhance the activity of other T- and B-lymphocytes are distinguished among the subpopulations of lymphocytes. Name these cells.
A *T-helper
B T-cytotoxic lymphocytes (T-killer)
C T-suppressor
D T-memory cell
E NK-cells

Cells having receptors of T cells (TCR+) which are not immunoglobulins; recognize antigens associated with major histocompatibility complex; produce perforins and other proteins that destroy other cells infected by viruses and some tumor cells are detected among the subpopulations of lymphocytes by immunological methods. Name these cells?
A *T-killer
B T-helper
C T-suppressor
D T-memory cell
E NK-cell

The cells which have membrane receptors for the IgM, under the influence of specific antigens become activated, proliferate by mitotic division, differentiate into plasma cells that produce antibodies (immunoglobulins) are distinguished among subpopulation of lymphocytes. What are these cells?
A *B-lymphocytes
B T-memory cells
C T-killers
D T-suppressors
E B-memory cells

To prevent epidemic of California virus vaccine (heterogenous protein) was injected into the organism of human. What cells will take place in specific immunity?
A. *Lymphocytes
B. Adipose cells
C. Pigmentocytes
D. Fibroblasts
E. Adventitial cells

Burn wound was covered with pig skin (heterotransplantation). Call effector cells, which will reject transplant (pig skin).
A. *T killer
B. T helper
C. T suppressor
D. B lymphocytes
E. Natural killer

THE ENDOCRINE SYSTEM

Checking your primary level of the knowledge:

1. General notions about endocrine system and comparing of it to nervous system.
2. Classes of hormones.
3. Regulation of hormone secretion and feedback mechanism
4. Classification of endocrine system.
5. Pituitary gland (hypophysis) gross structure.
6. Development of pituitary gland.
7. Pars distalis general structure.
8. Types of pars distalis basophiles.
9. Types of pars distalis acidophils.
10. Chromophobes structure.
11. Folliculo-stellate cells structure.
12. Pars intermedia structure.
13. Pars tuberalis structure.
14. Posterior lobe of the pituitary gland (neurohypophysis) structure.
15. Oxytocin and vasopressin functions.
16. The hypothalamus structure.
17. Releasing and inhibiting hormones of hypothalamus.
18. Pineal gland structure.
19. Pineal gland function.
20. Adrenal glands general plan of structure.
21. Adrenal gland development.
22. Zona glomerulosa structure and functions.
23. Zona fasciculata structure and functions.
24. Zona reticularis structure and functions.
25. Adrenal medulla structure and functions.
26. Thyroid gland general structure.
27. Follicular cells and parafollicular cells structure.
28. Synthesis and secretion of thyroglobulin.
29. Thyroid gland functions.
30. Parathyroid glands general structure.
31. Principal (chief) cells and oxyphil cells structure.
32. Parathyroid gland functions.
33. Parathyroid gland development.

Standard answers for theoretical questions

1. **General notions about endocrine system and comparing of it to nervous system.**

The endocrine system produces various secretions called **hormones** that serve as effectors to regulate the activities of various cells, tissues, and organs in the body. Its functions are essential in maintaining homeostasis and coordinating body growth and development. The endocrine system communicates through the release of hormones, secretory products of endocrine cells and organs that pass into the circulatory system for transport to target cells that possess receptors for the hormones. Functionally, the endocrine system and the nervous system are closely interrelated and may overlap in function. Both systems may act simultaneously on the same target cells and tissues, and some nerve cells secrete hormones. The endocrine system produces a slower and more prolonged response than the nervous system. In general, a hormone is described as biologic substance acting on specific target cells.

2. **Classes of hormones.** Cells of the endocrine system release more than 100 **hormones** and **hormonally active substances** that are chemically divided into three classes of compounds:

- **Steroids** are synthesized and secreted by cells of the ovaries, testes, and adrenal cortex.
- **Small peptides, polypeptides**, and **proteins** are synthesized and secreted by cells of the hypothalamus, pituitary gland, thyroid gland, parathyroid gland, pancreas, and scattered enteroendocrine cells of the gastrointestinal tract and respiratory system.
- **Amino acids** and **arachidonic acid analogs**, and their derivatives, including the **catecholamines** and **prostaglandins**, **prostacyclins**, and **leukotrienes**. They are synthesized and secreted by many neurons as well as a variety of cells including cells of the adrenal medulla. Also included in this group of compounds

are **thyroid hormones**, the iodinated derivatives of the amino acid tyrosine that are synthesized and secreted by the thyroid gland.

3. **Regulation of hormone secretion and feedback mechanism.** Regulation of hormonal function is controlled by feedback mechanisms. Hormonal production is often controlled through **feedback mechanisms** from the target organ. Two types of feedback are recognized; a **negative feedback** occurs when the response diminishes the original stimulus. It is much more common than a **positive feedback**, which occurs when the response enhances the original stimulus.

4. **Classification of endocrine system.** We can classify endocrine glands into four groups of compounds**.** The first group includes master (central) organs of endocrine system such as hypothalamus, pituitary gland (hypophysis) and pineal gland. The second group includes peripheral organs such as thyroid, parathyroid and adrenal glands. The third group includes organs, which perform combined endocrine and other functions. To this group belongs pancreas, sex glands (testis, ovaries), placenta etc. Finally, the fourth group of cells is so called dissociated endocrine system, which includes large group of cells.

5. **Pituitary gland (hypophysis) gross structure.** The pituitary gland is a pea-sized, compound endocrine gland. It is centrally located at the base of the brain, where it lies in a saddle-shaped depression of the sphenoid bone called the **sella turcica**. A short stalk, the **infundibulum**, and a vascular network connect the pituitary gland to the hypothalamus. The pituitary gland has two functional components: **anterior lobe (adenohypophysis)**, the glandular epithelial tissue and **posterior lobe (neurohypophysis)**, the neural secretory tissue. The **anterior lobe** of the pituitary gland consists of three pars:

Pars distalis, which comprises the bulk of the anterior lobe of the pituitary gland.

Pars intermedia separates pars distalis from pars nervosa

Pars tuberalis which is superior extension of pars distalis

The **posterior lobe** of the pituitary gland consists of the **pars nervosa**, which contains neurosecretory axons and their endings and **infundibulum**, which is continuous with the **median eminence** and contains the neurosecretory axons forming the hypothalamohypophyseal tracts.

6. **Development of pituitary gland.** The anterior lobe of the pituitary gland is derived from an evagination of the **ectoderm of the oropharynx** toward the brain **(Rathke's pouch)**.

The posterior lobe of the pituitary gland is derived from a down growth (the future infundibulum) of **neuroectoderm of the floor of the third ventricle** (the diencephalon) of the developing brain.

7. **Pars distalis general structure.** The cells within the pars distalis vary in size, shape, and staining properties. The cells are arranged in cords and nests with interweaving capillaries. Using mixtures of acidic and basic dyes, histologists identified three types of cells according to their staining reaction, namely, **basophils (10%)**, **acidophils (40%)**, and **chromophobes** with **folliculo-stellate cells (50%)**.

8. **Types of pars distalis basophiles:**

- **Corticotropes (ACTH cells, adrenocorticotropes)** are polygonal, medium-sized cells with round and eccentric nuclei produce a precursor molecule of **adrenocorticotropic hormone (ACTH)**. ACTH release is regulated by **corticotropin-releasing hormone (CRH)** produced by the hypothalamus.
- **Gonadotropes (FSH and LH cells)** are small, oval cells with round and eccentric nuclei produce both **luteinizing hormone (LH)** and **follicle-stimulating hormone (FSH)**. They are scattered throughout the pars distalis. The release of FSH and LH is regulated by **gonadotropin-releasing hormone (GnRH)** produced by the hypothalamus.
- **Thyrotropes (TSH cells)** are large, polygonal cells with round and eccentric nuclei produce thyrotropic hormone called **thyroidstimulating hormone (TSH)**, which acts on the follicular cells of the thyroid gland to stimulate production of thyroglobulin and thyroid hormones. Release of TSH is under the hypothalamic control of **thyrotropin-releasing hormone (TRH)**, which also stimulates secretion of PRL.

