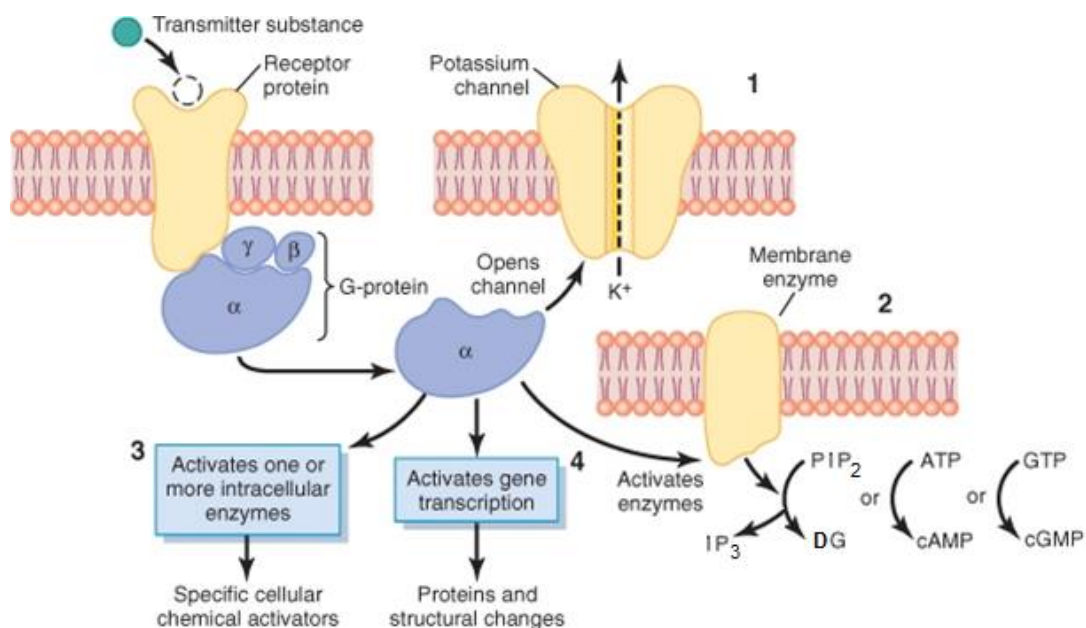


# Practical works in physiology



## Manual for practical studies and individual work for English-speaking students 221 "Stomatology"

### Part 1

Edited by associate professor I.M.Karvatsky

Київ  
«Книга-плюс»  
2021

УДК 612 (075.8)  
ББК 28.073я73  
III 37

Recommended at the Academic Council of the Bogomolets National  
Medical University (the report №9 from 24.06.2019)

**Authors:**

T.A.Alieva	I.A.Lukyanenko
I.M.Karvatsky	O.Yu.Scherbak
L.O.Klymenko	I.G.Strokina
T.S.Lagodych	O.O.Vinogradova-Anik
I.V.Leschenko	

*Group of translators:* T.A.Alieva, I.G.Strokina, O.O.Vinogradova-Anik.

**Reviewers:**

L.M.Shapoval, Doctor of Biology, Leading Research Associate,  
Bogomoletz Institute of Physiology National Academy of Science,  
Ukraine.

M.V.Kryshstal, Doctor of Medicine, Head of Patophysiology department  
of Bogomolets National Medical University, professor.

**Practical works in physiology.** Edited by I.M.Karvatsky. Manual for practical studies and individual work of stomatological faculty students. 2-th Vol. – Kyiv. Книга-плюс, 2021. V.1 – 106 p.

**Department of Physiology**

In the manual for practical training and individual work for students in physiology materials which will promote mastering of physiology by students of faculties of the higher medical educational institutions which study on credit-transfer system (ECTS) are submitted. These materials are developed on the basis of long-term pedagogical experience of the collective of Physiology department of National O.O.Bogomolez Medical University, and as experience of introduction of credit-modular system of the organisation of educational process. In the manual materials for principal kinds of individual work of students (IWS) are submitted, practical works which are carried out by students on practical training, and schemes of reports of practical training in which students have possibility to write down results of researches and other tasks are described. It will promote formation of abilities to analyze results of researches of functions of an organism and make conclusions on certain algorithm. This Manual is published in English for foreign students of medical high schools for whom English is a training language.

ISBN 978-966-460-121-1

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## INTRODUCTION

The practical works in physiology is the manual to a practical training and independent work of students which study on credit-transfer system which is a component of Bolonsky process in the higher medical educational institutions.

The subject "Physiology" is structured on modules which provide realisation of ultimate goals of the subject which are formulated in educational-qualifying characteristics (EQC) and educational-professional programs (EPP) preparations of experts of medical faculties, and are confirmed by ME Ukraine.

The credit- transfer system of the organisation of educational process induces students to regular studying of the subject because studying of each module comes to the end with the total control of the level of students` preparation, thus current progress is the important making certification of students for each module and the subject as a whole.

The manual is written on the basis of introduction of credit-modular system at National O.O.Bogomolez Medical University and the experience of collective of department.

Feature of the grant is that students will use it as a writing-book to a practical training where they will write down the results of research of functions, analyze these results and write down the conclusions, the established laws.

In a practical work themes of practical training and independent work of students (IWS) according to the curriculum and the subject program, and also the list of tasks to the total modular control are submitted.

The practical work in physiology is the subsequent development of those materials which are printed in the Grant in physiology edited by professor V.G.Shevchyuk. Vinnitsa: the NEW BOOK, 2005. - 576 p., but basic feature of this edition is its appointment - record of reports of researches on practical training and performance of tasks by students.

The practical work consists of four parts, in each of them materials which are a part 1 and 2 are presented. Such division of the material is convenient for students because the practical work is simultaneously a *writing-book* to a practical training in physiology where not only the technique of carrying out concrete researches is described, but also the additional information, including inquiry one contains.

We hope that the practical work will be pleasant for students, and will promote their successful study.

Ighor Karvatsky.

## **ORGANIZATION OF STUDYING PROCESS FOR SUBJECT “PHYSIOLOGY” ACCORDING TO CREDIT-TRANSFER SYSTEM**

### **Educational purpose of the subject**

The end purposes of studying of the subject are defined in educational-professional programm (EPP) and studying programm in Physiology (2020):

- *Make conclusion about a state of physiological function of an organism, its systems and organs;*
- *Analyze age percularities of functions of an organism and their regulation;*
- *Analyze regulated parameters and make conclusions about mechanisms of nervous and humoral regulations of physiological functions of an organism and its systems;*
- *Analyze a state of human health under different conditions on the base of physiological criteria;*
- *Interpret mechanisms and regularities of functioning of excitable structures of an organism;*
- *Analyze a state of sensory processes and their role in vital activity;*
- *Explain physiological bases of a researched methods of organism`s functions;*
- *Explain mechanisms of integrative activity of an organism.*

### **The structure of the subject**

The subject Physiology is divided into 2 parts, in each of them there are some semantic sections.

### **The structure of the subject for stomatological faculty**

#### **Part 1. “General physiology”**

##### **Semantic sections:**

1. *Introduction into physiology.*
2. *Excitable structures.*
3. *Biological regulation.*
4. *Sensory systems.*
5. *Nervous regulation of motor functions.*
6. *Nervous regulation of visceral functions.*
7. *Humoral regulation of visceral functions.*

#### **Part 2. “Visceral systems` physiology and higher integrative functions”**

##### **Semantic sections:**

8. *The system of blood.*
9. *System of blood circulation.*
10. *System of respiration.*
11. *System of digestion.*
12. *Energetic metabolism and metabolic rate.*
13. *Termoregulation.*
14. *The system of excretion.*
15. *Higher integrative functions of nervous system.*

Semantic sections are realised by all kinds of studies which are provided by the curriculum: at lectures, practical training, during individual work of students (IWS), the total modular control.

## 6 Practical works in physiology

Practical training provides: a) research by students of functions in experiments on animals, isolated tissues, cells, models or on the basis of the experiments which have been recorded in video films, in computer programs and other educational technologies; b) research of functions of a healthy person; c) solving situational tasks (an estimation of parameters of functions, parameters of a homeostasis, mechanisms of regulation, etc.) which have an experimental or clinico-physiological direction.

Duration of practical training – 3 academic hours (3×45), duration of control lesson – 2 academic hours (2×45).

It is recommended to students on a practical training shortly to write down reports of the spent researches which form is submitted for each work in the manual which should be used by them as a writing-book to a practical training.

Mastering of each section of the subject comes to the end with the total modular control which is carried out on last control employment of the certain module.

## PART 1. GENERAL PHYSIOLOGY

### SECTION 1. Introduction into physiology.

#### Practical study 1.

**Subject and tasks of physiology. Methods of physiological researches. Functions of cell`s membrane. The mechanisms of substances transport through membrane**

#### 1.Urgency of the topic:

This lesson is an introductory into physiology studying. Physiology is characterised by specificity not only an object and a research aim, but also research methods. Therefore, beginning to study physiology, on the first practical lesson students study the basic concepts of physiology and methods of physiological researches directly during carrying out researches with the equipment which is used.

#### 2.Educational purposes

- *To explain physiological bases of research methods of functions of an organism in the experiment on isolated organs and at research of functions of a person in different physiological states.*
- *To treat the concept “physiological system” of an organism and a role of regulatory mechanisms in achievement of adaptive reaction.*
- *To explain the mechanisms of substances transport through cells` membrane and the role of these processes in physiological functions.*
- *To analyze the results of researches and to make conclusions.*

#### 3.Approximate pattern for independent work at preparation for practical study

##### 3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study

Term	Determination
Physiology	Physiology is a science about objective regularities of functions in their interrelation and interaction of an organism with an environment.
Function	Function is an activity which is carried out by cells, tissues, organs, systems and an organism as a whole.
Functional system	The functional system of an organism is a set of its structures, which co-operate with each other to provide final adaptive result of an organism.
Excitable structures	Excitable structures are those which hand over the information or cause function by the change of membrane potentials. Nervous, muscular and secretary cells belong to excitable structures.
Membrane proteins	They are the proteins which are in the content of membrain and fulfill specific functions, for exsample, adhesion moleculars, ion channels, receptors, pumps, carriers (transporters), catalisators.
Ion channels	They are integrative proteins which are permeable for some ions in active state.
Exocytosis	There are some pellets in vesicles in a cell. Excytosis is a process of the pellets expelling out of the cell.

Endocytosis	This is a process of capture of particles with a cell as a result of which intracellular vesicle is being formed.
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### **3.2.Theoretical questions**

- 1) Physiology as a science.
- 2) Functions of an organism, its systems, tissues, organs, cells.
- 3) Methods of physiological researches.
- 4) Devices which are used in physiological researches.
- 5) Electric current as an irritator.
- 6) An isolated nervous-muscular preparation of a frog as the most simple object for research of physiological properties of nerves, muscles and nervous-muscular synapses. A technique of electrostimulation of this preparation and registration of muscle`s contraction.
- 7) The modern conception about structure and functions of cell membrane. Membrane proteins.
- 8) The transport of lyophilic (lyophilic) and water-soluble (hydrophilic) substances through membrane.
- 9) Passive transport of substances through ion channels.
- 10) Active transport, its types.
- 11) Exocytosis and its role in the transport of matters are being synthesized in a cell. The types of exocytosis.
- 12) Endocytosis, its role in vital activity of a cell. The types of endocytosis.

### **3.3.Practical works**

- 1) The preparation of the isolated nervous-muscular preparation of a frog.
- 2) The research of influence of a standard physical activity on heart rate in a person.
- 3) The general principles of sodium-potassium pump`s work.

## **4.Materials for individual work and self-control**

### **4.1.Answer the question**

- 1) Who is the founder of experimental physiology and due to which researches?
- 2) What is the significance of researches which were fulfilled by I .P.Pavlov and I.M. Sechenov for physiology development?
- 3) How and why does the layer of intercellular liquid covering the nerve influence on the force of electric irritation of the examined nerve?
- 4) You know from biology that a cell is an open system. What is an organization of streams of matters, energy and information in a cell?
- 5) What are the peculiarities of the cell membrane structure in excitable structures? What is the state of ionic channels gates controlled by?
- 6) What are the main elements of cell membrane? What is the specificity of its structure?



- 7) What kinds of matters regarding their solubility in water do you know? Make an examples. Is a cell membrane they permeable for them?
- 8) How the passive transport of matters through a cell`s membrain is carried out? What structures can take part in it? What forces can act on this process?
- 9) What mechanisms of matters` active transport through a cell`s membrain do you know?

