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: 12:
HISTOPHYSIOLOGY OF NERVOUS TISSUES

Duration 4 hours

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THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

Nervous tissue- the basic structural and functional element of nervous system providing perception of irritation, excitation and transfer of nervous impulses. The knowledge histophysiologies a nervous tissue creates a basis for understanding of structure and function of nervous system, is initial for mastering by corresponding sections of medical and biologic and clinical disciplines (normal physiology, pathology pharmacology, nervous illnesses, and psychiatry).

THE PURPOSE

Studying of microscopic and ultramicroscopic structure neurons, glial cells, nervous fibers and the nervous endings.

PROBLEMS

The student should know:

1) Cytological features of nervous cells and (nervous fibers) at microscopic and ultramicroscopic levels.

2) Microscopic and ultramicroscopic features mialenated and nonmeletaed nervous fibers.

3) The Microscopic structure, functional value and classification of cells.

4) The Structure синапсов, their functional structure and classification.

5) The Microscopic and submicroscopic structure the receptors of the nervous

The student should be able:

1) To identify on micro preparations various types of neurons: a chromatophilous substance (substance Nissle) and neurofibriles: to learn to define it.

2) On preparations and electronic microphotos to distinguish mialenated and non-meletaed nervous

3) To identify the nervous endings.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat from medical biology and genetics questions on the general cytology.

CONTROL QUESTIONS FROM RELATED SUBJECTS

The Structure of microtubules, microfibrilles and microfilaments

CONTROL QUESTIONS ON THE THEME

1) Sources of formation of a nervous tissue. Differentiation of a neural plate.
2) Classification of a nervous tissue.
3) Structural components of a nervous tissue.
4) Neurons. Cytological features of neurons.
5) Neuroglia – macroglia,microglia
6) Nonmylinatied nervous fibers. Their formation.
7) Mylinatied nervous fibers. Their formation.
8) Mutual relation neurons with glia, blood vessels. Hemato-encephalic barrier.
9) The Structure and classification of synapses.
10) Regeneration of a nervous tissue.

THE PRACTICAL PART

1) The Scheme of structure of neurons – to enter designations (Exercise №1 in album).

2) To fill the table classification neurons Exercise № 2 in album).

3) The Scheme neuroglia (Exercise №3 in album).

4) To list kinds of the nervous endings to fill the table classification of contacts (Exercise №10 in album).

5) To sketch and designate the scheme of a structure of chemical synapses (Exercise №1 in album).

6) The Scheme of the mechanism of transfer of a nervous impulse in chemical synapses – to study, describe the processes in synapses during the moment of transfer of a nervous impulse (Exercise № 12 in album).

7) To study the nervous endings – to enter their classification, to describe a structure of various kinds the nervous endings, to specify localization (Exercise № 13 in album).

8) Microscopy and a sketch in an album of histological preparations (the task № 3, 8, 10, 16 in an album).

9) Studying diagrams

SLIDES

1) Chromatophilous substance (substance Nussle)

2) Spinal cord

3) Nonmyelinated nervous fibers

4) Myelinated nervous fibers.

5) Nervous endings.

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1) Give the characteristic of substance (chromatophilous substance) of neurons.

2) Make the characteristic neurofibrills

3) Features of nervous fibers. Kinds of nervous fibers, characteristic structural features and speed of carrying out of a nervous impulse

HISTOPHYSIOLOGY OF NERVOUS TISSUE

Embryogenesis of the nervous tissue

Nerve tissue can percept irritation from various physical and chemical stimuli of the external or internal environment (irritability) and to transmit excitation (conductivity) to other nerve cells or effector organs such as muscle and glands.

It consists of the nerve cells *(neurons) and glial cells.* Nerve cells *provide main functions. They* are specialized to receive information and conduct it, as impulses, to other parts of the nervous system. Neuroglia carrying supporting, nutritive, protective and other functions [1, 2].