9. **Types of pars distalis acidophils.**

Somatotropes (GH cells) are most commonly found within the pars distalis. These medium-sized, oval cells exhibit round, centrally located nuclei and produce **growth hormone (GH; somatotropin)**.

Two hormones regulate the release of GH from somatotropes. **Growth hormone–releasing hormone (GHRH)**, stimulates GH release from the somatotropes, and **somatostatin**, inhibits GH release from the somatotropes.

• **Lactotropes (PRL cells, mammotropes)** are large, polygonal cells with oval nuclei. They produce **prolactin (PRL)**. Secretion of PRL is under inhibitory control by **dopamine**, the catecholamine produced by the hypothalamus. However, thyrotropin-releasing hormone (TRH) and **vasoactive inhibitory peptide (VIP)** are known to stimulate synthesis and secretion of PRL.

10. **Chromophobes structure.** Chromophobes are parenchymal cells that stain poorly. They appear as small cells under the light microscope; the cells lack (or have only a few) secretory granules and are arranged

close to one another in clusters. Chromophobes sometimes resemble degranulated chromophils, suggesting that they may represent different stages in the life cycle of various acidophil and basophile populations. They may also represent undifferentiated cells that are capable of differentiating into acidophils and basophils.

11. **Folliculo-stellate cells structure.** Folliculo-stellate cells are characterized by a starlike appearance with their cytoplasmic processes encircling hormone-producing cells. The long branching processes of folliculo-stellate cells form a supporting network for the other cells. They have the ability to make cell clusters or small follicles. Folliculostellate cells are interconnected by gap junctions which transmits signals from the pars tuberalis to pars distalis. These signals may regulate hormone release throughout the anterior lobe of the pituitary gland.

12. **Pars intermedia structure.** The parenchymal cells of the pars intermedia surround colloid-filled follicles. The cells lining these follicles appear to be derived either from folliculo-stellate cells or various hormone-secreting cells. The pars intermedia contains **basophils** and **chromophobes**. The function of the pars intermedia cells in humans remains unclear. Melanocyte-stimulating hormone is found in the human pars intermedia in small amounts, the basophils of the pars intermedia are assumed to be corticotropes**.**

13. **Pars tuberalis structure.** It is a highly vascular region containing veins of the hypothalamohypophyseal system. The parenchymal cells are arranged in small clusters or cords in association with the blood vessels. Nests of squamous cells and small follicles lined with cuboidal cells are scattered in this region. Some functional gonadotropes are present in this region.

14. **Posterior lobe of the pituitary gland (neurohypophysis) structure.** The posterior lobe of the pituitary gland, also known as the neurohypophysis, consists of the **pars nervosa** and the **infundibulum** that connects it to the hypothalamus. The pars nervosa contains the nonmyelinated axons and their nerve endings of approximately 100,000 neurosecretory neurons whose cell bodies lie in the **supraoptic nuclei** and **paraventricular nuclei** of the hypothalamus. The axons form the **hypothalamohypophyseal** tract. The nonmyelinated axons convey neurosecretory products to the pars nervosa. Neurosecretory vesicles form accumulations that dilate portions of the axon near the terminals. These dilations, called **Herring bodies**, are visible in the light microscope.

Although the neurohypophysis consists mainly of axons from hypothalamic neurons, about 25% of the volume of this structure consists of a specific type of highly branched cell called a **pituicyte**.

The neurosecretory vesicles that form Herring bodies contain either **oxytocin** or **antidiuretic hormone** (**ADH**; also called **vasopressin**).

15. **Oxytocin and vasopressin functions. Vasopressin** decreases amount of urine by increasing resorption of water in the kidney. It also increases blood pressure by promoting the contraction of smooth muscle in small arteries and arterioles.

Oxytocin promotes contraction of **uterine smooth muscle** during orgasm, menstruation, and labor and also contraction of the **myoepithelial cells** of the mammary gland during breastfeeding (suckling).

16. **The hypothalamus structure.** The hypothalamus is located in the middle of the base of the brain, and it encapsulates the ventral portion of the third ventricle. It coordinates most endocrine functions of the body and serves as one of the major controlling centers of the autonomic nervous system. The hypothalamus produces numerous neurosecretory products. The anterior part of hypothalamus has supraoptic and paraventricular nuclei. Antidiuretic hormone and oxytocin are secreted by these nucleuses.

There are arcuate, periventricular, paraventricular, ventromedial and dorsal nuclei in the middle part of hypothalamus. Hypothalamic neurons cell bodies are located in these nuclei and secrete polypeptides that promote and inhibit the secretion and release of hormones from the anterior lobe of the pituitary gland. **Releasing hormones** and **inhibiting hormones** are hormones whose main purpose is to control the release of other hormones, either by stimulating or inhibiting their release. They are also called **liberins** and **statins** or **releasing factors**. These **hypothalamic polypeptides** also accumulate in nerve endings near the median eminence and infundibulum and are released into the capillary bed of the hypothalamohypophyseal portal system for transport to the pars distalis of the pituitary gland.

17. **Releasing and inhibiting hormones of hypothalamus.** There are four releasing hormones: growth hormone–releasing hormone, corticotropin releasing hormone, gonadotropin releasing hormone and thyrotropin releasing hormone. There two inhibiting hormones: somatostatin and dopamine.

18. **Pineal gland structure.** The pineal gland contains two basic types of parenchymal cells: pinealocytes and interstitial (glial) cells.

Pinealocytes are the most common parenchymal cell in the pineal gland. They secrete 2 kinds of amines, serotonin and melatonin. They are arranged in clumps or cord within the lobules formed by connective tissue septa that extend into the gland from the pia matter that covers its surface. These cells have a large, deeply infolded nucleus with one or more prominent nucleoli and contain lipid droplets within their cytoplasm.

Pinealocytes show typical cytoplasmic organelles along with numerous, dense-cored, membrane-bounded granules in their elongated cytoplasmic processes. The expanded club-like endings of the processes are associated with the blood capillaries. This feature is strongly suggestive of neuroendocrine activity.

The **interstitial (glial)** cells comprise about 5% of the cells in the gland. They have staining and ultrastructural features that closely resemble those of astrocytes and are reminiscent of the pituicytes of the neurohypophysis.

In addition to the two cell types, the human pineal gland is characterized by the presence of calcified concretions, called brain sand.

19. **Pineal gland function.** In humans, pineal activity, as indicated by changes in the plasma level of melatonin, rises during darkness and falls during light. **Melatonin** helps regulate sleep-wake or circadian rhythms, can suppress libido and early puberty by inhibiting secretion of luteinizing hormone and follicle stimulating hormone. In addition to its hormone actions, melatonin also has strong antioxidant properties and it may help strengthen the immune system. As an antioxidant, it hunts down and eliminates cell-damaging free radicals, possibly helping to prevent or delay the development of heart disease, cancer and other conditions. **Serotonin** regulates mood and also is called hormone of happiness.

20. **Adrenal glands general plan of structure.** The adrenal glands have a flattened triangular shape and are embedded in the perirenal fat at the superior poles of the kidneys. The glands are covered with a thick connective tissue capsule from which trabeculae extend into the parenchyma, carrying blood vessels and nerves. The secretory parenchymal tissue is organized in cortical and medullary regions. The **cortex** is the steroid-secreting portion. It lies beneath the capsule and constitutes nearly 90% of the gland by weight. The adrenal cortex is divided into three zones on the basis of the arrangement of its parenchymal cells. The zones are designated as zona glomerulosa, the narrow outer zone, zona fasciculata, the thick middle zone and zona reticularis, the inner zone. The **medulla** is the catecholamine-secreting portion. It lies deep to the cortex and forms the center of the gland.

21. **Adrenal gland development.** Parenchymal cells of the cortex and medulla are of different embryologic origin. Embryologically, the cortical cells originate from mesodermal mesenchyme, whereas the medulla originates from neural crest cells that migrate into the developing gland.