#### 4.2. Solve the tasks individually

1. In the experiment for the research of irritation of a nervous fiber the current generator is used. Will the current strength which moves on a fiber change if to reduce its resistance during the experiment?
2. Sodium channels have been blocked on membrane. Can sodium enter the cell the other way?
3. All receptors channels have been blocked on membrane. Can proteins, lipids, carbohydrates, aminoacids, water,  $\text{Na}^+$ ,  $\text{O}_2$ ,  $\text{Cl}^-$  move through membrane?
4. Dinitrofenol, acting on cells, blocks metabolic processes which deliver energy. How and why will the ionic asymmetry be changed during the action of dinitrophenol on it?
5. Will the glucose transport stop if the cell is placed into solution without potassium but with the sufficient amount of glucose. Explain youe answer.

#### 4.3. Choose the correct answer

1. Physiology is the science that studies:
  - A. Structure of the organism
  - B. electrical processes
  - C. chemical processes
  - D. physical processes
  - E. functions of the organism
2. General functions that have all the cells of organism are:
  - A. contraction
  - B. respiration
  - C. secretion
  - D. incretion
  - E. thermoregulation
3. Specific functions, that have a part of cells in the organism are:
  - A. metabolism
  - B. nutrition
  - C. contraction
  - D. respiration
  - E. excretion
4. Estimation of pulse rate without any influence on the organism activity belongs to one of the following methods for studying:
  - A. chronic experiment
  - B. acute experiment
  - C. observation
  - D. modeling
5. The adequate stimulus, which is used in experiment for nerve fibers irritation is:
  - A. mechanical stimulus
  - B. chemical stimulus
  - C. thermal stimulus
  - D. electric current

6. Excited structures of an organism include those that transmit information away from irritation due to the occurrence:
- simple diffusion
  - facilitated diffusion
  - biological potentials
  - active transport
  - osmosis
7. There are the following substances in cell membrane:
- proteins
  - phospholipids
  - cholesterol
  - carbohydrates
  - all above mentioned
8. According to Fick law the rate of diffusion across cell membrane will decrease when there is an increase of:
- concentration gradient at both sides of the membrane
  - membrane thickness
  - membrane surface
  - temperature of the solution
  - solubility coefficient
9. Transport of sodium and potassium ions through a plasma membrane against concentration gradients is carried out with the participation of:
- osmosis
  - diffusion
  - filtration
  - receptor proteins
  - ion pumps
10. Ion channels in cell membrane are formed by:
- phospholipids
  - cholesterol
  - carbohydrates
  - integrative proteins
  - receptor proteins
11. The type of endocytosis is one of the following:
- Lymphocytosis
  - Alpha cytosis
  - Pinocytosis
  - gamma cytosis
  - polycytemia
12. Due to exocytosis the substances move:
- Against osmotic gradient
  - Into space between brain ventricles
  - Out of the cell
  - Out of the tissue
  - To the external surface of exocytoma
13. The ions can move through the membrane:
- without any problem
  - can't move
  - only through specific channels
  - by pinocytosis
  - by exocytosis
14. An example of symport can be:
- sodium intake and calcium yield
  - work of sodium-potassium pump
  - active magnesium transport
  - Transport of amino acids with sodium
  - pinocytosis

**Protocol of practical study №1. " \_\_\_\_\_ " \_\_\_\_\_ 20 \_\_\_\_\_**

**Work 1. Preparations of the isolated nervous-muscular preparation of a frog.**

**Purpose of the work:** to master a technique of preparation of a nervous-muscular preparation of a frog "a sciatic nerve - soleus muscle".

**It is necessary to have for the work: a set of** tools, a dissecting plate, Ringer`s solution, a pipette, a frog

**The work course.** A frog is taken by the left hand in such a way that its front extremities are pressed to its body, and the back ones are straightened. The sharp end of the scissors are put into the mouth and cut off frog`s head, doing a cut at the level of the mouth corners and leaving the lower jaw .The preparation is called spinal.

A probe is brought into the spinal channel against the stop and, rotating it, destroy the spinal cord. At the moment of destruction the tone of muscles raises. If the procedure is fulfilled correctly, after a while this tone disappears.

It is necessary to remember that at the moment of the spinal cord destruction the evacuation of four places of a frog can be observed therefore it should be held vertically over a bowl.

After the destruction of the spinal cord the tone of muscles disappears and if you lift a frog for back extremities, its paunch will droop, and on the dorsal part of the body two bends will appear (in the parts of the coxal-femoral joint and coccyx). The spine column is cut only from the coccyx - lumbar joint approximately in the middle. Skin and paunch muscles are cut too. The top part of the body with internal organs is deleted. Two back pads, pelvic bones and the spine column are left.

After the operation it is necessary to wash up hands and tools because the channels of glands which secrete caustic slime are open.

The preparation is taken by the left hand for the part of the spinal which remained and the skin is grasped and removed with the help of a gauze by the right hand. By the way the frog needs to be held further from the face in order that drops of the slime from a skin have not got to eyes.

Remove the tail bone, the body is bent and, having brought the scissors under the coccyx in parallel to it, delete it. The body is put upwards on a dissecting plate and, holding tweezers for a backbone, divide it into two parts. After that start separation of the sciatic nerve. Holding with the tweezers the backbone rests, raise it and cut off connective tissues, releasing a nerve. During the preparation you can't pull the sciatic nerve and take it with the tweezers.

Overturn the frog's body to a dorsal side and move apart muscle hips on the back surface. Between them the sciatic nerve is seen. Muscles are cut near a basin and taken aside. Raise the sciatic nerve for the rests of a backbone and cut lateral branches. The nerve is separated to a knee joint. After that the nerve is placed on a shin of the preparation and take off a head of the femur from the coxofemoral joint with scissors, and hip muscles are deleted.

The prepared preparation has the name "the reo-scope pad". It can be used in some physiologic researches. To prepare from it a preparation "the sciatic nerve - soleus muscle" it is necessary to cut achilles a sinew in its distal site and to remove a part of a shin which remained.

The prepared preparation is usually moistened with the Ringer's solution.

## **Work 2. The research of influence of standard physical activity on heart rate in a person.**

**The work purpose:** to establish, how the frequency of heart contraction in a person changes under the influence of physical activity and explain the mechanisms and the role of such changes.

**The work course.** Estimate a pulse rate of a person for 1 minute in the state of rest, having arranged fingers on a projection radial or carotid arterials. Then 20 squattings for 30 seconds (standard physical activity) are carried out and at once after it the pulse rate per 1 minute is calculated again.

### **Results of the work:**

1. A pulse rate per 1 minute at rest \_\_\_\_\_.

2. A pulse rate for 1 minute

After standard physical activity \_\_\_\_\_

**Conclusions:** (to note how the frequency of heart contraction has changed under the influence of physical activity and explain the mechanisms and the role of such changes.)

1. Frequency of heart contraction under the influence of physical activity

by \_\_\_\_\_ %, \_\_\_\_\_

## **Work 3. The general principles of sodium-potassium pump's work.**

**The purpose of the work:** to study the work of sodium-potassium pump.

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**The course of the work.** The work of sodium-potassium pump is shown in the video, the role of  $K^+$  and  $Na^+$  ions in the creation of ionic asymmetry between the internal and the external membrane surfaces.

**The results of the work:**

The pump \_\_\_\_\_ out of the cell in exchange to \_\_\_\_\_

They enter the cell.

**Conclusions.** (in conclusions answer the question: What is the role of sodium-potassium pump?)

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

### The literature

#### *Basic*

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

#### *Additional*

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2. Ganong's Review of Medical Physiology 25<sup>th</sup> ed. McGraw-Hill Education. 2015. – 750 p.
3. E.B. Babsky, B.I. Khodorov, G.I. Kositsky, A.A.Zubkov Human physiology. Mir Publishers Moscow, 1975, V.1, P. 7-14; 30-53.

**FOR NOTES**

## SECTION 2. Excitable structures.

### Practical study 2.

#### **Registration of resting potential and action potential of nervous and muscular cells**

##### 1. Urgency of the topic:

The basic function of all excitable structures is excitation.

Excitation is a process which arises on a membrane of excitable structure with irritation and is accompanied by the diminishing of the membrane potential.

Considering that excitable tissues in a complete organism provide its ability to react to the action of external and internal stimuli, registration and the analysis of parameters of electric activity of excitable tissues has not only theoretical, but also practical significans. The registration of the change of membrane potentials during excitation lies in the base of such clinical methods of research, as electrocardiogram, electroencephalography, rheotachygraphy and others.

##### 2. Educational purposes:

- *To Treat the concept "excitability", "excitation" and to explain the role of structural elements of a membrane of excitable cells in the origin of its bioelectric potentials: the role of ionic channels and pumps in transport of ions through membranes, ionic gradients, ionic asymmetry, the role of active and passive transport in asymmetry creation.*
- *To Explain ionic mechanisms of an origin of membrane resting potential (MRP), registration methods to interpret its parameters and a physiologic role.*
- *To Explain ionic mechanisms of origin of action potential (AP), physiological bases of methods of registration AP of nervous and muscular fibers, to interpret the role of different ions in dynamics of phases AP, its parameters and a physiological role.*
- *To Interpret changes of excitability of nervous and muscular fibers during the development of AP, mechanisms of an origin of the refractory periods and their physiological significans.*
- *To Explain electrophysiological bases of the use of AP registration methods of nervous and muscular tissue in clinical practice (an electrocardiogram, EEG, EMG).*

##### 3. Approximate pattern for independent work at preparation for practical study

##### **3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Membrane resting potential (MRP)	Membrane resting potential (MRP) is a difference of potentials between external and internal surfaces of a cell membrane in the state of the rest.
Action potential (AP)	This is fast highly peak change of membrane potential which provides an information transfer in nervous and muscular cells on distance and starts many other cells functions.
Diffusive potential	This is a difference of potentials which arises between external (E) and internal (i) membrane surfaces thanks to ion diffusion due to a concentration gradient if the membrane is permeable for this ion.
Diffusive equilibrium potential	This is a diffusive potential which is created thanks to the action of equal and opposite forces on ion movement through a membrane, - chemical and electric moving forces. The

	balance between these forces stops the subsequent ionic movement when the electrochemical balance is reached.
Depolarization	This is reduction of membrane potential magnitude.
Hyperpolarization	This is increase of membrane potential magnitude.
Repolarization	This is restoration of the value of membrane potential magnitude.
Excitability	This is a physiological property of a cell that is its ability to generate AP on membrane at the action of stimulus.

### 3.2. Theoretical questions

- 1) MRP of nervous and muscular fibers, mechanisms of its origin, registration methods; physical characteristics and physiologic role of MRP.
- 2) The conception about depolarization and hyperpolarization of a cellular membrane.
- 3) Action potential as an indicator of excitation which expends in nervous and muscular fibers.
- 4) Methods of action potential registration of separate fibers.
- 5) Action potential physical characteristics and its physiological role.
- 6) Action potential physiological characteristics (extends along a cellular membrane at any distance, without dying away; all submits to the law „all or none”; it is accompanied by refractory it can not be summarised).
- 7) Changes of excitability during action potential development.

### 3.3. Practical works

- 1) MRP registration by a damage method.
- 2) Action potential registration by bipolar and unipolar methods.

## 4. Materials for individual work and self-control

### 4.1. Answer the question

- 1) What are the conditions for the work of sodium-potassium pump?
- 2) Membrane sodium permeability has increased under the humoral factors influence. How will it act on MRP magnitude of this cell and why?
- 3) The potassium ions concentration in the liquid surrounding a cell has been increased. How and why will it act on the MRP magnitude of this cell?
- 4) Under the external influence the number of inactivated  $\text{Na}^+$  channels on the cell's membrane has increased. How will it act on AP parameters which arises on the cell's membrane and why?

### 4.2. Solve the tasks individually

- 1) Under the influence of the chemical factor the potassium channels quantity which can be activated in case of AP generation has increased. How will it act on AP parameters and why?
- 2) In case of deterioration of blood circulation in myocardium potassium ions concentration in intercellular liquid rises. How will it act on AP generation in myocardium tissue and why?

