Ministry of health Republic of Belarus
Establishment of education "Gomel state medical university"

Department of histology, cytology and embryology

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

Topic: 13:
HISTOPHYSIOLOGY OF NERVOUS SYSTEM

Duration 4 hours

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MOTIVATIONAL CHARACTERISTIC OF THE THEME

In a basis of the structural organization of nervous system reflex arches which represent circuits neurons, having special function (afferent, associative, efferent) lay. The knowledge of histophysiology peripheral nervous system (nerves, nerve ganglions) and the central nervous system (spinal cord and a brain) is necessary for understanding of integrating and coordinating function of nervous system, and also for correct diagnostics of the diseases connected with infringement of work of these bodies.

THE PURPOSE

Studying of a microscopic structure of organs of nervous system.

PROBLEMS

The students should know:

1) Development of organs of nervous system.
2) The structure of reflex arches (somatic and vegetative).
3) The basic structural elements of nerves.
4) Morphofunctional characteristic of neurons.
5) Microstructural features of white and grey substance of a spinal cord.
6) Structure of a cerebellum, their functional characteristic.
7) Structure of hemispheres of a brain.

The student should be able:

1) To distinguish organs of peripheral and central nervous system on the basis of their microscopic structure.
2) To define tissues elements of organs CNS and PNC at a microscopic level.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat questions of an anatomic structure of bodies of nervous system from a rate of normal anatomy.

CONTROL QUESTIONS FROM RELATED SUBJECTS

1) Anatomic and physiological classifications of nervous system
2) The Anatomic structure of a spinal cord
3) Spending ways of a spinal cord
4) The Anatomic structure of brain.
5) The Anatomic structure of a cerebellum.
6) The Central and peripheral independent sympathetic and parasympathetic nervous system
7) Environments of brain and a spinal cord
8) The structure of somatic and vegetative reflex arches

CONTROL QUESTIONS ON THE THEME OF EMPLOYMENT

1. Structural components of reflex arches.
2. The organization of a somatic reflex arch.
3. The organization of an vegetative reflex arch.
4. A peripheral nerve.

5. Concept about the nervous centers. The nuclear and screen centers of nervous system

THE PRACTICAL PART

1) Classification of nervous system – to fill the scheme (Exercise № 1 in album)

2) To denominate peripheral nervous system (Exercise № 2 in album)

3) To define as concept «the reflex arch» (Exercise № 3 in album)

4) To sketch the scheme of a reflex arch and to designate its parts (Exercise № 3 in album)

5) To define as concepts: «the nervous center», «the nervous center of nuclear type», «the nervous center of screen type» to specify localization sympathetic vegetative nervous centers of screen type (Exercise № 4 in album)

6) The Scheme of the module of hemispheres of the brain – to study (Exercise № 14 in album)

7) The Scheme of a structure of a spinal cord – to study and enter designations (Exercise № 8 in album)

8) Schemes of vegetative and somatic reflex arches – to study and enter designations (Exercise № 10 in album)

9) The Scheme of the neural organization of a cerebellum – to study and enter designations (Exercise № 11 in album)

10) Microscopy and a sketch in an album of histologic preparations (Exercise № in 5, 6, 7, 9, 12 and 13 in album)

SLIDES

1. Across section cut of a nerve fibres; 2) endoneurium; 3) perineureum; 4) blood vessels

2. Spinal ganglion

3. Vegetative ganglion

4. A spinal cord.

5. Cerebellum.

6. Cerebrum

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1. Specify the basic kernels of a spinal cord. Make the table 1.

2. Make the table layers of cerebellum. Specify functional value of cells. Layers of cortex of cerebellum

Table 1 – The basic kernels of a spinal cord

Topography	Morphological type neurons	Functional value

Table 2 – The table layers of cerebellum

Layers of a cerebellum	Kinds (name) neurons	Function of neurons

HISTOPHYSIOLOGY OF THE NERVOUS SYSTEM

The 2 fundamental functions of the nervous system.

(1) Detection, analysis and transmit the information from the internal and external environment.

(2) Integration and coordination of the most functions of the body, especially the motor, visceral, endocrine, and menial activities.

The human nervous system contains at least 10 billion neurons, which establish interrelationships, forming complex functional chains or circuits and form integrated communications network. Its structural and functional unit is reflex arc – chain of the neurons, including receptor, intercalated neurons and efferent neuron [1 – 4].

The nervous system is divided into *central nervous system* (CNS) and *peripheral nervous system* (PNS). CNS consists of the brain and spinal cord.

PNS consists of nerves and ganglia**.**

By function nervous system may be divided into *somatic*, which supply skeletal muscle and *autonomic* or vegetative, which supply viscera. Autonomic N.S. consists of sympathetic and parasympathetic parts [3].