22. **Zona glomerulosa structure and functions.**

The cells are relatively small columnar or pyramidal shaped. The cells of the zona glomerulosa secrete **mineralocorticoids,** compounds that function in the controlling electrolyte homeostasis (mainly sodium and potassium) and blood pressure and also maintaining the osmotic balance in the urine, increase inflammatory processes in the body. The principal secretion is **aldosterone** (95% of mineralocorticoids).

23. **Zona fasciculata structure and functions.** The cells of the zona fasciculata are large and polyhedral. They have a lightly staining spherical nucleus. The generally acidophilic cytoplasm contains numerous lipid droplets. The cells have highly developed sER, mitochondria, a well-developed Golgi complex and numerous rER. The zona fasciculata secretes **glucocorticoids,** so called because of their role in regulating **gluconeogenesis** and **glycogenesis**. The most important of the glucocorticoids secreted by the zona fasciculata is **hydrocortisone (cortisol).** Also they secrete **cortisone** and **corticosteron**. This compound acts on many different cells and tissues to increase the metabolic availability of glucose and fatty acids. Glucocorticoids depress the immune response and the inflammatory response and, as a result of the latter, inhibit wound healing. They also provide resistance to stress and suppress some allergic reaction.

24. **Zona reticularis structure and functions.** The cells of the zona reticularis are smaller than those of the zona fasciculata, and their nuclei are more deeply stained. They are arranged in anastomosing cords, separated by fenestrated capillaries. The cells have relatively few lipid droplets. Both light and dark cells are seen. They have a well-developed sER and numerous mitochondria, but they have little rER.

The principal secretion of the cells in the zona reticularis consists of weak androgens, mostly **dehydroepiandrosterone (DHA).** The cells also secrete some glucocorticoids, in much smaller amounts than those of the zona fasciculata. Here, too, the principal glucocorticoid secreted is **hydrocortisone**.

25. **Adrenal medulla structure and functions.** Adrenal medullary cells are modified postganglionic neuronal cells that have a secretory function. The **medulla**, is composed of large, epithelioid cells, called **chromaffin cells**, connective tissue, numerous sinusoidal blood capillaries, and nerves. The catecholamines epinephrine (80%) and nor-epinephrine (20%) secreted by the medullary cells are produced by different cell types. One population of cells contains only large **dense core granules**. These cells secrete norepinephrine. The other population of cells contains granules that art smaller, more homogeneous, and less dense. These cells secrete epinephrine. Catecholamines have sympathomimetic functions (increases

heart rate, blood pressure, sweating, rate of respiration and decreases blood flow to viscera and skin, digestion, urine production and others.

26. **Thyroid gland general structure.** The thyroid is a bilobed endocrine gland located in the neck, anterolateral to the larynx and upper trachea. The lobes are connected by a thin band of thyroid tissue, the isthmus that crosses anterior to the upper part the trachea. A thin connective tissue capsule surrounds the gland. It sends trabeculae into the parenchyma to partially outline irregular lobes and lobules. **Secretory follicles** constitute the functional and structural units of the gland. The follicle is a spheroidal cyst-like compartment with a wall formed by a simple squamous or cuboidal epithelium, the follicular epithelium. The lumina of the follicles are filled with a gel-like mass called colloid. The apical surfaces of the follicular epithelial cells are in contact with the colloid, and the basal surfaces rest on a typical basal lamina. The follicles are surrounded by an extensive network of fenestrated capillaries. Two basic cell types are present in the follicles principal or follicular cells and parafollicular or C cells. **Follicular** cells secrete thyroxin (tetroidothyronine T_4) and triidothyronin T_3. **Parafollicular** cells secrete calcitonin.

27. **Follicular cells and parafollicular cells structure.** The nuclei of **follicular cells** are spherical. The active cuboidal or columnar cells reveal the presence of organelles commonly associated with both secretory and absorptive cells. The organelles include typical junctional complexes at the apical end of the lateral plasma membrane, short microvilli on the apical of the cells, rough surfaced endoplasmic reticulum in the basal region, supranuclear Golgi complex, abundant lysosomes and multivesicular bodies, and membrane limited vesicles, identified as colloidal resorption droplets in the apical region. Colloid contains thyroglobulin, the inactive storage form of the thyroid hormones.

Parafollicular cells (C cells, calcitonin cells) are present within the follicular epithelium or are scattered in the connective tissue. C cells are pale staining and occur as solitary cells or small clusters of cells. In the follicles they are located near the basal lamina and do not extend to the follicular lumen to the contact the colloid. They have numerous, small, membrane-bounded secretory granules and a prominent Golgi apparatus.

28. **Synthesis and secretion of thyroglobulin**. The protein portion of thyroglobulin is synthesized in the rER of the follicular epithelial cells and glycosylated there and in the Golgi complex before it is secretes by exocytosis into the lumen of the follicle.

- **Uptake and concentration of iodide** from the blood by follicular epithelial cells, release of iodide into the colloid, and **oxidation of iodide to iodine** by thyroid peroxidase in the colloid;
- **Iodination of some tyrosine residues of the thyroglobulin** occurs in the colloid near the microvilli of the apical cell su|rface; Addition of one iodine atom to a single tyrosine residue forms monoiodotyrosine (MIT). Addition of a second iodine atom to the MIT residue forms diiodotyrosine (DIT) residue.
- **Formation of T3 and T4 hormones** in the colloid by oxidative coupling reactions; The thyroid hormones are formed by oxidative coupling reactions of two iodinated tyrosine residues in close proximity.
- **Resorption of colloid**. In response to TSH, follicular cells take up thyroglobulin from the colloid by a process of receptor-mediated endocytosis. Thyroglobulin is degraded by lysosomal proteases into constituent amino acids and carbohydrates, leaving free T4, T3, DIT, and MIT molecules
- **Release of T4 and T3 from the cell into the circulation**.

These active thyroid hormones T_4 and T_3 cross the basal membrane and enter blood and lymphatic capillaries. About 90% of all thyroid secretions is T4. Other hormone T3 is secreted in comparatively small amounts also its metabolic effects are much stronger than those of T_4.

29. **Thyroid gland functions.** It function is essential to normal growth and development. The thyroid gland produces three hormones, each of which is essential to normal metabolism and homeostasis. **T_4** and **T_3** regulate cell and tissue metabolism, influences body and tissue growth and development of the nervous system in the fetus and young child. **Calcitonin** lowers blood calcium level by suppressing bone resorption and increasing the rate of osteoid calcification. Secretion of calcitonin is regulated directly by blood calcium levels. High levels of calcium stimulate secretion, low levels inhibit it.

30. **Parathyroid glands general structure.** They are small endocrine glands closely associated with the thyroid. They are ovoid, a few millimeters in diameter, and arranged in two pairs, to comprise the **superior** and **inferior parathyroid glands.** They are usually located in the connective tissue on the posterior surface of the thyroid. Structurally, each parathyroid gland is surrounded by a thin connective tissue capsule that separates it from the thyroid. Septa extend from the capsule into the gland to divide it into lobules and to separate the densely packed cords of cells.

31. **Principal (chief) cells and oxyphil cells structure.** Principal (chief) cells and oxyphil cells constitute the epithelial cells of the parathyroid gland. **Principal (chief) cells** are responsible for synthesis, storage, and secretion of large amounts of parathormone (PTH). They are small, polygonal cells,

with a centrally located nucleus. The pale-staining, slightly acidophilic cytoplasm contains lipofuscin-containing vesicles, large accumulations of glycogen, and lipid droplets. Small, dense, membrane-limited vesicles are thought to be the storage form of PTH.