- 3) Membrane potassium permeability has increased under the humoral factors influence. How will it act on MRP value of this cell and why?
- 4) AP duration of the nervous fibre makes 1 ms, the threshold of depolarization makes 20 mV. Will the next AP arise, if the next irritation with the electric current with the voltage of 40 mV is applied through 0.5 ms after the first one? Explain.
- 5) According to Lapič's law, the short-term action of D.C. with the threshold force does not cause the excitation of tissue and its manifestation requires the factor of time. Draw the graph to show the dependence between the force of current and the duration of irritant's action.

### 4.3. Choose the correct answer

1. In the state of the rest the membrane of the excitable cell has great permeability for:
  - A. sodium
  - B. potassium
  - C. magnesium
  - D. calcium
  - E. proteins
2. The poison of Fugu fish is tetrodotoxine. It blocks the activation gates of voltage-gated sodium channels. After the eating such a fish there is one of the following processes on the membrane of excitable structures:
  - A. Increasing of excitability
  - B. Decreasing of MRP
  - C. Increasing of absolute refractory phase
  - D. Decreasing of relative refractory phase
  - E. the absence of AP generation
3. Resting potential directly depends on:
  - A. diffusion potassium outflow
  - B. diffusion potassium inflow
  - C. sodium-potassium pump
  - D. diffusion sodium inflow
  - E. diffusion sodium outflow
4. The ascending phase of action potential directly depends on:
  - A. diffusion potassium outflow
  - B. diffusion potassium inflow
  - C. sodium-potassium pump
  - D. diffusion sodium inflow
  - E. diffusion sodium outflow
5. During the development of action potential of nerve fiber the second stimulus with above threshold voltage was applied at the beginning of repolarization phase. As a response to the second irritation the action potential:
  - A. appeared with normal amplitude.
  - B. appeared with the amplitude less than normal one.
  - C. appeared with the amplitude more than normal one.
  - D. hadn't overshoot (the potential's reversion).
  - E. Didn't appear.
6. The resting potential is directly created first of all by:
  - A. passive K<sup>+</sup> movement from inside to outside
  - B. passive K<sup>+</sup> movement from outside to inside
  - C. passive Na<sup>+</sup> movement from inside to outside
  - D. passive Na<sup>+</sup> movement from outside to inside
  - E. active transport
7. The ascending phase of the action potential is directly created first of all by:
  - A. passive K<sup>+</sup> movement from inside to outside
  - B. passive K<sup>+</sup> movement from outside to inside
  - C. passive Na<sup>+</sup> movement from inside to outside

- D. passive Na<sup>+</sup> movement from outside to inside  
E. active transport
8. The repolarization phase of the action is created first of all by:  
A. passive K<sup>+</sup> movement from inside to outside  
B. passive K<sup>+</sup> movement from outside to inside  
C. passive Na<sup>+</sup> movement from inside to outside  
D. passive Na<sup>+</sup> movement from outside to inside  
E. active transport
9. Sodium- potassium pump pumps:  
A. Na<sup>+</sup> from inside to outside, K<sup>+</sup> from outside to inside  
B. Na<sup>+</sup> from outside to inside, K<sup>+</sup> from inside to outside  
C. Na<sup>+</sup> and K<sup>+</sup> from outside to inside  
D. Na<sup>+</sup> K<sup>+</sup> from inside to outside
10. Due to sodium-potassium pump's work there is created:  
A. Potential difference between inside and outside membrane surfaces  
B. Concentration gradient for sodium and potassium  
C. Concentration gradient for sodium only  
D. Concentration gradient for potassium only  
E. Resting potential

### **Protocol of practical study №2. \_\_\_\_\_ " \_\_\_\_\_ " \_\_\_\_\_ 20\_\_\_\_\_**

#### **Work 1. Registration of membrane resting potential (MRP) by damage method.**

Classical method which allows to establish presence MRP on a membrane of nervous and muscular fibers at rest is the damage method.

For revealing MRP one of registering electrodes is placed on the intact surface, and the second one - on the damaged site of a nerve or a muscle. MRP is defined by the difference of potentials between these sites because the potential of the intact site is the potential of the extracellular liquid which covers nervous or muscular fibers, and the potential of the damaged site is potential of cytoplasm of these fibers.

During revealing MRP by a damage method a turnout galvanometer is used. This device has small internal resistance as compared with the resistance of tissues of an organism. Therefore by means of a galvanometer, one registers not the potential difference which exists between cytoplasm of fibers and their internal environment, but the current caused by it („a rest current”).

During the acquaintance with a design of a galvanometer it is necessary to pay attention to the fact that near its entrance plugs "minus" and "plus" are designated. These marks concern registering electrodes which are connected with galvanometer plugs. One of the registering electrodes can be considered negative, and the second one- a positive pole. The galvanometer design provides that the arrow of the device deviates in the positive part of its scale (that is, to the right of zero) in the case when signs on charges of points of assignment of investigated object answer signs on polarity of the registering electrodes located in these points. Otherwise the arrow of a galvanometer will deviate in a negative part of its scales. Taking into consideration the told above, it is possible to define signs on charges on poles of different generators EDS by means of a galvanometer. As the rest current is constant, it can cause polarization of electrodes. Therefore it is necessary to apply electrodes which are not polarized to its registration.

**The work purpose:** to find out the presence of potentials` difference between cytoplasm and an extracellular liquid of muscular fibres.

**It is necessary to have for the work:** a set of tools, a dissecting plate, a frog, Ringer`s solution, a turnout galvanometer (with sensitivity of a current nearby 0,1 mcA), registering electrodes which are not polarized.

**The work course.** Prepare the frog`s body and after removal its skin put it on a dissecting plate. Connect entrance plugs of the galvanometer with registering electrodes. Place both electrodes on the soleus muscle of the frog`s body. With the help of scissors damage a part of the muscle under one of



the registering electrodes. Remove the galvanometer from arretir and pay attention to the position of its arrow.

***The results of the work.***

*The arrow of the galvanometer after its turn on in a registration chain deviates zero position to the \_\_\_\_\_ the part.*

***Conclusions:***

*1. The deviation of the arrow of the galvanometer from zero position testifies about*

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*2. The damaged surface of muscles (cytoplasm) has \_\_\_\_\_ charge in compared to the intact surface (an extracellular liquid) which has \_\_\_\_\_ charge*

**Work 2. Registration of action potential by bipolar and unipolar methods.**

In dependence with the location of electrodes on an object two methods of AP registration are distinguished - bipolar and unipolar. Endocellular registration of AP is carried out only by a unipolar method.

Bipolar method of registration of electric potentials is that with which both registering electrodes are located on the sites of an object of the research which electric potentials change in time. In case of using unipolar method of registration one registering electrode (active) is located on a site of an object of the research which electric potential changes in time, and the second one (passive) - on a site of the same object which electric potential is constant (for example, zero). Let us consider an essence of methods of bipolar and unipolar registration of AP on an example of its removal from the isolated nerve.

In the case of bipolar AP registration of a nerve both registering electrodes are placed on its surface in such a way that the wave PA (an excitation wave) which extends along the nervous fibers, can pass at first under the first electrode, and then under the second one. As a result of it the curve AP which is taken away with the bipolar method, will be formed as the algebraic sum of two as if different AP, and, therefore, it should have the two-phase form.

By the design of the cathodic oscillograph it is provided that registering electrodes can be conditionally considered as different poles (one that is connected on an input with the earth, is negative, and the second - a positive pole). Therefore both phases of two-phase AP are always registered multidirected: when passing an electronegative wave of excitation under the negative registering electrode the oscillograph beam deviates upwards from an isoline, that is to the positive part of its scale. When passing the same wave under a positive registering electrode the oscillograph beam deviates downwards from an isoline.

In the case of unipolar AP registration of a nerve registering electrodes are placed on its surface in such a way that AP passes only under one electrode ("active") and cannot reach that site of a nerve on which the second electrode ("passive") is placed. The curve AP, registered by a unipolar method, always has the one-phase form.

If unipolar drawing aside of AP from the isolated nerve is necessary one can transform one of the registering electrodes into passive, by the damage the site of a nerve located between registering electrodes, and in such a way depriving it the possibility to spend excitation.

**The work purpose:** to find out the form of the AP curve, registered by a bipolar method, explain the origin of the first phase and the second one.

**It is necessary to have for the work:** installation for AP registration (a cathodic oscillograph), an amplifier, an electrostimulator irritating and registrating electrodes, a damp chamber, vaseline oil, an isolated sciatic nerve of a frog, concentrated (9,5 %) ammonia solution.

**The course of the work.** 1. A preparatory stage of the work.

The isolated sciatic nerve of a frog is placed in the damp chamber, and attach to it irritating and registrating electrodes (on distance of 3-5 cm). Fill in a nerve with vaseline oil. The stimulator is transferred in the regime of „A rhythmic series”, and the oscillograph – in the regime of „expectation on expansion” with the start from a synchronising impulse of a stimulator. Devices and the amplifier are turned on.

Giving a rhythmical series of electric impulses on a nerve (with frequency 10-30 imp/s), increase their force by the time of appearance the AP image of a nerve of enough big amplitude on the screen of the oscillograph. Select desirable speed of expansion on the oscillograph then stop nerve stimulation.

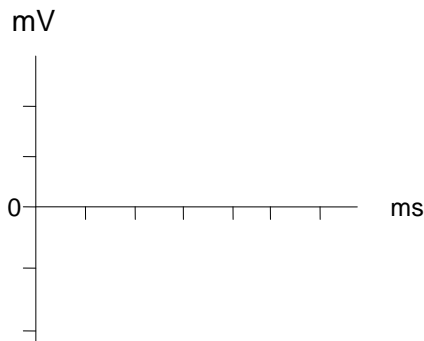
2. The main stage of the work.

To renew the nerve stimulation without changing the before hand selected voltage of characteristics of electric impulses.

To note, what form the AP curve taken away from a nerve has on the screen of the oscillograph. Kill a part of the nerve, which is located between registrating electrodes by means of 9,5 % ammonia solution. Note, how the form of AP curve has changed on the screen of the oscillograph.

**Results of the work:**

*The summary AP of the isolated nerve of a frog is registrated on the oscillograph screen. It has the following form:*



**Conclusions:**

1. The summary AP of the isolated nerve has \_\_\_\_\_ the form when registrating by \_\_\_\_\_ (write the method of registration.) (Bipolar or unipolar)

2. Summary AP generation under the nerve irritation by electric current testifies about the appearance \_\_\_\_\_ (the process) \_\_\_\_\_ in nervous fibers

3. The first phase of summary AP is formed \_\_\_\_\_ the second one is formed \_\_\_\_\_

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

## The literature

### *Basic*

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### *Additional*

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2. Ganong's Review of Medical Physiology 25th ed. McGraw-Hill Education. 2015. – 750 p.
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### **FOR NOTES**

### Practical study 3.

#### **Studying the spread of excitation along the nerves and through nervous-muscle synapse. Studying of action potential of nerves and muscles**

##### 1. Urgency of the theme:

Mechanisms of excitation transmission by nervous and muscular fibres and through nervous-muscular synapse is a way for information transmission. These regularities have not only theoretical interest. A doctor has often to observe the infringement of excitation transmission by nervous and muscular fibres and through nervous-muscular synapses and to influence purposefully on these processes by means of pharmacological means.

##### 2. Educational purposes:

- *To Explain mechanisms of excitation transmission by nervous and muscular fibres.*
- *To Analyze the role of major factors which define the speed of excitation transmission by nervous and muscular fibres.*
- *To Treat regularities of excitation transmission by nervous and muscular fibres.*
- *To Explain and analyze the mechanism of AP formation and property which are registered from complete nerves and muscles; formation mechanisms of electroneurogramm and electromiogram.*
- *To Explain and analyze mechanisms and regularities of excitation transmission through nervous-muscular synapses and possibilities of blockage of a neuromuscular transmission.*

##### 3. Approximate pattern for independent work at preparation for practical study

##### 3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study

Term	Definition
Nervous-muscular synapse	Place of contact of the nervous ending of motoneuron with a muscular fibre
The neurotransmitter	The chemical substance which are secreted from the nervous ending through it, presynaptic membrane and carries out the information transmission through synaptic cleft to the next structure of synapse - the postsynaptic membrane.
N-Cholinergic receptors	Superficial proteins of postsynaptic membranes with which neurotransmitter acetylcholine co-operates
End-plate potential (EPP)	Local depolarisational potential which arises on postsynaptic membrane (EPP) of the nervous-muscular synapse as a result of neurotransmitter acetylcholine interaction with Acetyl-choline-gated sodium ion transport proteins of the end plate, thanks to this the end plate permeability for sodium ions through chemodepended sodium channels increases.