Peripheral nervous system

A peripheral nerve is bundle of nerve fibers – both myelinated and nonmyelinated held together by connective tissue covers, endoneurium, perineurium and epineurium. Endoneurium is the connective tissue surrounding individual nerve fibers. Perineurium surround a nerve fascicle. Epineurium binds together several nerve fascicles into a common bundle. Epineurium contains blood vessels that penetrate into the perineurium.

The peripheral nerves carrying impulses from CNS to the organs are called ***efferent*** **or** ***motor*** nerves. The nerves carrying impulses from peripheral organs to the CNS are called ***afferent*** **or** ***sensory*** nerve.

Aggregations of the cell bodies of neurons that present outside the CNS are called ***ganglia.*** There are two main types of ganglia: *sensory* and *autonomic* or *vegetative.*

Sensory ganglia are present on the dorsal nerve roots of spinal cord *(spinal ganglia)* and near the brain stem. The neurons in these ganglia are pseudounipolar. Their cell bodies are located mainly at the periphery of the ganglion. The dendrites begin by *receptors* and bring impulse from the periphery to the cell body. Axons carry impulse from the cell body into the spinal cord and form its *dorsal roots* [5 – 7].

A layer of flattened *satellite cells* surrounds the cell body of each sensory neuron. The satellite cells are oligodendrocytes. Outside the satellite cells there is a layer of delicate connective tissue. The center of the ganglion is filled by groups of myelinated nerve fibers. All ganglions are covered on the outside by connective tissue *capsule.*

Autonomic ganglia are divided into two types: *sympathetic* and parasympathetic. In sympathetic ganglia the neurons synthesizes catecholamines (epinephrme and norepinephrine) as neurotransmitter. In parasympathetic ganglia the neurons synthesize acetylcholine. Physiological effects of the sympathetic and parasympathetic divisions of N.S. are usually antagonistic. Sympathetic ganglia are located into vertebral and paravertebral sympathetic chain. Parasympathetic ganglia usually lie close to the viscera or into wall of viscera. These ganglia are yet called paraganglia and intramural ganglia.

The neurons of the autonomic ganglia are multipolar and visceral efferent neurons.

Their axons leave ganglia as postganglionic fibers to reach and supply smooth muscle or gland. Satellite cells and connective tissue are present so well as in sensory ganglia.

Intramural ganglia have 3 types of the neurons: Dogel cell 1 type with long axon (effector), D c 2 type with equal processes (sensory) and Dc 3type – associative. These neurons form local reflex arcs independent from CNS [5 – 7].

Central nervous system

In the central nervous system, neurons bodies are concentrated in groups **(nuclei).** The brain and spinal cord are composed of **gray matter and white matter.** White matter does not contain nerve cell bodies; it consists of neuronal processes and neuroglia. It takes its name from the presence of a whitish material called **myelin** that envelops most of the neuronal processes.

In the spinal cord and brain stem the white matter is on the outside whereas the grey matter forms one or more nuclei embedded within the white matter. In the cerebrum and cerebellum there is an extensive, but thin, layer of grey matter on the surface. This layer is called the cortex. Deeper the cortex there is white matter, but within it several nuclei of grey matter are present [1 – 3].

Spinal cord

A spinal cord is a flattened cylindrical structure. In cross section butterfly-shaped gray matter have a *posterior, anterior and lateral horns.* The peripheral substance is called white matter. The cell bodies of neurons form some nuclei in gray matter. Here are also thin unmyelinated fibers and neuroglia.

In the anterior horn there are two motor nuclei: one is *medial,* other – *lateral.* The axons of motor neurons form *anterior roof. Posterior horn* has two integrative nuclei of somatic nervous system: one of them is called *proper* nucleus and other – *Klark's* nucleus. Intermediate part has *medial* and *lateral* nuclei. Both of nuclei consist of intercalated neurons of ANS.

The white matter of spinal cord consists of myelinated fibers. Bundles of axons in the white matter are called *tracts.*

Neuron Interrelations

Functional unit of the NS is *reflex arc,* including receptor, intercalated neurons and efferent neuron. There are *somatic reflex arc* and *autonomic* (vegetative) *reflex arc.*

Somatic reflex arc

An impulse arises in a sensory end (receptors, which located, for ex., in the skin). Then it is carried by the dendrite of sensory' neuron to its perikaryon, which is located in the spinal ganglion. Then impulse travels by the axon to the spinal cord. Here it passes through the intercalated neuron to the motor efferent neuron, which lies in the ventral horn (anterior). Then impulse leaves spinal cord by way of axon of motor neuron, passing through the ventral root to an effector, namely, to the skeletal muscle [7].