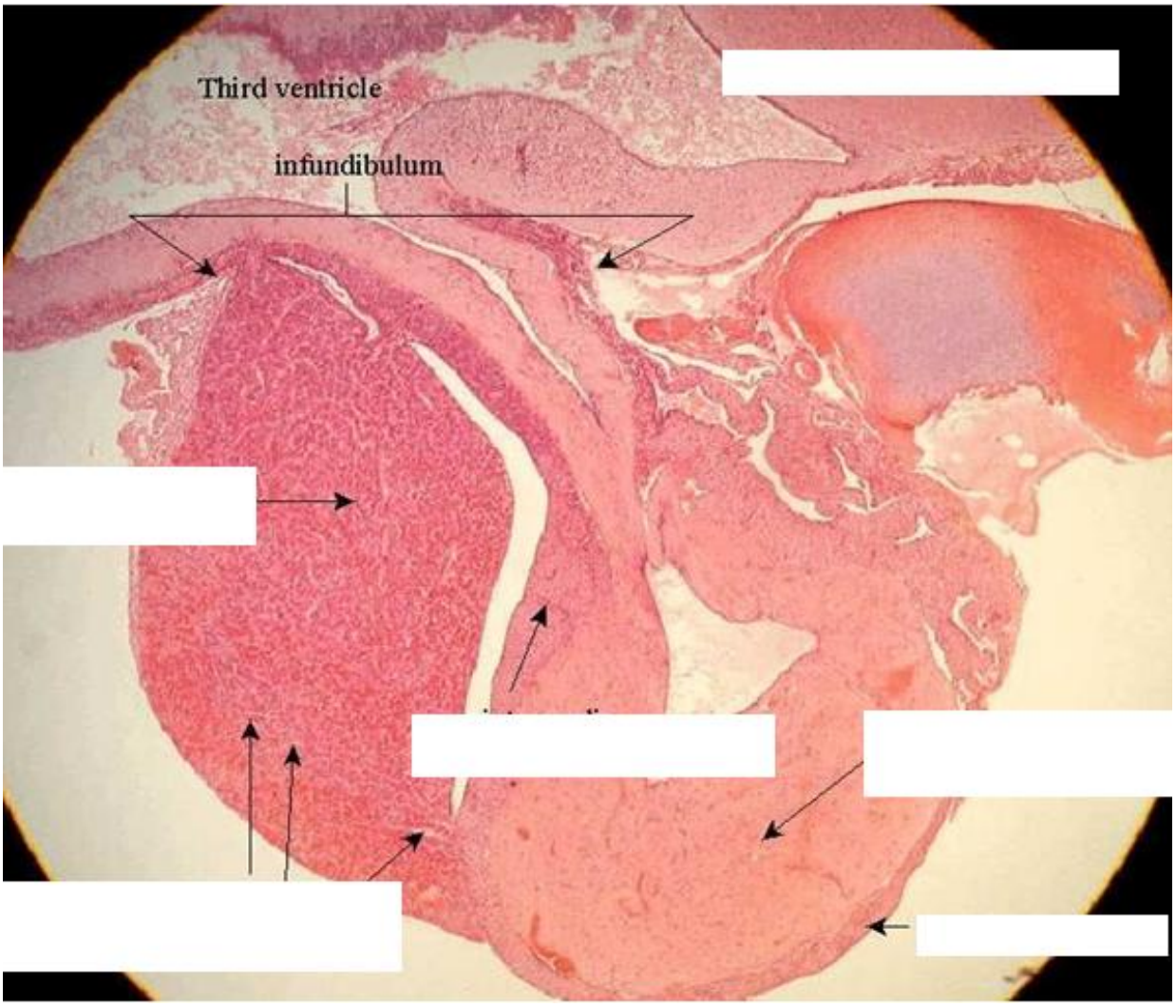
Oxyphil cells They constitute a minor portion of the parenchymal cells. They are found singly or in clusters; the cells are more rounded, considerably larger than the principal cells, and have a distinctly acidophilic cytoplasm. Mitochondria almost fill the cytoplasm. No secretory vesicles and little if any rER are present. Cytoplasmic inclusion bodies consist of occasional lysosomes, lipid droplets, and glycogen distributed among the mitochondria.

32. **Parathyroid gland functions.** The parathyroids function in the regulation of blood ion levels of calcium and phosphate. Parathyroid hormone is essential for life. Release of this hormone causes the level of calcium in the blood to increase. Simultaneously, it reduces the concentration of phosphate. Bone resorption is stimulated by PTH. During osteolysis, calcium and phosphate are both released from calcified bone matrix into the extracellular fluid.

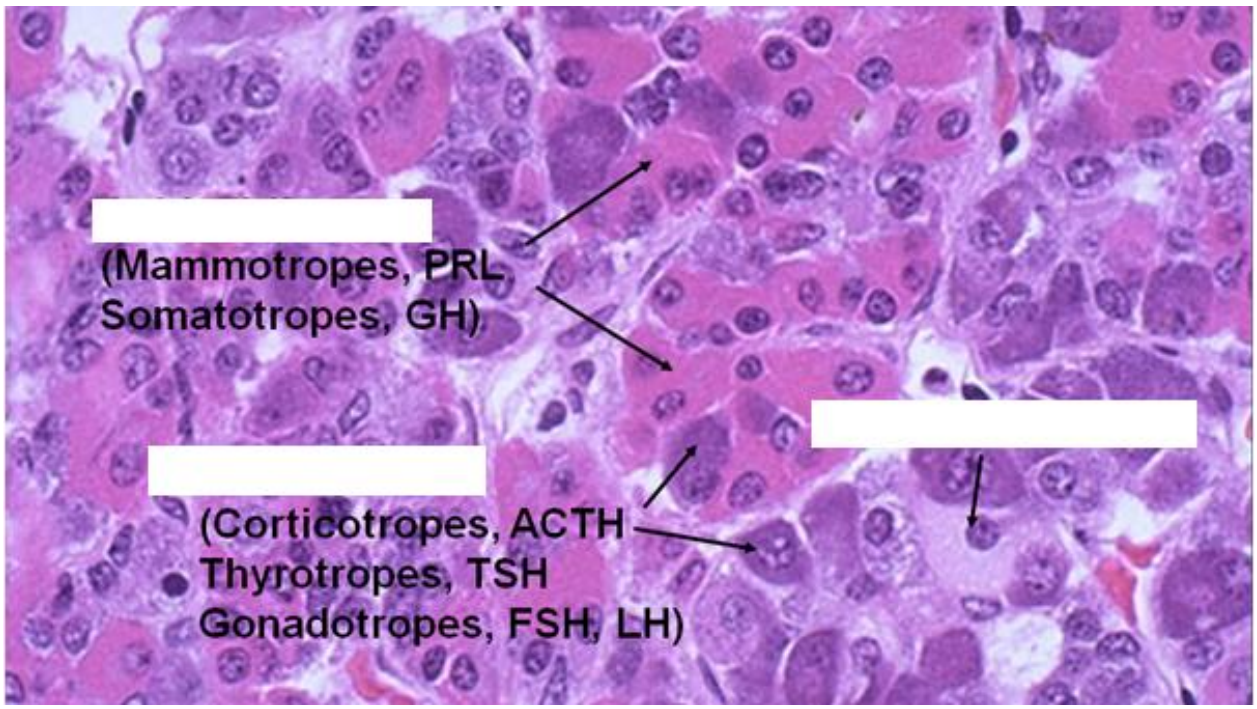
33. **Parathyroid gland development.** Embryologically, the inferior parathyroid glands (and the thymus) derive from the third branchial pouch; the superior glands, from the fourth branchial pouch.

PRACTICAL QUESTIONS

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



2. Fill in the white gaps with designations in the pictures below.



3. What parts of the hypophysis do you know? How do they subdivide?

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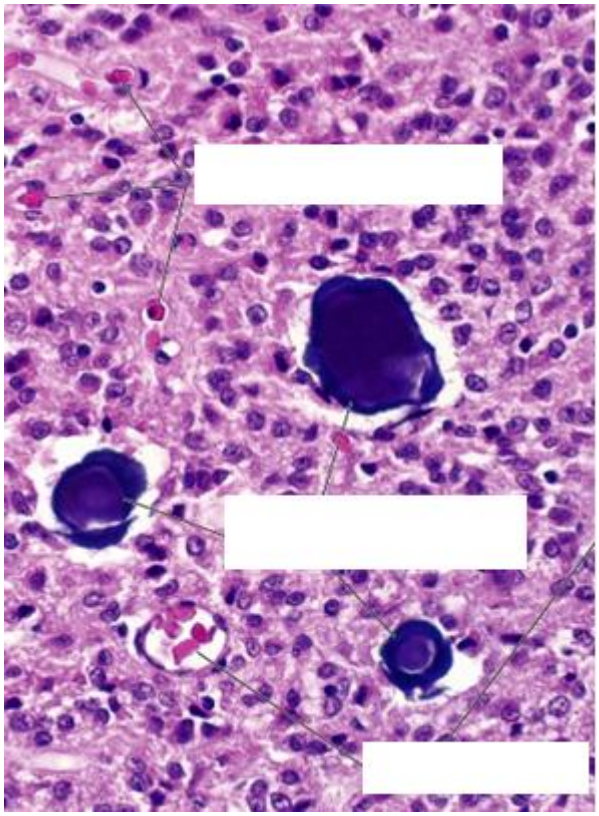
4. Fill in the white gaps with designations in the pictures below.