##### 3.2. Theoretical questions

- 1) Mechanisms of excitation transmission by nervous and muscular fibres, peculiarities of excitation transmission by myelin nervous fibres.
- 2) Factors which define the speed of excitation transmission by nervous and muscular fibres. Reliability factor. Classification of nervous fibres according to their diameter.
- 3) Regularities of excitation transmission by nervous and muscular fibres, their significance for an information transmission.
- 4) Action potential of whole nerves and muscles. The mechanism of their formation and property. General ideas of AP turning away from a volume conductor.

- 5) Elektromiography, formation mechanisms of electromyogramm.
- 6) Mechanisms and regularities of excitation transmission through nervous-muscular synapse. Neurotransmitter, membrane cytoceptors and blocks of the nervous-muscular synapse.

### **3.3. Practical works**

- 1) The research of the summary AP properties of the isolated nerve.
- 2) The research of speed of excitation transmission by the isolated nerve.
- 3) The research of mechanisms of the excitation transmission through nervous-muscular synapse

## **4. Materials for individual work and self-control**

### **4.1. Answer the question**

- 1) How will the speed of nervous impulses conducting change with the increase in membrane permeability of nervous fibres for potassium ions? Why?
- 2) Name two reasons of the great increasing of sodium entrance into an axon at the enlargement of sodium permeability of axonic membrane.
- 3) What of the laws of nervous impulses conducting will be broken, if the resistance of the membrane of nervous fibres which are a part of this nerve decreases? Why?
- 4) The distance between irritating and taking away electrodes located on a nervous fibre, equals 10 sm. AP is registered under taking away electrode through 0,1 ms after irritation of the fibre. What group (A, B or C) this nervous fibre belongs to?

### **4.2. Solve the tasks individually**

- 1) The amplitude of AP has been increased by a few millivolts. Will this cell's excitability be changed?
- 2) What of the laws of nervous impulses conducting can be broken, if the resistance of the membrane of nervous fibres which are a part of this nerve decreases? Why?
- 3) How will the speed of nervous impulses conducting change with the increase in membrane permeability of nervous fibres for sodium ions? Why?
- 4) How will the MRP of excitable tissue be changing under the slow increase of the force of irritating current? Draw the graf.

- 5) How will the damage of myelin sheath influence on the speed of excitation conduction?
- 6) The firing level of cell membrane increased from  $-50$  mV to  $-40$  mV. How and why will the excitability be changed under these conditions?

#### 4.3. Choose the correct answer:

1. When irritating an isolated nerve of a frog by the constant electric current the latency period of AP appearance on a nerve was 1,5 ms, the distance between taking away and irritating electrodes to the anode is 6 cm, to the katod is 4,5 cm. The speed of conducting of excitation along the nerve will equal:

- A. 10 m / s
- B. 30 m / s
- C. 36 m / s
- D. 40 m / s
- E. 70 m / s

2. The speed of excitation conducting along the axon axon excitation rate will increase if it decreases:

- A. membrane resistance ( $R_m$ )
- B. capacity of the membrane ( $C_m$ )
- C. axon diameter
- D. refractory period
- E. axon excitability

3. The release of neurotransmitter in the neuromuscular synapse by exocytosis is most effectively blocked by the prevention of:

- A. AP distributions to the membrane of the nervous ending
- B. depolarization of the nervous endings
- C.  $Na^+$  input through the membrane of the nervous ending
- D.  $K^+$  output through the membrane of the nervous ending
- E.  $Ca^{2+}$  input through the membrane of the nervous ending

4. Ionic channels of the end plate of a skeletal muscle have one of the properties:

- A. Highly selective for  $Na^+$
- B. Are activated thanks to depolarization
- C. Are activated thanks to acetylcholine
- D. Are blocked by atropine
- E. Cause relative refractory period

5. AP amplitude was measured during excitation conduction along myelinated nervous fibre. In the proximal part of the nerve it made 120 mV, the next part was damaged and AP amplitude decreased here to 60 mV. What voltage of AP amplitude would be in the distal intact part of the fibre if the threshold of depolarization was 20 mV:

- A. 20 mV
- B. 60 mV
- C. 120 mV
- D. Will not arise

6. When irritating an isolated nerve of a frog by the unipolar method the summarized AP was registered. It had three waves: the first one arose quickly and had the largest amplitude, the second one arose later and had less amplitude, the third one even later with the least amplitude. The noted testifies about:

- A. Different speed of conduction
- B. Different excitability
- C. Small force of irritation
- D. Absolute refractory period
- E. Nerve's exhaustion

7. Anesthetics stop the conduction of the nervous impulse because they interact with the open activation gates:

- A. potassium channels and increase  $K^+$  output
- B. calcium channels and reduce  $Ca^{2+}$  input
- C. sodium channels and reduce  $Na^+$  input
- D. Chloric channels and increase  $Cl^-$  input

8. When diminishing the resistance of membrane of a nervous fibres the following violation will take place:

- A. Bilateral conduction of excitation
- B. Isolated conduction of excitation
- C. sodium activation
- D. sodium inactivation
- E. potassium activation

9. In a patient muscular weakness was stated as a result of neuromuscular transmission violation. For the improvement of neuromuscular transmission it is advisable to apply:

- A. Blockade of acetylcholinesterase
- B. Calcium introduction
- C. ATP introduction
- D. Potassium introduction

10. The speed of AP conduction along the nervous fibre will increase:

- A. when  $\text{Na}^+ - \text{K}^+$  pump is stimulated
- B. when  $\text{Na}^+ - \text{K}^+$  pump is inhibited
- C. as the diameter of the fiber decreases.
- D. in myelinated fibres
- E. in unmyelinated fibres

### **Protocol of practical study №3 “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_**

#### **Work 1. The research of the properties of the summarized AP of the isolated nerve**

AP of the integral nerve or muscle is summarized one. The summarized AP are formed as the sum of single AP that are distributed by the membrane of their individual fibers. The essence of the summation in a simplified form is as follows.

Single excited nerve fibers are equivalent to the elementary generator of electromoving force (EMF), the poles of which are excited place and the adjoining portion of the outer membrane of this fiber. EMF is 120 mV. Its internal resistance is the resistance of the cytoplasm. Taking away electrodes are located on excited and adjacent non-excited areas of fiber as it is on the generator's poles when the registration of AP is extracellular one. Taking away electrodes are shunted due to the resistance of the layer of extracellular fluid.

The propagating AP of the fiber is recorded with the help of these electrodes. There is a decrease in the voltage due to resistance. AP causes the electric current which is generated by the fiber-generator. The amplitude of this AP is always much smaller than the EMF of the excited fiber, since part of the EMF is lost due to the resistance of the cytoplasm.

It is known that in the case of a parallel connection of generators, their total internal resistance decreases. Clearly, with simultaneous excitation in the nerve containing several fibers, the overall resistance of their cytoplasm will decrease, and as a result, the rate of voltage drop on this resistance will increase, that is, the potential difference will increase, which is recorded as the summarized AP. This summation occurs not on the fiber membrane (this is impossible, since the AP is accompanied by the refractory of the cell membrane), but on the “taking away electrodes”.

Due to the peculiarities of the mechanism of formation, the summarized AP of integral nerves and muscles have some specific properties.

The main feature of the summarized AP is that they have a small amplitude. Even when all its fibers are excited in the nerve or muscle, the amplitude of their summarized AP can not reach the value of the EMF of the single excited fiber (110-130 mV), which is formed by the ion permeability of its excited membrane. This is due to the fact that part of this EMF will necessarily be lost on the support of the cytoplasm as the internal resistance of fiber generators.

Thus, the summarized AP of the nerves and muscles in amplitude only approaches the membrane of a single fiber, which is equal to its EMF generated during excitation, but can never reach it, and even more so, exceed it.

A small amplitude of summarized AP is also due to a certain methodological factor: the presence of the distance between the “taking away” electrodes, which are located on the surface of the nerve or muscle, and the membrane of separate fibers contained in their depth. On the supports of the tissue layers, which separate the taking away electrodes from the deep-seated fibers, part of the voltage generated by these fibers during excitation is lost, and their contribution to the summarized AP is reduced.

The second feature of the summarized AP of integral nerves and muscles is that, in contrast to single AP of separate fibers, they are subordinated to the law of forced relationships. In the event of an increase in the strength of the nerve or muscle irritation, the number of its excited fibers increases, and as a consequence, the amplitude of the summarized AP that are diverted from them increases.

**The work purpose:** to find out the basic properties of the summarized AP of the isolated nerve.

**It is necessary to have for the work:** installation for registration PA (a cathodic oscillograph, an amplifier, an electrostimulator, irritating and registrating electrodes), a damp chamber, vaseline oil, an isolated sciatic nerve of a frog, concentrated (9,5% ) ammonia solution.

**The work course:** 1. A preparatory stage.

The isolated sciatic nerve of a frog is placed into the dump chamber. Irritating and registrating electrodes are placed on it on distance of 2-5 cm one from another. With 9,5% solution of ammonia destroy a nerve site on which the registrating electrode is located. This electrode is more removed than irritating electrodes. Thus it provides unipolar AP turning away. Pour the nerve with vaseline oil.

The electrostimulator is converted in the regime "A rhythmic series", and the oscillograph - «expecting allotment» with the start from a synchronising impulse of the stimulator. The stimulator, the oscillograph and the amplifier are turned on.

Rhythmical series of electric impulses (with frequency 10-30 imp/s) are brought on a nerve, increase their force till the appearance of AP of the nerve of enough big amplitude on the screen of oscillograph. Select desirable speed of expansion on the oscillograph, then stop stimulation of the nerve and return the handle of the stimulator which regulates amplitude of irritable impulses, in position 0.

2. The main stage.

Stimulate the nerve with electric impulses, gradually increasing the amplitude (beginning from 0).

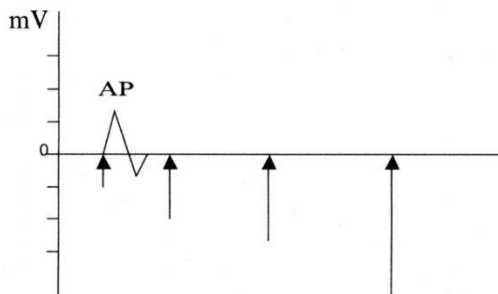
Note, how the character of the registered curve of summarized AP of the nerve will change in case of increase in force of electric irritation.

Increase the force of irritation by the moment when AP amplitude which is taken away, having reached the maximum voltage, will stop to change and measure it.

Stop stimulation of the nerve and give gauge tension on the oscillograph screen. Calculate limiting amplitude of summarized AP of the nerve which is taken away.

**Results of the work:**

A) the diagramm of the summarized AP of the nerve of a frog with the increase in the force of electric irritation



**The force of irritating electric currents is shown with the help of the arrows**

**Conclusions:**

- 1) With the increase in the force of electric irritation of a nerve the amplitude of summarized AP of the nerve \_\_\_\_\_ to the limit value which is caused by \_\_\_\_\_



### Work 2. Determination of the speed of excitation conduction by a nerve

Nerve and muscle impulses are propagated by fibers of nerves and muscles with high speed. In homoiotherm animals, the speed of AP conduction by motor neural fibers is on average equal to 100 m / s, and by skeletal muscle - 4 m / s . The speed of AP propagation by nervous and

muscular fibres can be calculated by the following formula:  $V = \frac{S \times \lambda}{\tau}$

where S is a reliability factor that reflects how much the AP amplitude as the exciting current in the adjoining regions of the membrane is greater than the depolarization threshold ( $\Delta E$ ), that is, the depolarization required for the AP occurrence in adjacent areas.

$\lambda$  is the constant of length, which reflects the distance at which the reduction of the electrotonic potential before the front of the AP occurs. It mainly depends on the resistance of the membrane ( $r_m$ ) and the cytoplasm ( $r_i$ ):  $\lambda = \sqrt{r_m/r_i}$ .

In turn, the resistance of the cytoplasm is inversely proportional to the diameter of the fiber. Thus,  $\lambda$  reflects the slope of the decrease in the amplitude of the electrotonic potentials on both sides of the aroused AP.  $\tau$  is the time constant for the membrane. It reflects the growth rate of depolarization of the membrane to the firing level. It depends on the resistance and capacity of the membrane. By knowing AP amplitude,  $\Delta E$ , the resistance of the membrane and the cytoplasm, one can calculate the speed of AP propagation.