Functions of neurons are provided by mechanism of membrane depolarization. Initially, the charge of the resting membrane is negative (– 70 mV), because there is sodium\potassium ion pump. The nerve impulse can be measured as a rapid sweep of an *action potential* along a neuron. The action potential is due to changes in permeability of the

plasmalemma and an influx of sodium ions into the cytoplasm. After the influx of the sodium ions it is positive (+ 30 mV) and this *depolarization* constitutes the action potential.

Morphology of the neurons coordinates to its functions.

Despite the great differences in size and shape, most neurons have a cell body, consisting of a nucleus and surrounding cytoplasm, which is called *perikaryon* and some cell processes – *dendrites and axon.* Neurons usually receive information through dendrites and cell bodies, where it is integrated, and then transmit this information onward via the axons.

Neurons nave euchromatic nucleus, large nucleolus, prominent Golgi apparatus and numerous mitochondria. In the cytoplasm, large clusters of ribosomes and rFR appear as areas of basophilia called *Nissl bodies or chromophilic substance.* Nissl bodies is usually absent in the axon.

All of these features are indicative of the high level of anabolic activity for the maintaining these large, nondividing cell. Specific organelles are neuro*fibrils* [1 – 4].

The bundles of specific **microfilaments called neurofibrils** course through the the perikaryon from one dendrite into another or into the axon. The neurofibrils constitute the support and drain system of neurons and their processes.

Residual bodies (lipofuscin granules by LM) may be numerous in aged nerve cells.

Centrosome is seldom observed in light microscopic preparations. Since neurons do not proliferate, the role of this organelle in the adult nerve cell is unknown.

Whereas there are usually several dendrites, there is only one *axon.*

Dendrites are usually short and contain all cytoplasmic organelles. Small evaginations of the membrane, called dendritic spines, are receptive areas for synapse with other neurons. Dendrites always carry a wave of depolarization toward the cell soma [3].

The axon carries the response of the neuron in the form of action potential to other cells or to the functional organs. This cell process often arises from a small conical elevation on the perikaryon, called the axon hillock. This initial segment is the site where various excitatory and inhibitory stimuli impinging on the neuron are summed, resulting in the "decision" to propagate an action potential or not. It is known that several types of ion channels, participating in generating the nerve impulse, are localized in the initial .segment.

The plasma membrane of the axon is called the *axolemma;* the cytoplasm is called the *axoplasm.*

All processes complete of the nerve endings [4 – 6].

The microtubules and neurofibrils in both processes provide the transport of substances. Axonal transport is in two directions: *anterograde,* from the cell body to the terminal bouton, and *retrograde,* from the bouton to the cell body. Some materials travel slowly (1 to 2 mm a day) constituting a *slow transport.* In contrast other materials (mainly in the form of vesicles) travel 100 to 400 mm a day constituting a *rapid transport.*

The retrograde transport is in dendrites.

The cytolemma of the processes is the material basis for the conducting of the nerve impulses. Note impulse travels along the dendrite -to the cell body, along the axon – from the cell [4 – 6].

The nerve cells are arranged as an integrated communications network, and several neurons arranged in a complex chain-like fashion. The specialized contacts between neurons are called *synapses*. They provide for the transmission of information from one neuron to the next in the chain [6, 7]

Synapse.

The place of contact may be between axon and dendrite:

– a) axodendritic, between axon and body of the another cell;

– b) axocomatic, and frequently may be contact between two axons;

– c) axoaxonic [3].

In the place of synapse can be visible the end of axon expands and forms rounded enlargement as bouton (bud), closes to the dendrite or cell body of the other neuron. In these endings there are many mitochondria, lysosomes, synaptic vesicles with neurotransmitters. There are pre- and postsynaptic membranes, separated by a narrow extracellular cleft, that is a synaptic cleft. From a physiological standpoint the synapse may be excitatory or inhibitory.

During the transmission of the nerve impulse the neurotransmitter is released from synaptic vesicles into the synaptic cleft [4 – 6].