5. What cells of the pineal gland do you know? Describe them.

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6. What functions do they perform?

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7. What is brain sand?

_____

8. Identify the structure labeled 1 in the picture below. Use picture in the left as a clue.

_____

9. Identify the structure labeled 2.

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10. Identify the structure labeled 3.

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11. Identify the structure labeled 4.

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12. Identify the structure labeled 5.

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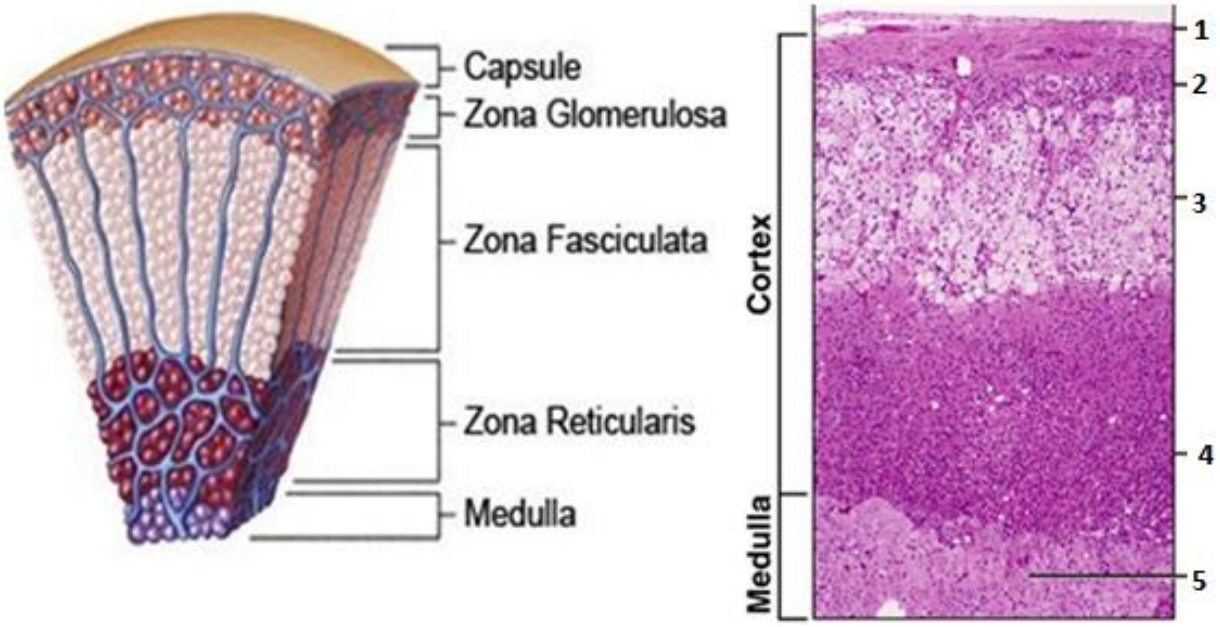
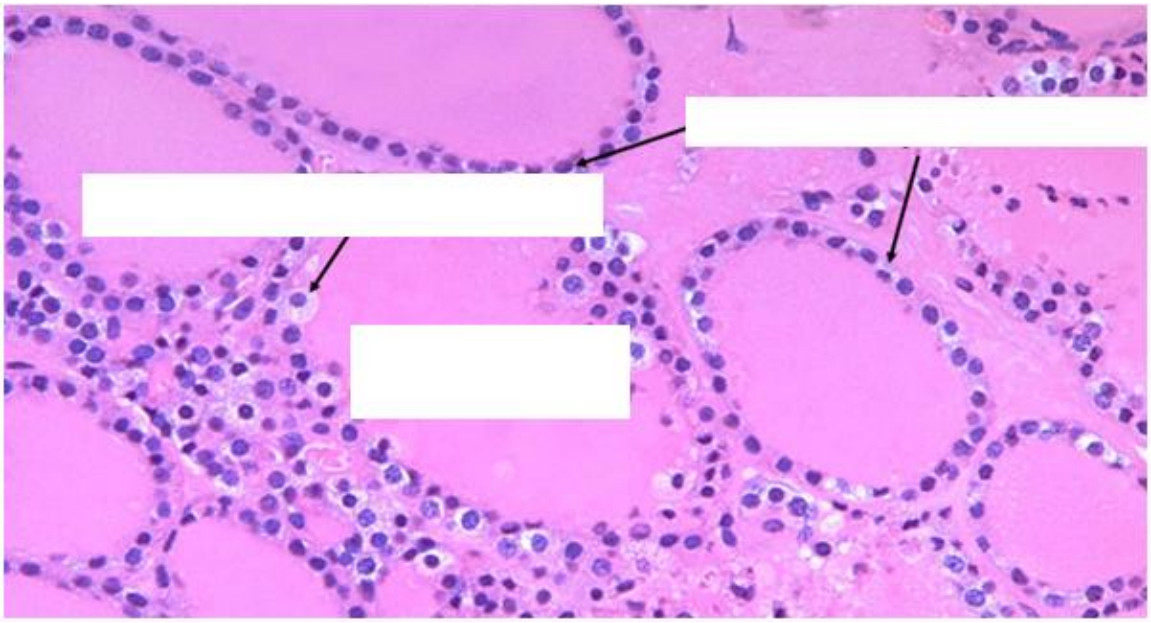


13. Fill in the white gaps with designations in the pictures below.



14. How is called structural and functional unit of the thyroid gland?

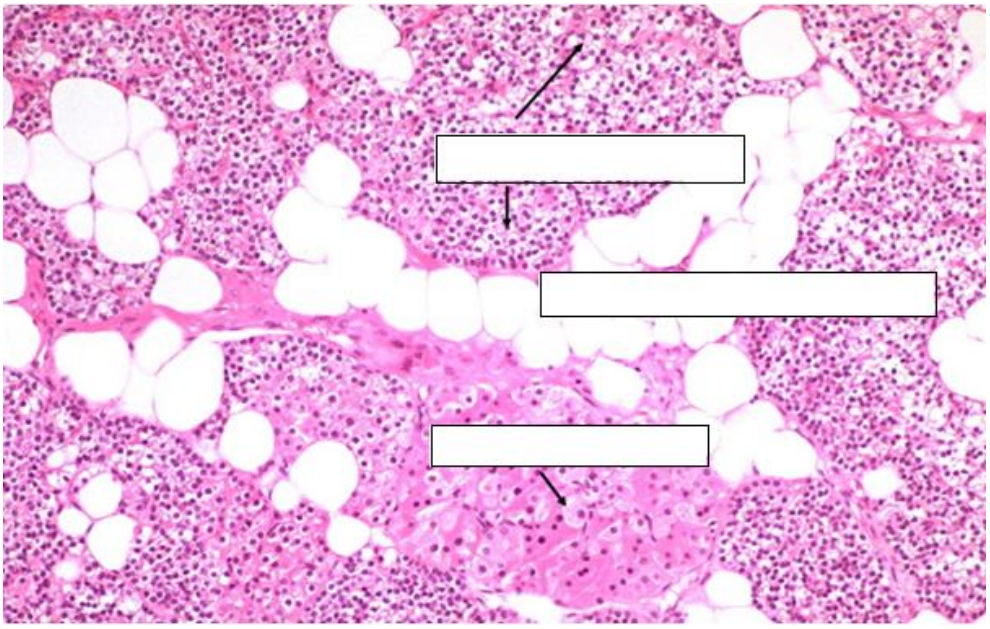
_____

15. What hormones synthesize follicular and parafollicular cells of the thyroid gland?

_____

_____

16. Fill in the white gaps with designations in the pictures below.



SLIDE 1

Hypophysis

Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Capsule
2. Anterior lobe

a. Chromophiles

b. Chromophobes

3. Pars intermedia
4. Posterior lobe

SLIDE 2

Thyroid and parathyroid glands

Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Follicle
2. Follicular cells
3. Colloid
4. Stroma with blood vessels and parafollicular cells
5. Parathyroid gland capsule
6. Principal cells