**The work purpose:** to determine the speed of excitation conduction along a sciatic nerve of a frog.

**It is necessary to have for the work:** an installation for AP registration, a cathodic oscillograph, an amplifier, an electrostimulator, irritating and registrating electrodes, a damp chamber, vaseline oil, an isolated sciatic nerve of a frog.

**The work course.** 1. A preparatory stage.

The isolated sciatic nerve of a frog is placed in the damp chamber. Irritating and registrating electrodes are placed on it on the distance of two cm from one another and filled in with vaseline oil.

The devices are converted in the necessary operating regime. The force of irritation and the speed of expansion are selected in such a way that on the oscillograph screen there was accurately seen visible artefact of an irritating current and AP of the nerve which is taken away.

2. The basic stage.

Measure the distance from an artefact of an irritating current to the beginning of ascending phase of AP on the screen of the oscillograph. Do it with a pair of compasses. Knowing the speed of expansion of a beam of the oscillograph, calculate, what interval of time this distance corresponds, that is, define the time (T) of AP distributions from irritating electrodes to the registrating one. Speed of AP conduction of the nerve is defined with the formula:

$$V(\text{m/s}) = \frac{L(\text{m})}{T(\text{s})}; \quad \frac{0.02}{0.0005} = 40 \text{ m/s}$$

where L is a distance between irritating and registrating electrodes, T - time of excitation distribution from irritating electrodes to the first registration electrode.

Recommendations concerning the design of the results of the work: to show the value of speed of excitation conducting along the nerve of a frog.

In conclusions answer: what factors the speed of excitation conduction along nervous fibres depends on.

**Results of the work:**

Calculation of speed of excitation transmission by the nerve of a frog:

**Conclusions:**

the fastest nervous fibres which are a part of the nerve of a frog, belong to the group

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2) The speed of the excitation transmission by nervous fibres depends on such factors:

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**Work 3. The research of the mechanisms of the excitation conduction through nervous-muscular synapses**

Acetylcholine is the neurotransmitter in the nervous-muscular synapses, and molecular cytoceptors on postsynaptic membranes –are Acetyl-choline-gated sodium ion transport proteins. Chemical substances which block an excitation conduction from motoneurons nerves on muscular fibres are called myorelaxants. All the myorelaxants are curariform substances (diplacin, ditilin and etc.). Blocking action of relaxants on nervous-muscular synapses is caused by their ability to bind selectively with contact Acetyl-choline-gated sodium ion transport proteins of the postsynaptic membranes in these synapses. Therefore Acetyl-choline-gated sodium ion transport proteins can not bind with acetylcholine any more.

**The work purpose:** 1) to find out the myorelaxants action on nervous-muscular synapses.

2) whether the muscle`s contraction is observed under direct and undirect irritation respectively on the both sides of the frog.

3) Explain the mechanism of diplacin action.

**It is necessary to have for the work:** an electrostimulator, irritating electrodes, tools, a preparational desk, Ringer`s solution, a pipette, a syringe, 2% solution of diplacin, a frog.

**The work course.** Lifting a little skin on a back of a frog, inject to it hypodermically 0,3-0,5 ml of 2% diplacin solution. In 7-10 minutes decapitate a frog and destroy its spinal cord. Put the frog on the prepared desk, bare the sciatic nerve and soleus muscle on one of its back extremities.

Place irritating electrodes on the soleus muscle, and then on the sciatic nerve, fulfil direct and indirect irritation of the muscle by electric impulses of different amplitude. Observe the results of direct and indirect irritation of the muscle.

**Results of the work.**

*After introducing of 2% diplacin solution and the electric stimulation of the sciatic nerve (indirect stimulation), one observes that the soleus muscle*

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*At the direct stimulation of the soleus muscle with electric current one observes*

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**Conclusions:** *Diplacin blocks the nervous-muscular excitation conduction due to the action on*

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**Protocol revised** \_\_\_\_\_

*(date, Preceptor's signature)*

## **The literature**

### ***Basic***

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### ***Additional***

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### **FOR NOTES**

## Practical study 4.

### ***Studying of the skeleton muscles` contraction mechanisms***

#### **1.Urgency of the theme:**

Studying contractive function of skeletal muscles allows to analyze causes of this function violation and to reach its normalisation under corresponding conditions, or to define physiological conditions for trainings in sport medicine. Knowing the mechanisms and regularities of the skeletal muscles` contraction, it is possible to understand the peculiarities of myocardium and smooth muscles contraction. All these questions are of great interest for clinical physicians because in many pathological states of an organism the doctor can meet patients who have a violation of the contractive functions of skeletal muscles, a myocardium and so forth.

#### **2.Educational purposes:**

- *To explain mechanisms of excitation-contraction coupling in cross-striped muscular fibres, contraction and relaxation.*
- *To interpret the dependence of character of muscles contraction on the force and the frequency of irritation.*
- *To interpret the role of the factors on which the force of muscles contraction depends on.*
- *To interpret EMG.*

#### **3.Approximate pattern for independent work at preparation for practical study**

##### ***3.1.The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study***

<b>Term</b>	<b>Definition</b>
Sarcomere	The area between 2 adjacent Z lines
Filaments (miofilaments)	These are structural and functional units of sarcomere with the participation of which the contractional force providing filaments sliding relative to each other, is generated.
Thin filaments	They are formed of proteins actin, tropomyosin, troponin
Thick filaments	They are formed of protein myosin
Excitation-contraction coupling (electromechanical coupling)	It is a process of the combination of excitation (action potential generation on the membrane of a muscular fibre) and contraction of a muscular fibre. The base of it is calcium ions liberation from the sarcoplasmic reticulum. Thanks to this process the sliding of thick and thin filaments relatively each other begins.
Isotonic contraction	This is the decrease of the length of a muscle during contraction without change of its tension.
Isometric contraction	This is the increase in the tension of a muscle during contraction without change of it`s length because the contractive force is insufficient for cargo moving
Tetanic contraction or tetanus	This is a prolonged contraction of a muscle as a result of many times repeated action potentials appearance on a muscular fibre membrane during its contraction.
Single contraction	This is a contraction of a muscle as a result of one action potential occurrence on a muscular fibre membrane.

### 3.2. Theoretical questions

- 1) The types of the skeletal muscles contraction depending on a mode of their loading and irritation of muscular fibres. Skeletal muscles contraction in a physiological condition.
- 2) Physiological factors which define degree of muscles contaction and their tension set in the weight of the cargo.
- 3) The mechanism of excitation-contaction coupling in skeletal muscles.
- 4) The mechanisms of muscle contraction and relaxation. An energy role in contraction and relaxation of muscles.

### 3.3. Practical works

- 1) The research of the dependence of degree of muscle`s contraction on the quantity of fibres which take part in contaction.
- 2) The research of the dependence of the character of muscle`s contraction on the frequency of its irritation.

## 4. Materials for individual work and self-control

### 4.1. Answer the question

- 1) Name the main processes that determine the presence and duration of the latency period of isometric single contraction of muscle fiber, caused by its direct irritation.
- 2) Will the duration of the latency period of the single contractions of a muscle fibre be the same when it lifts loads with different weight?
- 3) How will the amplitude of single contractions of a muscular fiber change if under the influence of caffeine in this fiber the activation period increases? Why?
- 4) During exhaustion of the isolated muscle as a result of its prolong contraction the incomplete relaxation of a muscle takes place. Explain mechanisms of an incomplete relaxation of a muscle.

### 4.2. Solve the tasks individually

1. What increases the amplitude of tetanic muscle contraction?
2. The content of the mixed muscles includes muscle fibers with duration of single contraction 100 ms (the period of contraction is 50 ms) and 40 ms. (The period of contraction is 20 ms). What type of contraction will arise with the frequency of nervous impulses 25 Hz which arrive from spinal motoneurons to the noted groups of muscle fibers?
3. Laboratory assistant of 30 years old liked to drink only distilled water. It caused the disfunctions of skeleton muscles. He consulted a doctor with the complains about the increased muscular fatiguability and in sufficient muscular force. The examination showed no pathological changes and the doctor decided that the man was almost healthy. What wasn't taken into

consideration by the doctor? Why did the patient complain of the muscular weakness? What recommendations can you propose?

**4.3. Choose the correct answer:**

1. Repeated stimulation of a skeletal muscular fiber causes the tetanic contraction thanks to the increase endocellular concentration of one of following substances:
  - A. Na<sup>+</sup>
  - B. K<sup>+</sup>
  - C. Ca<sup>2+</sup>
  - D. ATP
  - E. troponin
2. The main function of troponin in a muscular fibre is one of the following:
  - A. It regulates the opening of the active centers of actin
  - B. It promotes the excitation-contraction coupling
  - C. It pumps out Ca<sup>2+</sup> ions into the tanks
  - D. It opens Ca<sup>2+</sup> channels of the tanks
3. Reducing the formation of ATP in muscular fiber will lead to the absence of:
  - A. Formations of cross-bridges between actin and myosin
  - B. Ions of Ca<sup>2+</sup> ions liberation from the tanks
  - C. Changing of the angle of the myosin's head relative to actin
  - D. Cross-section bridges dissociation during contraction
  - E. Excitation-contraction coupling
4. Long muscle's contraction with its length diminishing is one of following types of contraction:
  - A. isotonic
  - B. isometric
  - C. tetanic
  - D. active
  - E. passive
5. Duration of single contraction is 0.1 s. With what minimum frequency is it necessary to put irritation by electric current that the incomplete tetanus should arise?
  - A. <10 Hz
  - B. > 10 Hz

- C. 10 Hz
  - D. > 20 Hz
  - E. > 25 Hz
6. Duration of single contraction is 0,05 s, and the shortening period is 0,02 s. With what minimum frequency is it necessary to put irritation by electric current that the complete tetanus should arise?
  - A. <20 Hz
  - B. 25 Hz
  - C. <50 Hz
  - D. 50 Hz
  - E. > 50 Hz
7. Duration of the single contraction is 0.2 s, the shortening period is 0,1 s. What type of contraction will arise when irritating a muscle with frequency of 50 Hz?
  - A. Single contractions
  - B. Incomplete tetanus
  - C. Complete tetanus
  - D. Isometric
  - E. Isotonic
8. A tension without ATP expenses takes place in a skeletal muscle at one of the types of contraction:
  - A. Isotonic
  - B. Isometric
  - C. Tetanic
  - D. Active
  - E. Passive
9. The force of muscle contraction will increase:
  - A. With the decrease of its initial length
  - B. With the increase of ATP formation
  - C. With the increase of troponin quantity
  - D. With the increase of quantity of cross-bridges
10. During the latency period in the muscular fiber there arises first of all:
  - A. AP generation
  - B. Ca<sup>2+</sup> pumps activation
  - C. Cross-bridges formation
  - D. Blockade of ATF-ase

**Protocol of practical study №4. “ \_\_\_ ” \_\_\_ 20 \_\_\_****Work 1. Research of dependence of degree of a muscle contraction on the quantities of fibres which take part in contraction.**

One of major factors which define both degree of muscle's contraction and the force of their tension set in the weight of a moved cargo, is the quantity of muscular fibers which take part in contraction. This dependence is caused by the fact that with the increase of the quantity of contracting fibers in a muscle, the number of working bridges increases in it simultaneously, and therefore, the total force, generating these bridges increases. Thus the force of contraction of every single myocyte does not change.

Therefore during the isometric contractions the muscles have an opportunity to develop more tension, that is to keep more load, and during the isotonic contraction both to develop more tension keeping more load and to be contracted more intensively, that is to move large load on a longer distance.

The dependence of muscle contraction's degree on the number of its fibers can be seen in the experiment on the isolated muscle by means of its electric irritation of different force. Fibers of muscles are characterized by different excitability, and, hence differ in threshold force of irritation. Therefore with the increase in force of electric irritation of a muscle the quantity of its fibres which are contracted (while all the fibres will be excited) will gradually increase. Registering of isotonic contractions, it is possible to be considered that in the process of increase in force of irritation of a muscle their amplitude enlargers.