When an impulse reaches the bouton, calcium enters the bouton. The action of the calcium causes the vesicles to migrate to and fuse with ihe presynaptic membrane and then discharge the transmitter into the synaptic cleft by exocytosis. The transmitter diffuses across the synaptic cleft and binds to receptors in the postsynaptic membrane. The transmitter-receptor reaction causes channels to open in the postsynaptic *membrane, which, in turn, allow ions to pass, depolarizing the membrane and thereby generating a nerve impulse.*

The neurotransmitters are as follows: acetylcholine, adrenaline, dophamine. A synapse transmits an impulse only in one direction [3].

Classifications.

The nerve cells are classified according to the number of processes (morphological classification).

1. *Unipolar* neuron contains only one process – axon. True unipolar cells are found only in early embryonic stages.

2. *Bipolar* neuron has two processes -one is axon and one is dendrite. Typical bipolar neuron is located in the retina, nasal epithelium.

3. Pseudounipolar – one process divides close to the cell body into two long branches. One branch is directed to the periphery as dendrite and another traveling to the CNS – as axon. (craniospinal ganglia)

4. Multipolar neurons have several dendrites and one axon. They form the most numerous type.

By the chemical nature of the neurotransmitter (i.e., adrenergic, cholmergic).

According to functional classification neurons fall into three groups:

1. ***Sensory*** (afferent) neurons. The dendrites of these cells always finish with the receptors.

2. *Associative* (intercalated) neurons, which are links between neurons. Their processes participate in the synapses formation. More than 99,9% of the CNS cells belong to intercalated neurons.

3. *Motor* (efferent) neurons, which transmit impulses to muscles or glands. The axons of the motor neurons are always finished with the motor nerve endings.

Nerve endings are terminal part of the neuron processes. They are *synapses, sensory* and *motor* nerve endings [4 – 7]

Sensory *nerve ending (afferent, receptors)* is the ending of dendrite of sensory neuron, which receives irritation from viscera (i*nteroceptors), from* muscles and tendons (p*roprioceptor)* or outside the body (e*xteroceptors)*.

Sensory nerve endings are classified:

1. *Free* nerve ending – is the simplest type. It consists of terminal branches of the dendrite with slight enlargements. They are situated in epithelium or connective tissue and receive temperature, mechanical and pain stimuli.

2. *Encapsulated* nerve endings contain dendrites terminals are surrounded with glial cells and may be enclosed within connective tissue capsule: They are:

a) *tactile corpuscles of Meissner* (they are touch receptors);

b) Corpuscles of Fater-Pacini (pressure receptor);

c) *Muscle spindles.* They are proprioceptive receptors and located in striated muscle. They contain intrafusal muscle fibers. Some intrafusal fibers look like bag with big amount of nuclei and called nuclear bag fibers and they are connected with the extrafusal (ordinary) fibers. Other intrafusal fibers have a row of nuclei and called nuclear chain fibers [1 – 3].

The sensory fibers wind spirally around the nuclear region of intrafusal fibers *(annulospiral endings)* and respond to stretch. Other are located away from the nuclear region *(flower spray endings).* Muscle spindles provide information to the brain about the extend and rate of stretching of muscle.

Each muscle spindle is Innervated by sensory as well as motor nerves. The sensory endings are of two types, *primary* and secondary. The motor innervatlon of Intrafusal flbres is (mainly) by axons of gamma neurons located In the ventral grey column of the spinal cord.

Contraction of Intralusal fibres makes the spindle more sensitive to stretch [4 – 7].

3. The motor endings. In the striated muscles the end of motor neuron axon form *Motor end plate.* Near the striated muscle fiber the axon loses its myelin sheath and divides into the branches. The axon terminal is rich in mitochondria and vesicles with the acetylcholine, similar to synapse. The sarcolemma curves in this region and forms numerous folds.

Nerve endings in smooth muscle are simpler. At the point of contact the axon contains vesicles with noradrenaHne or acetylcholine.