SLIDE 3

Adrenal gland

Dye: hematoxylin-eosin

SLIDE'S DESIGNATION

1. Capsule
2. Cortex

a. Zona glomerulosa

b. Zona fasciculata

c. Zona reticularis

3. Medulla
4. Stroma with blood vessels

To the doctor turned a 27-year-old man. An enlargement of hands, feet and lower jaw were revealed during the examination. Moreover the deformation of joints and hormonal disorders (impotence, testicular atrophy) were observed. What gland has impaired function?
A. *****Anterior hypophysis
B. Adrenal glands
C. Pineal gland
D. Thyroid gland
E. Parathyroid gland

The patient has a significant increase in daily urine output. Which hormone of the hypothalamus has impaired secretion?
A *Vasopressin
B Oxytocin
C Liberins
D Statins
E Thyroid

A 25-year-old woman consulted a doctor with complaint about reduction in milk production a month after delivery. What hormone is produced in insufficient amount?
A *Prolactin
B Adrenocorticotropic hormone
C Somatostatin
D Insulin
E Glucagon

The parenchyma of the anterior hypophysis is presented by trabecules which are formed by glandular cells. There are cells with granules that stain with basic dyes and contain glycoproteins among cells of adenohypophysis. What are these cells?
A *Gonadotropes, thyrotropes
B Somatotropes
C Melanotropes
D Mammotropes
E Chromophobes

Pocket of Rathke, which is directed to the base of the future brain, is formed from the ectodermal epithelium lining the upper part of the oral fossa of the human embryo. What develops from this embryonic rudiment?
A *Adenohypophysis
B Neurohypophysis
C Medial eminence
D Hypophyseal stalk
E Anterior hypothalamus

Roentgenological examination of skull base bones revealed enlargement of sellar cavity, thinning of anterior clinoid processes, destruction of different parts, and destruction of different parts of sella turcica. Such bone destruction might be caused by a tumor of the following endocrine gland:
A *Hypophysis
B Epiphysis
C Thymus gland
D Adrenal glands
E Thyroid gland

An endocrine gland with parenchyma consisting of epithelium and neural tissue is under morphological examination. Epithelial trabeculae have two types of cells: chromophilic and chromophobic. Identify this organ:
A *Hypophysis
B Adrenal glands
C Hypothalamus
D Thyroid gland
E Parathyroid gland

Epithelial strands, which are composed of chromophilic (acidophilic, basophilic) and chromophobic cells are revealed in a histological specimen of endocrine glands. What organ is presented in a histological specimen?
A *Adenohypophysis
B Adrenal gland
C Neural hypophysis
D Thyroid gland
E Pineal gland

A 32-year-old patient consulted a doctor about the absence of lactation after parturition. Such disorder might be explained by the deficit of the following hormone:
A *Prolactin
B Somatotropin
C Vasopressin
D Thyrocalcitonin
E Glucagon

Examination of a patient revealed overgrowth of facial bones and soft tissues, tongue enlargement, wide interdental spaces in the enlarged dental arch. What changes of the hormonal secretion are possible?
A *Hypersecretion of the somatotropic hormone
B Hyposecretion of the somatotropic hormone
C Hypersecretion of insulin
D Hyposecretion of thyroxin
E Hyposecretion of insulin

A 40-year-old patient complains about intensive heartbeats, sweating, nausea, visual impairment, arm tremor, hypertension. From his anamnesis: 2 years ago he was diagnosed with pheochromocytoma. What hormones hyper production does the given pathology cause?
A *Catecholamines
B Aldosterone
C Glucocorticoids
D ACTH
E Thyroidal hormones

A man has suddenly reduced dieresis after loss of 1,5 liter of the blood . The increased secretion of what hormone caused such diuresis alteration?
A *Vasopressin
B Corticotropin
C Natriuretic
D Cortisol
E Parathormone

The aim of the morphological study was to investigate an endocrine gland with parenchyma consisting of epithelium and neural tissue. In the epithelial trabeculae the study revealed two types of cells: chromophile and chromophobe. Identify this organ:
A *Pituitary gland
B Adrenal gland
C Hypothalamus
D Thyroid gland
E Parathyroid gland

The patient was diagnosed with acromegaly in endocrinology department. What cells of the pituitary gland are hyperactive, which causes this disease?
A *Somatotropes
B Gonadotropes
C Chromophobes
D Mammotropes
E Thyrotropes

The milk secretion is reduced in the woman, who is breast-feeding a baby. The secretory process in lactotropic cells is not violated. What hormone is insufficient?
A *Prolactin
B Oxytocin
C Progesterone
D Estrogens
E Follicle stimulating hormone

A 45-year-old man consulted a doctor with complaints about increase in size of hands, feet, brow, cheekbones, and nose. The patient was diagnosed with acromegaly. What cells of hypophysis are hyperactive?
A *Somatotropes
B Adrenocorticotropes
C Gonadotropes
D Thyrotropes
E Mammotropes

Proportionally built child has growth retardation. Which cells of the anterior hypophysis are affected?
A *Somatotropes
B Mammotropes
C Gonadotropes
D Adrenocorticotropes
E -

The patient with acromegaly has the enlargement of extremities and bony skeleton of the face. What cells causing this disease are hyperactive?
A *Somatotropes
B Mammotropes
C Gonadotropes
D Adrenocorticotropes
E -

Muscles of the myometrium don't contract sufficient in the woman during childbirth. This is manifested by weakness of labor. What nuclei of hypothalamus have hypofunction?
A *Paraventricular
B Arcuate
C Suprachiasmatic
D Supraoptic
E Dorsomedialis

Axons of neurosecretory cells of supraoptic nucleus of the hypothalamus were cut in the animal during an experiment. What hormone of the pituitary gland has impaired storage?
A *Vasopressin
B Somatotropin
C Prolactin
D Adrenocorticotropin
E Lipotropin

Reduce of uterine contractive activity appears in the woman during childbirth. Which hormone of the hypothalamus can increase the contractile activity of the uterus in this situation?
A *Oxytocin
B Vasopressin
C Liberins
D Statins
E -

The woman had a weak contraction of the myocytes of uterus during childbirth. Insufficiency of what hypothalamic hormone can cause this condition?
A *Oxytocin
B Folliberin
C Prolactoliberin
D Somatoliberin
E Vasopressin

Both sex glands were removed from the woman during surgical intervention for malignant ovarian tumors. What will happen with gonadotropic cells of the pituitary gland in this case?
A *Hypertrophy
B Atrophy
C Necrosis
D Malignization
E Lysis

A 40-year-old woman has weak labor activity caused by weak contraction of myometrium. What hormone should be injected to help this woman?
A. *Oxytocin
B. Hydrocortisone
C. Dexametasone
D. Aldosterone
E. Prednisolone

Increasing of the cavity of sella turcica and thinning of processus clinoideus anterior and damaging of different areas of sella turcica were revealed in the base of the cranium bones during X-ray examination. Tumor of what endocrine gland can cause such damaging of bones?
A. *Hypophysis
B. Thymus
C. Pineal gland
D. Thyroid gland
E. Adrenal gland

For morphological investigation endocrine gland was represented. Parenchyma of this gland consists of epithelium and nervous tissue. In epithelial trabeculae revealed two types of cells chromophiles and chromophobes. Name this organ.
A. *Hypophysis
B. Adrenal gland
C. Hypothalamus
D. Thyroid gland
E. Parathyroid gland