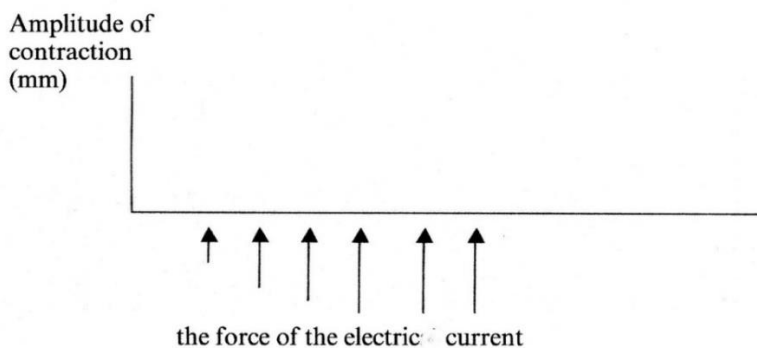
**The work purpose:** to find out the dependence of degree of muscle contraction on the number of its fibers which take part in the contraction.

**It is necessary to have for the work:** a stimulator, a damp chamber, miograph with the load in weight 15-20 g, kymograph, a set of tools, a desk for preparation, Ringer's solution, a pipette, a frog.

**The work course.** Prepare the isolated nervous-muscular preparation of a frog (sciatic nerve – soleus muscle), fix it in the damp chamber, connecting with a miograph. Attach irritating electrodes to the muscle (irritation of the muscle is direct). Approach the miograph to a drum surface. Check up, whether the miograph's lever is set in a plane touching a drum surface. Register muscle contraction on a motionless drum of kymograph. Turn on the electrostimulator. Frequency of irritation makes 1 imp/s. Gradually increase the force of electric irritation of the muscle beginning with 0, and write down contractions until their amplitude will stop to change. After the record of every next contraction of the muscle move a drum of kymograph on 0,5-1 cm.

**Results of the work:** The results of the work are to issue in the form of the scheme of the record received on a drum of kymograph.

Gastrocnemius muscle contraction under the electric current irritation



**Conclusions:**

*With the increase in the force of irritating electric current the amplitude of a skeletal muscle contraction increases, because (to explain the reasons)*

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**Work 2. Research of the dependence of character of a muscle contraction on the frequency of its irritation.**

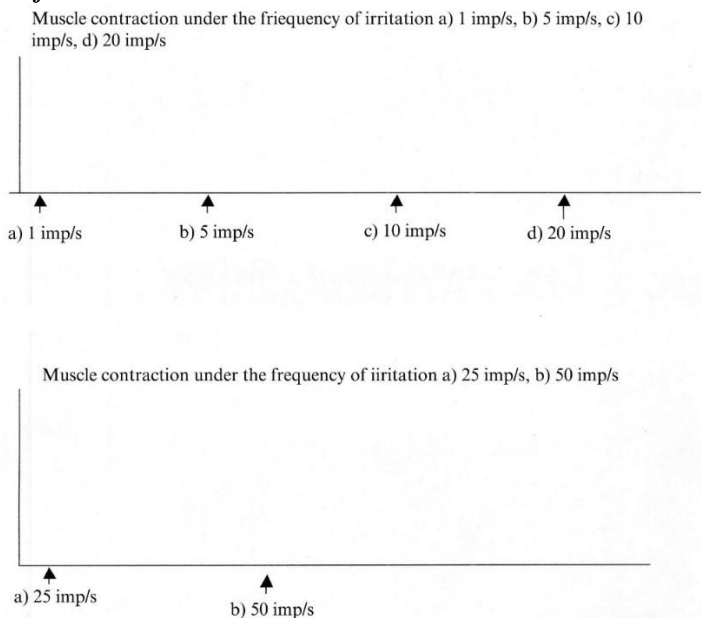
**The work purpose:** to find out, how the form, duration and amplitude of a muscle contraction will change in the case of increase in the frequency of its irritation.

**It is necessary to have for the work:** a stimulator, a damp chamber, miograph with a load in weight 15-20 g, kimograph, a set of tools, a desk for preparation, a plate, Ringer`s solution, a pipette, a frog.

**The work course.** Prepare the isolated nervous-muscular preparation of a frog (sciatic nerve – soleus muscle), fix it in the damp chamber, connect with miograph. Place the nerve of preparation on irritating electrodes (the irritation of the muscle is indirect). Approach miograph to a drum of kimograph. Check up, whether the miograph`s lever in a plane touching a drum surface. Turn on the drum of kimograph. Turn on the electrostimulator. Frequency of irritation makes 1 imp/s. Gradually increase the force of electric irritation of the muscle until the amplitude of its single contraction which are registered on a kymograph`s drum, will stop to increase.

By means of the corresponding switch of the electrostimulator increase the frequency of muscle`s irritation at first to 25 imp/s, and then to 50 imp/s, registering tetanic contractions.

Stop the drum of kimograph and turn off the electrostimulator.

**Results of the work:**



**Conclusions: (answer the following questions:1)** under which conditions of irritation arise a) single contraction, b) incomplete tetanus, c) complete tetanus? 2) Why the amplitude of the tetanic contraction is greater than the single one?)

1) Single contraction arises if \_\_\_\_\_

2) The incomplete tetanus arises if \_\_\_\_\_

3) The complete tetanus arises if \_\_\_\_\_

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

### **The literature**

#### **Basic**

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

#### **Additional**

1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P.32-52.

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3. E.B. Babsky, B.I. Khodorov, G.I. Kositsky, A.A.Zubkov Human physiology. Mir Publishers

**FOR NOTES**

## SECTION 3. Biological regulation.

### Practical study 5.

#### ***The general characteristic of biological regulation. Studying of a reflex arch***

##### **1.Urgency of the theme:**

Biological regulation is a set of processes in an organism which provide unity of its structures as a complete system, and interaction of an organism with the environment which has adaptive character. An organism is a self-regulating system therefore the analysis of processes of the organism's functions regulation allows the doctor to find out and to normalize the broken links in the regulation thanks to it adaptive reaction of an organism is reached.

##### **2.Educational purposes:**

- *To Treat the concept of biological functions regulation, its kinds, to analyze mechanisms of nervous regulation of the physiological functions of an organism and its systems.*
- *To Describe the contours of biological regulation of the functions, to analyze their regulated parameters, functions of the links and a role of direct and feedback connections in maintenance of adaptive reaction of an organism.*
- *To Describe the mechanisms of reflex regulation of the functions and the role of elements of the reflex arch as components of a contour of biological regulation in maintenance of adaptive reaction of an organism.*
- *To Analyze the structure of a reflex arch in the experiment, a role of the integrated and local reflex centres in maintenance of adaptive reaction of an organism.*

##### **3.Approximate pattern for independent work at preparation for practical study**

##### **3.1.The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Biological regulation	It is a set of processes which provide interaction between the structures of an organism, and interaction of an organism with environment to achieve some adaptive result.
Contour of biological regulation	It is a way for information conduction and processing which provides achievement of adaptive reaction of an organism.( the optimal value of regulated parameter).
Regulated parameter (RP)	It is the parameter which characterizes the adaptive reaction of an organism
The watching structure	It is an element of a contour which perceives the information about the change of RP, in an organism this function is carried out by receptors.
The command structure	It is an element of a contour which perceives the information, compares it with the set parameters, forms a corresponding signal (makes the decision) for achievement of adaptive reaction of a system; in an organism these functions are carried out by the central nervous system (CNS).
The feedback connection channel	It is a way for an information transmission from the regulated parameter to the command structure about the value of regulated parameter and its deviation from the set level due to the work of the watching structure.
The straight connection channel	It is the way for an information transmission from the command structure to the regulated parameter to support the set magnitude

	of regulated parameter thanks to the change of executive structures` functions.
The channel of external connection	It is the way for an information transmission to the command structure about external ("disturbance") influences which demand adaptive organism`s reaction achievement with corresponding characteristics of RP. This adaptation is a contradiction to the RP deviations because of "disturbance" influences.
Reflex	It is the answer of an organism to irritation with the CNS participation that provides adaptive reaction of an organism as answer to the changes of the external or internal environment.

### 3.2.Theoretical questions

- 1) Biological regulation, its significance and kinds. A contour of biological regulation. The feedback role in the regulation. Regulation "on the deviation (mismatching)" and "on the disturbance".
- 2) The concept about a reflex. The structure of reflex arch and the function of its links. The concept about the local and integrated reflex centres.
- 3) The comparative characteristic of conditioned and unconditioned reflexes.

### 3.3.Practical works

- 1) The Analysis of reflex arch structure.
- 2) Conditioned blinking reflex formation.

## 4.Materials for individual work and self-control

### 4.1.Answer the question

- 1) What is the significance of the feedback connection for the counter`s biological regulation activity? Why does this activity become impossible with the absence of the feedback channel?
  
- 2) What changes will take place at the damage of "watching structure" in a human organism? Can it threaten his health? Substantiate your answer, draw the chart of the contour of biological regulation under these contitions.
  
- 3) Can a contour of biological regulation provide the possibility of regulation "on disturbance"? If so, due to what link?
  
- 4) In what case will the contour of biological regulation provide the change of regulated parameters instead of their constancy?
  
- 5) Is the muscle contraction which is the result of efferent nerve irritation a reflex?

**4.2. Solve the task individually**

- 1) What will change in the character of reflex reaction if to keep only the local nerve centre in the reflex arch, having destroyed parts of CNS which are located above?
- 2) In a patient suffering from diabetes mellitus the receptor`s sensitivity of the target cell to hormone insulin was worsened. What changes in the work of contour of biological regulation have taken place? Draw the chart of the contour of biological regulation.
- 3) The damage in cervical part of spinal cord. It was stated in a diver. Name the element of the contour of biological regulation which was damaged.
- 4) Chloretil can be used at injury in sportmans during the sport competitions It is applied on injured surface to decrease the pain. What part of the reflex arch does this preparate act?

**4.3. Choose the correct answer**

1. During the experiment on a spinal preparation of a frog the time of withdrawal reflex was studied, dipping a preparation pad into a glass with 0,5 % solution of sulfuric acid. After skin`s removal from a site where the irritation was put, and experiment repetitions the loss of reflex reaction has shown. What link exception of a reflex arch has led to the reflex loss:

- A. receptive fields
- B. afferent neuron
- C. efferent neuron
- D. interneuron
- E. feedback connection

2. What link of a contour of biological regulation provides possibility of regulation "on a deviation":

- A. The channel of external connection
- B. The feedback channel
- C. The channel of straight connection
- D. Such link is absent

3. In the absence of the channel of straight connection the activity of a contour of biological regulation becomes impossible, because the command structure:

- A. Has no information about the regulated parameter
- B. Has no information about "disturbance"
- C. Does not influence on the executive organs

D. Does not influence on regulated parameter

4. A reflex is:

- A. An information transfer way in an organism at irritation
- B. An information transfer way on afferent neuron
- C. An information transfer way on efferent neuron
- D. The answer of an organism to irritation with the central nervous system participation
- E. An information transfer from the afferent neuron to the efferent

5. In experiment on a frog the conducting ways` transection between the brain and the thoracal part of the spinal cord was carried out. The irritation of skin receptors of back extrimity by 1 % solution of sulfuric acid will lead to withdrawal reflex of back extrimity thanks to:

- A. The integrated nervous centre
- B. The local nervous centre
- C. Increase in the force of irritation
- D. Increase in duration of irritation
- E. Everything that is above named

6. In the experiment on a spinal preparation of a frog a tone muscles disappearance on one of the back extrimity was caused by one of the influences:

- A. Damage of spinal cord segment

- B. Irritation of a sciatic nerve on the same side
- C. sciatic nerve transaction on the same side
- D. sciatic nerve transaction on both sides
7. At electrical current irritation of the ventral roots of a spinal cord it is impossible to register the action potentials in the dorsal roots because unilateral conductivity has:
- Central synapse
  - afferent nerves
  - efferent nerves
  - Receptors
  - Muscular fibers
8. At the action of conditioned irritant - a sound signal there is a conditioned protective reflex - eyelids fall. In opposite to such unconditioned reflex at the cornea irritation by the air the conditioned reflex provides:
- Protective reaction
  - Adaptive reaction
  - Bilateral reaction
  - Advancing reaction
- E. Inborn reaction
9. The irritation of skin receptors of back extremity of a spinal preparation of a frog by 0,5 % sulfuric acid solution leads to withdrawal reflex of extremity with small amplitude while the irritation by 1,0 % sulfuric acid solution increases amplitude of withdrawal reflex of the extremity thanks to occurrence in receptors:
- Action potentials with more amplitudes
  - Decrease of the threshold of depolarization
  - Increase of the magnitude of receptor potential
  - increase of receptive field
10. The conditioned reflex is formed under a condition
- The genetic heredity
  - A combination in time indifferent and unconditioned irritants
  - An unconditioned irritant advancing in time
  - All noted above

### **Protocol of practical study №5. “\_\_\_\_\_” \_\_\_\_\_ 20\_\_\_\_\_**

#### **Work 1. The analysis of reflex arch's structure.**

**The work purpose:** to establish necessity of all links of a reflex arch for reflex realization.

**It is necessary to have for the work:** a support with a hook, 0,5 % sulfuric acid solution, a cup, a pot with water, tools, a frog.