Neuroglia

is the complex of the additional cells of the nervous tissue.

Into the central nervous system there are 10 glial cells for each neuron. In contrast to neurons, glial cells retain their ability to undergo mitosis throughout the life of the organism. They are actively involved in regeneration of nerve tissue after injury and carry another important functions [4 – 6].

Functions ofneurogua

1. Provide mechanical support to neurons.

2. Serve as insulators and prevent neuronal impulses from spreading in unwanted directions.

3. Maintain a suitable metabolic environment for the neurons. They play a role in maintaining the blood-brain barrier.

4. Repair of damaged areas of nervous tissue (proliferation).

5. Microglia act as macrophages.

6. Form myelin sheaths of the nerve fibres.

It is known 2 types of neuroglia – *macroglia* and *microglia* [4 – 7].

1). Macroglia divides into *ependima, astrocytes, oligodendrocytes.* Macroglia is of ectodermal origin.

Ependima lines the central canal of the NS. These are elongated cells, that look like columnar epithelium. These cells provide the exchange of material between the brain and the cerebrospinal fluid and also produce the cerebrospinal fluid.

The modified cpendymal cells and associated capillary loops are called the *choroid plexus.*

Astrocytes are of two varieties. The *protoplasmic* astrocyte has numerous thick processes. Many processes attach to blood vessels and to the pia mater. The *fibrous* astrocyte is distinguished by long, thin and branched expansions. These cells are also often attached to blood vessels by means of their processes. Protoplasmic asctrocytes are found in gray matter and fibrous astrocytes in white mater between nerve fibers. The both types of these cells provide the nutrition and support for the nerve cells and their processes in CNS.

Astrocytes play a role in maintenance of the blood brain barrier.

Oligodendrocytes are smaller; their few, brief and slender processes have few branches. They always surround nerve cells and processes in the peripheral Nervous System (ganglia, plexuses, nerves) and provide the support and form covers of processes in the CNS and PNS. Other name of this cells in the PNS are Schwann cells [7].

Microglia.

They are small cells with few short extensions. Microglial cells are scattered everywhere throughout the brain and spinal cord and can migrate and provide phagocytosis (protective function). They arise from blood-borne monocytes and represent the mononuclear phagocyte system in nervous tissue.

Nerve fibers. The nerve cell processes form nerve fibers, terminated with the nerve endings. The nerve fibers are composed of the nerve cells processes and certain sheaths. All processes are enclosed by a sheath of Schwann cells, which invest (surround) them almost from their beginning to near their peripheral terminations (nerve endings).

There are two types of nerve fibers – *myelinated and unmyelinated.*

The *unmyelinated fiber* is the cell process which is invaginated into the cytoplasm of Schwann cells. That is in time of fiber formation the Schwann cells cover or surround the process. Sometimes several processes may invaginate into the cytoplasm of one Schwann cell.

The *myelinated fiber* has two membranes – myelin and the Schwann sheaths. Its formation explain its structure. The process lying near the Schwann cell, invaginates the cytoplasm of the Schwann cell. At that time the process comes to be suspended by a fold (duplication) of cell membrane. This fold is called *mesaxon.* The mesaxon becomes elongated and comes to be spirally around the process (rotates around the process), which is thus surrounded by several layers of cell membrane. These layers of the mesaxon form a rather thick sheath around the process – this is the myelin sheath and it consists of lipids and proteins (as each cell membrane). Outside the myelin sheath forms a layer of Schwann cell cytoplasm – displaced and flattened cytoplasm with nucleus and organelles, which is called Schwann sheath or neurilemma. Each process is related to a large number of Schwann cells over its length. One Schwann cell provides the myelin sheath for a short segment of the process. At the junction of two segments there is a short gap (interruption)

in the myelin sheath. It is the *node of Ranvier* – it is the place between neighboring Schwann cells along the length of the process and it is the place where myelin sheath is interrupted [5, 6].