The patient complaints about sharp increase in urine output (up to 5-7 L of urine per day). Examination showed that the patient has a reduced secretion of vasopressin. Which cells are showing a lack of secretory activity?
A *Neurosecretory cells of the hypothalamus
B Endocrine cells of the anterior pituitary
C Endocrine cells of intermediate part of the hypophysis
D Pituicytes
E Cells of tuberal part of the hypophysis

The very tall patient with long thick fingers, large lower jaw and protruding lower lip consulted a doctor. What hormone probably has an increased secretion?
A *Growth hormone of the anterior pituitary
B Gonadotropic hormone of the anterior pituitary
C Glucocorticoids of fascicular zone of the adrenal gland
D Thriiodothyronine of theroid follicles
E Somatostatin of D-cells of Langerhans islets

An endocrine gland, the parenchyma of which is formed by the epithelial and nervous tissues is presented in a histological specimen. In the epithelial tissue are determined chromophilic and chromophobic cells. There are cells secretory granules of which provide basophilic staining of the cytoplasm among chromophils. Name these cells
A *Thyrotropes, gonadotropes, adrenocorticotropes
B Mammotropes, adrenocorticotropes, gonadotropes
C Somatotropes, mammotropes
D Thyrotropes, somatotropes, gonadotropes
E Mammotropes and gonadotropes

One can see cells, the cytoplasm of which is stained basophilic in a histological specimen of anterior pituitary gland among endocrine cells. These cells synthesize follicle-stimulating and luteinizing hormones. What are these cells?
A. *Gonadotropes
B. Thyrotropes
C. Mammotropes
D. Somatotropes
E. Pituicytes

Student made an inaccuracy by telling that synthesis of glucocorticoids from cortical region of adrenal gland is stimulated by hypophysis hormones during characterization of stress. What clarification should he make?
A. *Adrenocorticotropic hormone
B. Somatotropin
C. Gonadotropic hormone
D. Mammotropic hormone
E. Thyrotropic hormone

Diuresis has significantly increased in a 50-year-old patient after infectious disease of the brain. Level of glucose was 4,1 mmol/L in the blood. The doctor decided that it is inadequate function of endocrine system. What hormone is most likely insufficient?
A. *Vasopressin
B. Glucagon
C. Insulin
D. Cortisol
E. Aldosterone

Experimental animal produces big amount of urine and have strong thirst. Urine doesn't have sugar. What cells disordered?
A. *Neurosecretory cells of supraoptic nucleus
B. Follicular endocrine cells of the thyroid gland
C. Principal cells
D. Endocrine cells of the zona glomerulosa of adrenal gland
E. Endocrine cells of the medullary region of adrenal gland

Patient has suffered from hypothyroidism for 7 years. Deficiency of thyrotropic hormones was revealed. What cells of adenohypophysis will be changed?
A. *Thyrotropes
B. Gonadotropes
C. Corticotropes
D. Somatotropes
E. Mammotropes

Increased amount of follicle stimulating hormone was revealed on the background of deficiency of sex hormones in a 30-year-old female. What cells synthesize this hormone?
A. *Gonadotropes
B. Thyrotropes
C. Corticotropes
D. Somatotropes
E. Mammotropes

One can see cells with oxyphilly stained cytoplasm in the specimen of adenohypophysis between endocrine cells. These cells secrete prolactin. Name these cells.
A. *Mammotropes
B. Thyrotropes
C. Adrenocorticotropes
D. Gonadotropes
E. Pituicytes

Examination of a 32-year-old patient revealed disproportional skeleton size, enlargement of superciliary arches, nose, lips, tongue, jaw bones and feet. What gland function was disturbed?
A *Hypophysis
B Epiphysis
C Pancreas
D Thyroid
E Suprarenal

A 35-year-old patient complains about permanent thirst, bad appetite. He drinks every day 9 L of fluid. Daily diuresis increased, urine discolored. Most probable reason of such pathology development in this patient is:
A. *Hypothalamic nucleuses
B. Epithelia of nephron tubules
C. Adenohypophysis
D. Pineal gland
E. Basal membrane of glomerulus capillaries

A 27-year-old patient has bronze color of the skin which typical for Addison disease after sepsis. Mechanism of hyper pigmentation is based on increasing of hormone secretion.
A. *Melanostimulating
B. Somatotropic
C. Gonadotropic
D. B lipotropic
E. thyreotropic

Cessation of bleeding connects with action of oxytocin to the uterus wall after parturition. Which layer of the organ does react at the action of this hormone?
A. *Myometrium
B. Endometrium
C. Perimetrium
D. Parametrium
E. Submucous

A 50-year-old patient complains about enlargement of ears, nose and hands size. Hyperfunction of which gland does these symptoms give?
A. *Hypophysis
B. Thyroid gland
C. Sex glands
D. Adrenal glands
E. Pineal gland

Endocrine system organ is represented in the slide. It surrounded by connective tissue capsule which extends trabeculae in the center of the organ and formed lobules. Each lobule contains two types of cells. Neurosecretory pinealocytes are polygonal cells with processes located in the center and glial cells (astrocytes) located in the periphery. What organ is this?
A. *Pineal gland
B. Hypophysis
C. Hypothalamus
D. Thyroid gland
E. Medullary region of the adrenal gland

Cortex and medulla, which are separated by a layer of connective tissue, are distinguished in a histological specimen of an endocrine gland. Parenchyma cells of the cortex form three zones: in the superficial zone there are round clusters, in the middle – parallel strands, in a deep – cell cords form a network. What gland is this?
A. Adrenal glands
B. Thyroid gland
C. Hypophysis
D. Pineal gland
E. hypothalamus

Endocrinologist observed a 40-year-old patient, who has insufficient function of the adrenal glands cortex, which is manifested by a reduction of the level of aldosterone in the blood. What cells of the cortex have impaired function?
A *Cells of the zona glomerulosa
B cells of the zona fasciculata
C Cells of the zona reticularis
D Cells of the intermediate zone
E Cells of X-zone

It is known that aldosterone regulates amount of sodium in the body. What cells of the adrenal gland do these hormones synthesize?
A. *Cells of zona glomerulosa
B. Chromaffin cells produce epinephrine
C. Cells of zona reticularis
D. Cells of zona fasciculata
E. Chromaffin cells produce norepinephrine

In the specimen parenchymal organ is represented. External layer of the cortex of it is formed by glomeruli created by endocrine cells. What organ is it?
A. *Adrenal gland
B. Lymph node
C. Spleen
D. Thyroid gland
E. Ovary

A patient has been given high doses of hydrocortisone for a long time. This caused atrophy of one of the adrenal cortex zones. What zone is it?
A *Fascial
B Glomerular
C Reticular
D Glomerular and reticular
E -

A histological specimen represents parenchymal organ, which has cortex and medulla. Cortex consists of epitheliocytes bars with blood capillaries between them; the bars form three zones. Medulla consists of chromaffinocytes and venous sinusoids. Which organ has these morphological features?
A *Adrenal gland
B Kidney
C Lymph node
D Thymus
E Thyroid

Large cells which impregnate by solution of potassium dichromate were found in the study of removed during surgery adrenal gland. What hormone is synthesized by these cells?
A *Adrenalin
B Aldosterone
C Secretin
D Thyroxin
E Cholecysrocinin

One of the adrenal glands was removed from the patient for medical reasons. How will change the structure of the second adrenal gland?
A *Hypertrophy of cells of the cortex and medulla
B Atrophy of the medulla cells
C Atrophy of the cortex cells
D Necrosis of the medulla cells
E Lysis of the cortex cells

As a result of stress the relaxation of smooth muscle cells of the intestine occurred in adult. Result of action of what substance can cause this condition?
A. *Adrenaline
B. Histamine
C. Gastrin
D. Cholecystokinin
E. Serotonin

The adrenal gland is a complex endocrine gland with many areas that produce complexes of various hormones. What hormones are produced by endocrinocytes of the zona fasciculate of the adrenal cortex?
A *Glucocorticoids
B Androgens, female sex hormones
C Aldosterone
D Noradrenalin, adrenalin
E Renin

Precocious puberty occur in the experimental animals after endocrine glands removal. By what gland removal is this happened?
A. *Pineal gland
B. Hypophysis
C. Adrenal gland
D. Thyroid gland
E. Parathyroid gland