**The work course:** Make decapitation of a frog, and hang a spinal preparation for the lower jaw on a support's hook. In 3-5 minutes put down a finger-tip of a back extremity of a frog in 0,5 % HCL solution and observe appearance of withdrawal reflex. After that wash off the acid with water, taking the back extremity of a frog in the pot with water. Repeat the research, acting with the same irritation on the skin of other extremities.

Then put off the skin from one back extremity, preliminary having made a circular cut of a skin below a knee joint, and again put irritation, but now in the absence of a skin where receptors are located. Repeat the research on other intact extremity and observe reflex reaction.

After that prepare the sciatic nerve on the intact extremity and cut it, then put the irritation on a skin of a foot and observe, whether there will be a reflex reaction.

Check, whether there are protective reflexes at skin irritation of forward extremities then destroy a spinal cord with a probe then repeat the research.

#### **Results of the work:**

1) At skin irritation of a spinal preparation with an acid solution the protective withdrawal reflex was observed.

2) At an exception stage by stage the links of a reflex arch: 1) skin receptors, 2) the afferent and efferent nervous fibers which are a part of a nerve, 3) spinal nerve centres reflex reaction is not observed

**The scheme of the reflex arch of spinal withdrawal protective reflex:(draw)**

**Conclusions** (to specify the reasons of withdrawal reflex absence at damage of any link of a reflex arch; which of the centres - local or integrated - is necessary for reflex reaction realization.

**Work 2. Conditioned blinking reflex formation**

**The work purpose:** to establish, under what conditions the conditioned reflex is formed and what significance in organism`s adaptive reaction realization it has?

**It is necessary to have for the work:** an electric call, a frame from spectacles connected with the device for giving of a current of air on the eye`s cornea.

**The work course:** Put on a frame from the spectacles to an examined person with the device for giving of a current of air on an eye`s cornea. Give a current of air on a eye`s cornea and observe the unconditioned protective blinking reflex display – closing eye-lids. After that begin to develop the conditioned blinking reflex on the base of unconditioned taking into consideration such conditions: 1) turn on a bell (indifferent irritant) and then in 3-5 seconds give a current of air on a eye`s cornea (supporting); 2) research has to be repeated 5-6 times with intervals about 1 minute; 3) then turn on a bell without a supporting (a current of air is not given on a eye`s cornea) and observe, whether protective blinking reflex arises under only the bell action as conditioned irritant.

**Results of the work:** to describe consequently your supervision and the conditions for the formation of conditioned blinking reflex.

**Conclusions** (to specify, under what conditions the conditioned blinking reflex is formed; what is its significance in adaptive reaction of an organism; where the local centre of this reflex is situated).

1) *Conditioned blinking reflex was formed under such conditions*

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2) *Conditioned reflex has such adaptive significance* \_\_\_\_\_

3) *The nervous centre of conditioned reflex (temporally links) is located* \_\_\_\_\_

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**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

## **The literature**

### ***Basic***

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### ***Additional***

1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P. 63-79.
2. Ganong's Review of Medical Physiology 25th ed. McGraw-Hill Education. 2015. – 750 p.

**FOR NOTES**

## Practical study 6.

### **Studying of excitation and inhibition in the central nervous system**

#### **1.Urgency of the theme:**

The CNS activity is caused by the interaction between two main nervous processes – excitation and inhibition which provide the reflex coordination. The absence of one of the processes leads to reflex disco-ordination or the absence of reflex activity thanks to inhibition. All noted has application in clinical practice because a doctor has possibility to strengthen, weaken or normalize excitation and inhibition processes.

#### **2.Educational purposes:**

- *To Explain the mechanisms of the information transmission in the CNS synapses, neurotransmitters` and neuromodulators` role.*
- *To Explain and analyze the development mechanisms of summation in CNS synapses and the role of these processes in integrative functions.*
- *To Analyze the main types of the central inhibition, the development mechanisms of postsynaptic and presynaptic inhibition, and also the neuronal mechanisms of negative feedback inhibition in CNS.*
- *To Analyze the role of the excitation and the inhibition summation in the neurons in the integrative CNS`s function, interaction mechanisms between neurons.*

#### **3.Approximate pattern for independent work at preparation for practical study**

##### **3.1.The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
The central synapse	The place for the contact of two neurons.
Excitatory postsynaptic potential (EPSP)	It is local depolarizational potential which arises on postsynaptic membrane of the excitatory synapse under the influence of excitatory neurotransmitter.
Inhibitory postsynaptic potential (IPSP)	It is local hyperpolarizing potential which arises on postsynaptic membrane of excitatory synapse under the influence of inhibitory neurotransmitter.

##### **3.2.Theoretical questions**

- 1) Communication mechanisms between central nervous system neurons.
- 2) Excitation in CNS. The types of the central excitation. Mechanisms and regularities of excitation transmission through central synapses.
- 3) Inhibition in CNS and its role. The main types of the central inhibition, mechanisms of their appearance.
- 4) Summation of excitation and inhibition with central nervous system`s neurons. The kinds of summation and its significance.

##### **3.3.Practical works**

- 1) Determination of general duration of the withdrawal protective reflex at a frog by Turk`s method.
- 2) The analysis of mechanisms of Sechenov`s inhibition appearance.
- 3) The research of excitation summation with CNS`s neurons.

#### **4.Materials for self-control**

##### **4.1.Answer the question:**

- 1) What structural element of the nervous system permits to carry out communicational connections between nervous cells and between neurons and their target cells of the other nature? Illustrate your answer with a chart.



- 2) How long does it take for excitation to conduct through the central synapse? How and why does it differ from the time of excitation conduction through nervous-muscular synapse?
- 3) The force of afferent nervous signal which arrives to the nervous motor centre increases. What displays will have the increase in force of excitation?

#### 4.2. Solve the tasks individually

- 1) In a patient during a fit of epilepsy involuntary inforced muscles contractions often appear which are connected with excitation redistribution along changed nervous tissue. What functional property of reflex centres is observed at it?
- 2) What the frequency of presynaptic nervous impulses (in Htz) should be for the time summation appearance on the neuron`s body, if the duration of single EPSP makes 15 ms?
- 3) On the plasmatic membrane of motoneuron 20 excitatory and 15 inhibitory postsynaptic potentials appear simultaneously. Will this neuron generate the efferent nervous impulses if the amplitude of single EPSP and IPSP appearing on the axonic hillock membrane equals to 1 mV? Name the state in which this neuron will be, the type of summation of excitation and inhibition.
- 4) The amplitude of single EPSP in the axonic hillock of motorneuron makes 1 mB, and threshold of depolarization of the axonic hillock membrane is 10 mB. What will be the reaction of motoneuron if to its body simultaneously arrive:) 5 excitatory; 20 exciatory nervous impulses?
- 5) During the labolatory researches in a dog the special neurons reacting only on some characteristics of signals, for example, on the movent of irritation, were discovered. What is the function of these neurons?
- 6) Can the inhibition be developed in the central synapses as a result of verapamil prescription for a pationt suffering from hypertonic disease? Verapamil blocks calcium channels on plasmatic membrane of vessels. Substantiate your answer, name the type of inhibition.

#### 4.3. Choose the correct answer:

1. The activation of the receptor`s proteins on the postsynaptic membrane took place, which led to IPSP occurrence. IPSP occurrence has taken place thanks to one of the following neurotransmitters:

- A. noradrenaline
- B. glycine

- C. acetylcholine
- D. dopamine
- E. serotonin

2. In an experiment on a frog the preparation strychnine which blocks development of process of inhibition in CNS was injected. At the mechanical irritation of a skin of the

right back extremity of a frog there will be a reflex contraction

- A. Muscles of the right back extremity
- B. Muscles of the left back extremity
- C. Muscles of forward extremity
- D. All groups of muscles of a trunk and extremities

3. In a person sick of a tetanus, in reply to insignificant irritation of skin receptors and muscles spasms occurs because under the influence of tetanic toxin in CNS there is decreased development of:

- A. Excitation and AP generation
- B. feedback inhibition
- C. presynaptic inhibition
- D. postsynaptic inhibition

4. In an experiment on a spinal preparation of a frog the increase of sulfuric acid concentration from 0,3 % to 0,5 % to which the irritation is put on a skin of foot of back extremity, led to the decrease of time of a reflex and increase in amplitude of back extremities bending. One of the processes in the spinal centres on motoneurons should be the mechanism of it:

- A. excitation irradiation
- B. Spatial summation of excitation
- C. Time summation of excitation
- D. feedback inhibition
- E. inhibition oppression

5. What should be the frequency of presynaptic nervous impulses (in Hz) in order that the time (consecutive) summation of EPSP has taken place on a neuron's body if the duration of the single EPSP is 15 mc:

- A. 30
- B. 67
- C. 55
- D. 33
- E. 44

6. In an experiment on a spinal preparation of a frog the increase in the area of irritation

of a skin of foot of back extremity led to the decrease in the time of reflex and increase in amplitude of bending of back extremity. One of processes in the spinal centres on motoneurons should be mechanism of it:

- A. excitation irradiation
- B. Spatial summation of excitation
- C. Time summation of excitation
- D. feedback inhibition
- E. inhibition oppression

7. In an experiment studying Sechenov's inhibition on thalamical preparation of a frog the time of protective withdrawal reflex increases under the simultaneous irritation by sulfuric acid of a skin of foot of back extremities and action of salt on thalamus. It is a consequence of one of the processes in the spinal centres:

- A. feedback inhibition
- B. presynaptic inhibition
- C. postsynaptic inhibition
- D. lateral inhibition
- E. Blockade of excitatory synapses

8. Blockade of calcium channels with preparation verapamil will lead to impossibility of development on motoneuron:

- A. presynaptic inhibition
- B. postsynaptic inhibition
- C. feedback inhibition
- D. excitatory postsynaptic potential
- E. Everything that is noted above

9. Motoneurons generate AP on axon's membrane with the maximum frequency to 50 Hz that is a consequence of development on motoneuron:

- A. feedback inhibition
- B. presynaptic inhibition
- C. postsynaptic inhibition
- D. lateral inhibition
- E. Blockade of excitatory synapses

### **Protocol of practical study №6. " \_\_\_\_\_ " \_\_\_\_\_ 20\_\_\_\_**

#### **Work 1. Determination of the general duration of protective flexing reflex in a frog by the Tyurk's method.**

The general duration of a reflex (reflex time), or its latent period is defined from the beginning of irritation action to the beginning of reflex reaction. The latent period is defined: a) by the time necessary for excitation appearance in receptors; b) the time necessary for an information transmission along afferent nervous fibers to the nervous centre; c) the time necessary for an information transmission from afferent neurons to efferent neurons («the central time of a

reflex») d) the time necessary for an information transmission from the nervous centre to efferent nervous fibers to organ-effector and reflex reaction appearance.

**The work purpose:** to determine the general reflex time and to analyse the roles of its components.

**For work it is necessary to have:** a support with a hook, a metronome or a stop watch, 0,1 % solution of sulfuric acid, a cup, a pot with water, tools, a frog.

**Work course:** Make decapitation of a frog, and hang a spinal preparation for the lower jaw on a support's hook. In 3-5 minutes put a finger-tip of back extremity of a frog into 0,1 % solution a sulfuric acids and from this moment measure the time till appearance of withdrawal reflex of extremity. After that acid is washed off with water, the back extremity of a frog is put into the pot with water.

Repeat the research three times and define average time of reflex.

**Results of the work.**

- 1) the general time of flexing reflex: a) \_\_\_\_\_  
 b) \_\_\_\_\_  
 c) \_\_\_\_\_  
 Average general time of flexing reflex \_\_\_\_\_

**Conclusions:** (to notice what is understood as the general time of a reflex and what periods it consists of)

## Work 2. The analysis of mechanisms of Sechenov's inhibition development.

There are both excitation and inhibition neurons in the nervous centres. I.M. Sechenov, the known Russian scientist has shown possibility of development of inhibition in CNS in 1861 for the first time in experience on thalamic preparation of a frog.

**The work purpose:** to establish the presence of inhibitory neuronal chains in CNS which activation results in development of inhibition process.