Also at the slide we can see that the myelin of each segment is interrupted by oblique cone shaped discontinuities. They are the incisures or *clefts of* Schmidt-Lanterman, consisting of the Schwann cell cytoplasm and providing a path for conduction of the metabolites into the rnyelin sheath and axon.

So, Schwann cells are necessary for the life and function of the processes of nerve cells, while myelin – for the insulation and increase of speed of conducting nerve impulse.

In myelinated axons the nerve impulse jumps as "current flow" from one node of Ranvier to the next. This process is designated as *saltatory conduction;* it is more rapid than a continuous wave of depolarization.

Myelin nerve fibers belong to the somatic nerves. Unmyelmated nerve fibers innervate viscera.

There are no Schwann cells in the central nervous system; here, the myelin sheath is formed by the processes of the oligodendrocytes. Oligodendrocytes differ from Schwann cells in that different branches of one cell can envelop segments of several axons [1 – 3].

REFERENCES

1. Lowe, J. S. Stevens & Lowe's human histology [Electronic resource] / J. S. Lowe, P. G. Anderson, S. I. Anderson. – 5th ed. – China : Elsevier, 2020. – VIII, [I], 426 c. : color. ill. + Student Consult online. – Mode of access: https://www.sciencedirect.com/book/9780723435020/stevens-and-lowes-human-histo logy-fourth-edition – Date of access: 25.01.2022.

2. Solodova, E. K. Histology and cytology: Teaching manual for higher educational institutions learns enrolled on specialty 1–79 01 01 «General Medicine» / E. K. Solodova. – Gomel : GoGMU, 2021. – 204 p. – Mode of access: https://elib.gsmu.by/handle/GomSMU/9227 – Date of access: 25.01.2022.

3. Singh, I. Textbook of Human Histology : with Colour Atlas and Practical Guide / I. Singh ; revised and edit. by N. Vasudeva, S. Mishra. – 8th edition. – New Delhi : Jaypee Brothers, 2016. – 300 p. – Mode of access: https://docs.google.com/file/d/0BxvjJ4mG_bfYV2ZjSTZzZ3VmVUU/edit?resourcekey=0-l0rcPJlIPE-C8jNx7fsOiA – Date of access: 25.01.2022.

4. Кузнецова, Т.Г. Гистология, цитология и эмбриология : учеб.-метод. пособие для студентов 1 курса фак-та по подготовке специалистов для заруб. стран, обуч. на англ. языке = Histology, cytology and embryology in English for 1-st year students of Faculty on preparation of experts for foreign countries, studying on speciality of “General Medicine» of medical higher educational institutions / Т.Г.Кузнецова, Е. К. Солодова, Ю.В.Бондарева, Т.В.Потылкина ; пер. Т.Г.Кузнецова, – Гомель : ГомГМУ, 2016. – Ч. I. – 92 с.

5. Кузнецова, Т. Г. Гистология, цитология и эмбриология : учеб.-метод. пособие для студентов 2 курса фак-та по подготовке специалистов для заруб. стран, обуч. на англ. языке = Histology, cytology and embryology in English for 2-nd year students of Faculty on preparation of experts for foreign countries, studying on speciality of “General Medicine» of medical higher educational institutions / Т.Г.Кузнецова, Е. К. Солодова ; пер. Т.Г.Кузнецова, – Гомель : ГомГМУ, 2016. – Ч. 2. – 64 с.

6. Солодова, Е. К. Тестовые задания по гистологии: учеб.-метод. пособие для студентов 1 курса факультета по подготовке специалистов для зарубежных стран медицинских вузов: в 2 ч. = Histology tests: teaching workbook for 1st year students of Faculty on preparation of experts for foreign countries of medical higher educational institutions: in 2 parts / Е. К. Солодова; ред. англ. текста А. Ф. Максименко. – Гомель: ГомГМУ, 2015. – Ч. 1. – 44 с. – Mode of access: https://elib.gsmu.by/handle/GomSMU/2466 – Date of access: 25.01.2022.