Sympathetic reflex arc

An impulse arises in the sensory end, which located in the epithelium of the gut (for instance) and travels by way of the dendrite of sensory neuron (or afferent neuron), which is located in the spinal ganglion.

The axon of this sensory cell conveys the impulse to the intercalated neuron, which is located in the lateral horn of spinal cord and also is called *preganglionic neuron.* Then im-

pulse leaves the spinal cord by way of the axon of *preganglionic neuron as* ***preganglionic fiber.*** The preganglionic fiber conveys the impulse to the efferent neuron located in the sympathetic ganglion. An axon of the motor cell carries impulse to the effector, namely, to the smooth muscle of the gut. The axon of the ganglion cell is called the *postganglionic* fiber [1 – 3].

Parasympathetic reflex arc

Parasympathetic reflex arc contain the same neuronal components, but preganglionic neuron is located in the sacral spinal cord segments or (and more often) in the brain stem. The efferent neuron is placed in the parasympathetic ganglia, which lie close to the viscera or into wall of viscera.

Therefore in somatic nervous system one neuron conducts impulses from CNS to the effector whereas in the autonomic nervous system a chain of two neurons conducts the impulses.

That's why somatic nerves system is voluntary, but autonomic nervous system is involuntary (not intended; reactions, which are not controlled by the will).

Brain stem

Brain stem includes *medulla oblongata, pans, midbrain* and *diencephalon.* The brain stem is not clearly separated into gray matter and white matter. The *nuclei* contain the cell bodies of the motor neurons of the cranial nerves. These motor nuclei are both morphological and functional counterparts of motor nuclei of the anterior horns of spinal cord.

Brain (cerebrum, cerebellum)

The gray matter of the brain forms an outer covering or ***cortex.***

The cortex contains cell bodies and the processes arising from or ending on them. Beside that, there are islands of gray matter, called *nuclei,* in the white matter of the cerebrum and cerebellum [2 – 6].

Cerebral cortex

The cerebral cortex contains six distinguishable layers. They are distinguished on the basis of predominant cell type and fiber arrangement. From the surface the layers are:

/. *The molecular (or plexiform) layer* consists *of fibers,* most of which travel parallel to the surface, and *horizontal ceils.*

//. *The outer granular layer* contains small pyramidal cells and stellate cells.

///. *The layer of medium pyramidal ceils* (or outer pyramidal layer) is not sharply demarcated from layer II, but cells larger and possess a typical pyramidal shape.

IV. The Inner granular layer contains many small stellate cells and granule cells.

V. The layer of large pyramidal cells (inner pyramidal layer). In motor area they are extremely large and are called Betz cells.

VI. The layer of polymorphic cells contains ceils with diverse shapes, many of which have a spindle or stellate shape. The main cells of this layer are called *fusiform cells.*

Therefore, there are three cell types, which predominant on the cerebral cortex: pyramidal cells, stellate cells (or granule cells) and fusiform cells [7].

Cerebellum

The main function of cerebellum is coordination movements of the body.

The cerebellum cortex contains three distinguishable layers: *molecular, ganglionic and granular.* The main cells, which perform coordinating function, are Purkinje cells. They constitute middle ganglionic fayer. These cells have large flask-shaped (or pear-

shaped) cell bodies and numerous dendrites that arborize in the upper, molecular layer. Single long axons are ended on the nuclei of white matter.

Molecular layer contain the *basket* cells and *stellate* ceils. Basket cells have a many short branching dendrites and a single long axon, which extend along junction between the molecular and ganglionic layers and give off collaterals. Connecting Purkinje cells between them in the transverse flatness to folium. These collaterals form baskets surrounding Purkinje cells.

Granular layer contains granule cells. They send axons into the molecular layer. Here axons branch in the form of a «T». So that axons connect the dendrites of several Purkinje cells in the parallel flatness to folium.

There are two incoming afferent fibers. Mossy fibers create synapses on the short dendrites of granule cells and form glomeruii of cerebellum.

Another afferent fibers called climbing fibers extend along axon of Purkinje cells and participate in the arrangement of cerebellum glomeruii.

Therefore climbing fibers form synapses on the Purkinje cell bodies [3, 7].

Blood-brain barrier

Blood-brain barrier restricts passage of some substances from the circulation to the parenchyma of the Central Nervous System, Studies with the EM have shown that complex tight junctions exist between the endothelial cells of the blood vessels of the brain. These junctions prevent passage of solutes and fluids from the lumen to the extracellular space via the intercellular space of endothelium.

The blood brain barrier regulates the microenvironment within cell bodies of neurons, their processes and peripheral nerves [2, 3].

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