In a histological specimen of adrenal cortex there are small polygonal cells that form roundish clusters and contain some lipid inclusions. What part of adrenal gland is represented in this histological specimen?
A *Glomerulosa zone
B Intermedial zone
C Fasciculata zone
D Reticularis zone
E -

Microscopic examination of a parenchymatous organ revealed that its epithelial cords formed glomerular, fascicular and reticular zones. The central part of the organ was presented by accumulations of chromaffin cells. Specify this organ:
A *Adrenal gland
B Thyroid gland
C Epiphysis
D Liver
E Hypophysis

There are large endocrine cells, secretory granules of which are osmiophilic and argyrophilic in the wall of follicles and interfollicular layers of connective tissue of the thyroid gland. Name these cells.
A *Calcitoninocytes
B Thyrocytes
C Parathyrocytes
D Pinealocytes
E Pinuicytes

A child has abnormal formation of tooth enamel and dentin as a result of low concentration of calcium ions in blood. Such abnormalities might be caused by deficiency of the following hormone:
A *Parathormone
B Thyrocalcitonin
C Thyroxin
D Somatotropic hormone
E Triiodothyronine

One can see roundish structures in the endocrine gland specimen. Their wall is formed with one layer of epithelial cells resting on the basal membrane. These structures contain homogeneous non cellular mass in the middle of them. What gland is it?
A. *Thyroid gland
B. Adrenal gland, cortex
C. Parathyroid gland
D. Anterior part of hypophysis
E. Posterior part of hypophysis

A 2-year-old child experienced convulsions because of lowering calcium ions concentration in the blood plasma. Function of what structure is decreased?
A *Parathyroid glands
B Hypophysis
C Adrenal cortex
D Pineal gland
E Thymus

Parodontitis is treated with calcium preparations and a hormone that stimulates tooth mineralization and inhibits tissue resorption. What hormone is it?
A *Calcitonin
B Parathormone
C Adrenalin
D Aldosterone
E Thyroxine

A patient suffering from thyrotoxic symptoms of vegetoasthenic syndrome was revealed. What of the following would show the histological appearance of a thyroid gland being stimulated by thyroid-stimulating hormone (TSH)?
A *Columnar-shaped follicular cells
B Decreased numbers of follicular cells
C Increased numbers of parafollicular cells
D An abundance of colloid in the lumen of the follicle
E Decreased numbers of parafollicular capillaries

Kidneys of a man under examination show increased resorption of calcium ions and decreased resorption of phosphate ions. What hormone causes this phenomenon?
A *Parathormone
B Thyrocalcitonin
C Hormonal form D_3
D Aldosterone
E Vasopressin

Columnar shape of thyrocytes, the increased number and height of microvilli, increased number of plasmolemma invaginations on the basal surface are determined in a histological specimen of the thyroid gland. What functional condition is characterized by such histological picture?
A *Enchancing of the functional activity
B Inhubition of the functional activity
C Normal function
D Involutional age-related changes
E -

A 30-year-old patient was diagnosed with thyroid gland hyperfunction. What shape do follicular cells have in the follicles?
A. *Columnar
B. Polygonal
C. Squamous
D. Spindle
E. Cuboidal

A 42-year-old patient after resection of thyroid gland had convulsions. After injection of calcium preparation she got relief. What endocrine glands disorder has caused this condition?
A. *Parathyroid
B. Adrenal
C. Ovary
D. Hypophysis
E. Pineal

Large argyrophilic cells located in the wall of follicles are visible in a histological specimen of the thyroid gland after impregnation with silver salts. Which hormone is synthesized by these cells?
A *Calcitonin
B Thyroxin
C Parathyrin
D Aldosterone
E Adrenaline

Stroma and parenchyma are visible in a histological specimen of the thyroid gland. What type of tissue forms the stroma of the gland?
A *Loose connective tissue
B Dense connective tissue
C Adipose tissue
D Muscle tissue
E Nervous tissue

Microscopic study of an endocrine gland revealed that its parenchyma consisted of follicular structures. Their wall was formed by simple cuboidal epithelium, and their cavity was filled with oxyphilic substance. What hormone is secreted by this gland?
A *Thyroxin
B Aldosterone
C Cortisol
D Parathormone
E Oxytocin

Tetany characterized by spasms of the striated muscles was developed in the patient after surgery of the thyroid gland. Histological examination of the removed material revealed the formation under capsule shared with thyroid gland. This formation is made up of cell trabeculae connected to each other by means of desmosomal junctions. There are some with basophilic cytoplasm, other with acidophilic cytoplasm among these cells. What formation is this?
A *Parathyroid gland
B Clusters of parafollicular cells
C Clusters of proliferating thyrocytes
D Interfollicular islet
E Tumor of the thyroid gland

A high level of basic metabolism without hyperthyroidism may be a manifestation of disease which at the molecular level is characterized by the damage of oxidative phosphorylation. What cellular component is damaged in this case?
A *Mitochondria
B Microtubules
C Lysosomes
D Golgi apparatus
E Peroxysomes

A 35-year-old patient has increase in body weight, decrease in body temperature, dry skin, hair loss, depression functions of central nervous system, bradycardia. What gland has impaired function?
A. *Thyroid gland
B. Parathyroid gland
C. Pancreas
D. Adrenal gland
E. Gonads

Endocrine gland was removed by mistake in the patient during operation. It caused decreasing of the calcium blood level. What gland was removed?
A. *Parathyroid
B. Hypophysis
C. Adrenal
D. Thyroid
E. Pineal

A 40-year-old patient consulted a doctor with complains about tachycardia, exophthalmos, fatigability, reduced weight of the body. What cells increasing function does this condition connect?
A. *Follicular cells
B. Parafollicular cells
C. Parathyroid cells
D. APUD cells
E. Acidophil endocrine cells

Under action of harmful environmental factors lysosomes formation were disordered in follicular cells. What part of hormone production in the thyroid gland will be disordered?
A. *Proteolysis of phagocytized colloid from follicles
B. Colloid synthesis
C. Iodination of colloid
D. Resorption of colloid
E. Thyroglobulin synthesis

Young woman consulted an endocrinologist with complains about sleepiness, depression, fatigue, bad appetite and increasing of the body weight. Disorder of what endocrine gland can cause such problems?
A. *Thyroid
B. Pancreas
C. Adrenal cortex
D. Adrenal medulla
E. Ovary

A patient has the sudden decrease of Ca^{2+} content in the blood. What hormone secretion will increase?
A *Parathormone
B Thyrocalcitonin
C Aldosterone
D Vasopressin
E Somatotropin

A 9 y.o. boy was admitted to the endocrine department. This boy has already had several fractures of wrist extremities due to bone brittleness. The function of the following endocrine gland is disturbed:
A *Parathyroid
B Thyroid
C Thymus
D Adrenal
E Epiphysis

Clinical examination of a female patient revealed reduction of basal metabolism by 40%, gain in body mass, drop of body temperature, face puffiness, sexual dysfunctions, inertness and apathy, lowered intelligence. These symptoms are caused by dysfunction of the following endocrine gland:
A *Hypofunction of thyroid gland
B Hypofunction of parathyroid glands
C Hypophysis hyperfunction
D Epiphysis hypofunction
E Hyperfunction of thyroid gland

After a surgical procedure an experimental animal died from intense convulsions. What endocrine glands were extracted?
A *Parathyroid
B Thyroid
C Adrenal
D Ovaries
E Testicles

During operation at thyroid gland two from four parathyroid glands were mistakenly removed. It caused decreasing of the calcium blood level. What cells are target for parathyroid gland hormone which increase level of calcium?
A. *Osteoclasts
B. Osteocytes
C. Osteoblasts
D. Fibroblasts
E. Chondrocytes

A two-year-old child had convulsions as a result of decreasing concentrations of calcium ions in the plasma. This is caused by declining function of:
A. *Parathyroid glands
B. Hypophysis
C. Adrenal cortex
D. Pineal gland
E. Thymu

Results of Credit 2.

Student _____ Group _____

Date	Mark	Signature