**For work it is necessary to have:** a support with a hook, a metronome or a stop watch, 0,3 % solution of sulfuric acid, a cup, a pot with water, tools, crystals of table salt, a filtering paper, a frog.

**Work course:** Prepare thalamic preparation of a frog. For this purpose it is necessary to make decapitation of a frog on back edge of orbits of eyeballs - the cut will pass at thalamic level. Hang a preparation for the lower jaw on a support's hook and dry up a surface of a cut of brain with a filtering paper.

Measure the general time of flexing reflex of thalamic preparation three times putting a finger-tip of back extremity of a frog into 0,3 % of sulfuric acid solution.

After that place a crystal of table salt on the cross-section of brain with tweezers. In 3-5 minutes define again the general time of flexing reflex - it, as a rule, increases.

**Results:**

1) Time of flexing reflex of thalamic preparation of a frog before the imposing of chloride sodium crystal on visual hills \_\_\_\_\_

2) Time of flexing reflex of thalamic preparation of a frog after imposing of chloride sodium crystal on visual hills \_\_\_\_\_

**Conclusions:** (to specify the reasons of increase in general time of flexing spinal reflex after an irritant action on visual hills; to draw the scheme which explains development mechanisms of presynaptic Sechenov`s inhibition in the spinal centres)

1)

2) *the scheme showing presynaptic inhibition of spinal flexing reflex development at visual hills activations under the influence of chloride sodium crystal:*

### **Work 3. Research of excitation summation by CNS`s neurons.**

**The work purpose:** to establish the ability of neurons of the nervous centre to excitation summation: consecutive (temporary); spatial (simultaneous).

**For work it is necessary to have:** a support with a hook, a metronome or a stop watch, 0,1 % and 0,3 % sulfuric acid solution, a cup, a pot with water, tools.

**Work course:** Make decapitation of a frog, and hang the spinal preparation for the lower jaw on a support`s hook.

Research of consecutive (temporary) summation of excitation.

In 3-5 minutes lower a finger-tip of back extremity of a frog into 0,1 % sulfuric acid solution and from this moment measure time till the reflex flexing of extremity appears. After that wash off the acid with water, putting a back extremity of a frog into the pot with water. Repeat the research in 3 minutes, putting irritation of 0,3 % solution of sulfuric acid.

Research of spatial (simultaneous) summation of excitation

Lower a fingertip of a back extremity of a frog into 0,3 % solution of sulfuric acids and measure the time from this moment till the appearance of withdrawal reflex of the extremity.

Repeat the experiment putting irritation with the same concentration of sulfuric acid, but increase the surface of irritation – lower all foot of a back extremity of a preparation. into 0,3 % solution of sulfuric acid.

#### **Result of the work:**

Research of consecutive summation of excitation.

1) The general time of flexing reflex of spinal preparation of a frog under irritation of a finger-tip of back extremity with of 0,1 % solution of sulfuric acid\_\_\_\_\_

2) The general time of flexing reflex of spinal preparation of a frog under irritation of a finger-tip of back extremity with of 0,3 % solution of sulfuric acid\_\_\_\_\_

Research of simultaneous summation of excitation

1) The general time of flexing reflex of a spinal preparation of a frog at irritation of a finger-tip of back extremity with 0,3 % solution of sulfuric acid\_\_\_\_\_

1) The general time of flexing reflex of a spinal preparation of a frog at irritation of all foot of back extremity with of 0,3 % solution of sulfuric acid\_\_\_\_\_

**Conclusions:**

irritation of a finger-tip of a back pad of the frog \_\_\_\_\_

Thanks to \_\_\_\_\_ summation development in the nervous centre

2) The general time of flexing reflex of a spinal preparation of a frog at increase in a surface of irritant action \_\_\_\_\_ - \_\_\_\_\_ thanks to \_\_\_\_\_ summation.

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

## The literature

### *Basic*

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### *Additional*

1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P.55-62, 80-94.

2. Ganong's Review of Medical Physiology 25th ed. McGraw-Hill Education. 2015. – 750 p.

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## FOR NOTES

## SECTION 4. Sensory systems.

### Practical study 7.

#### **Studying of somatosensory system**

##### **1. Theme urgency:**

Sensory systems include central and peripheral structures of CNS which detect and analyze information about environmental events and internal processes and form a certain feeling or image. Organism forms respective reactions based on this information which are adequate to the external influences or internal alteration.

Somatosensory system provides all the types of skin senses formation (tactile, temperature and pain sensitivity) and proprioceptive information that result in feeling of body position and motions of locomotor system.

A doctor should know the basis of sensory physiology especially somatosensory system.

##### **2. Educational aims**

- *to interpret the concept of sensory systems, general principles of their structures and functions.*
- *to explain the role of different levels of sensory system organization - receptors, spinal-brainstem part, thalamic and cortical parts.*
- *to analyze the mechanism of skin and proprioceptive sensation arising.*
- *to illustrate the scheme of sensoric system structure (after Pavlov) and the structure of somatosensory system.*
- *to choose the adequate methods of skin senses investigation and to analyze obtained results.*

##### **3. Approximate pattern for independent work at preparation for practical study**

##### **3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Determination</b>
Sensory system	combination of central and peripheral nervous structures which provide the information passage from the receptors to CNS its analysis on different levels of CNS that result in sensation appearing and image perception with the obvious participation of brain cortical centers
Information passage channels	pathways that conduct the signals from receptors to the different levels of CNS up to brain cortical centers. Can be determined in all the sensory system
Levels of sensory system organization	central and peripheral nervous structures where informational analysis is performed that leads to the sense formation or image perception by the brain cortical centers
Nociceptors or damage receptors	high threshold mechano-, thermo- and chemoreceptors signals from which go upstream to the CNS and result in pain feeling due to this information analysis in brain cortical centers
Absolute sensitivity threshold	minimal stimulus power (minimal irritation power) that causes to a certain sense appearing
Differential sensitivity threshold	minimal difference in stimulus power that leads to formation of sense intensity difference

Neospinothalamic pathway	the other name of lateral spinothalamic tract that transmit information from the trunk and extremities receptors through specific thalamic nuclei to the sensory zone of brain cortex
Paleospinothalamic pathway	the other name of ventromedial spinothalamic tract that transmit information from the trunk and extremities nociceptors through unspecific thalamic nuclei to the sensory zone of brain cortex

### 3.2. Theoretical questions

- 1) Concept of sensory systems.
- 2) General outline of sensory systems structure and functions.
- 3) Description of receptive, spino-brainstem, thalamic and cortical levels of sensory system.
- 4) Conception of specific, unspecific and associative signal pathways.
- 5) Somatosensory system.
- 6) Skin senses and their types.
- 7) Proprioceptive system.
- 8) Nociception. Concept of the pain sensation mechanisms.
- 9) Analysis of somatosensory information.

### 3.3. Practical works

- 1) General analysis of skin sensitivity (Horovyt's experiment).
- 2) Investigation of tactile skin sensations.
- 3) Investigation of cold and thermal sensitivity.
- 4) Research of skin pain sensitivity.

## 4. Materials for individual work and self-control

### 4.1. Answer the question

- 1). Show schematically the structure of sensory system (analyzer), mark the main parts and channels for information transmission.
  
- 2). Using the chart mark how the way for the information conduction in the cortex of large hemispheres will be changed if the left receptive field is lost.
  
- 3). There is a method of cold back shutdown of brain parts in an animals in chronic experiments. What reaction of a cat will be after the cold shutdown of all the specific thalamic nuclei to the action of different stimuluses, for example, a bell, bright light, mechanical skin irritation, a touch with hot subject, the smell of meat?
  
- 4). Draw the scheme of the main conductive pathways of the somatosensory system, in the scheme mark the types of receptors from which the information is conducted.
  
- 5). On the previous scheme to draw the line showing the "cut" level of spinal cord. It is upper the place of afferent (sensivity) roots entrance. What types of sensitivity and what side are lost after such a cut. Make the similar imaginative "cut" on the opposite side. What reaction will be?

- 6). At a slight touch with a needle the skin of back of the arm a patient felt touch in the most cases and sometimes a weak pain. At the more forced touch with a needle the patient felt only pain. Explain this phenomena.
- 7). An investigated held one hand in the water with the temperature  $35^{\circ}\text{C}$ , and the other in the water with the temperature  $10^{\circ}\text{C}$ . Then he put both hands into the water with the temperature  $18^{\circ}\text{C}$ . What sensations appeared in him wherein? Explain this phenomena.

#### 4.2. Choose correct answer

- A person after skin damage felt the pain and this sense was formed in the certain area of brain cortex, namely the...
  - postcentral convolution
  - gyrus precentralis
  - frontal parts
  - temporal convolution
  - orbitofrontal cortex
- A person suffers from the pain after getting sunburn. Choose the neurotransmitter which is involved in the pain felling formation:
  - 5-HT (serotonin)
  - histamine
  - epinephrine
  - acetylcholine
  - $\gamma$ -aminobutyric acid
- A person always carries a wedding-ring and does not fell it at all. Choose the processes which had happened in the skin mechanoreceptor membrane:
  - increase of the depolarization threshold
  - increase of the excitability
  - without the changes of excitability
  - without the changes of the depolarization threshold
  - decrease of the depolarization threshold
- During the mechanic senses examination the only Meissner's bodies were activated in response to the skin touch. Choose the process that causes their activation:
  - increase of pressure intensity
  - increase of the movement speed
  - influence of vibration
  - decrease of the movement speed
  - decrease of pressure and vibration intensity
- In the chronic experiment the evoked potentials were registered in somato-sensory cortex in response to the high threshold nociceptors activation. But these potentials were not detected because of some brain endogen peptides release which abolished pain feellings. What are these peptides?
  - statins
  - liberins
  - vasopressin
  - ACTH
  - endorphines
- After traumatic injure of the spinal dorsal sensory root the absence of all thoracic skin senses which is specially organized was detected. Choose the type of its organization:
  - half type
  - segmental type
  - longitudinal type
  - cross type
  - stripe longitudinal type
- The damage of post central convolution cause the absence of all skin senses types on the certain body part. Choose this part:
  - the same as the damaged side
  - the opposite to the damaged side
  - upper portion of the body
  - head skin
  - lower portion of the body
- It was discovered that a man after getting dressed start not to feel the cloths on her body with the lapse of time due to the tactile receptors adaptation. This adaptation is the result of ion membrane permeability changes. What changes take place?
  - decrease to calcium ions
  - increase to sodium ions
  - decrease to potassium ions
  - increase to calcium ions
  - decrease to sodium ions



9. It was found that our behavior alters in case of significant air temperature changes - from minus to plus. This is due to the quantity of thermoreceptors which are located in our skin in proportion:

- A. 5:1
- B. 3:1
- C. 8:1
- D. 2:1
- E. 6:1

10. A patient who was suffering from the chronic pain underwent a certain stereotaxic operation and the pain was removed. Choose the brain structures that were destroyed:

- A. thalamic ventromedial nuclei
- B. thalamic supraoptic nuclei
- C. thalamic ventroposteriolateral nuclei
- D. the whole thalamus
- E. nerve fibers that connect thalamus with the frontal cortex.

### **Protocol of practical study №7. " \_\_\_\_\_ " \_\_\_\_\_ 20 \_\_\_\_\_**

#### **Work 1. General analysis of skin sense (Gorovyts test)**

The skin can be irritated by the pressure, vibration, heat, cold and pain.

**Aim of work:** to find out what senses and in which order arise during the touching to the unknown thing, explain the reasons of this order.

**For work is needed:** glass, ceramic and metal cup filled with the water at a temperature 50-60 °C.

**Plan of work:** investigated person is sitting with closed eyes at the table with the extended hands. The researcher touch to his fingers cups warmed with the water with different surface (glass, ceramic and metal). After touching them investigated person feel the heat and remove his hand.

#### **Results:**

After short time contact of finger tips with the hot surface the feelings arise in the following order: \_\_\_\_\_

#### **Conclusions:**

1) Such an order of senses that are formed after touching to the unknown thing calls from: \_\_\_\_\_

#### **Work 2. Examination of the human skin touch sense**

In the human skin there are touch, thermal and pain sense receptors. Touching receptors are mostly located in the superficial skin layers (25 per each 1 sm<sup>2</sup> in average but there are zones where they are more or less concentrated).

Skin touching sense can be investigated by using esthesiometer (tactometer). These are wood or glass wands that carry a 3-5 sm long horsehair or caprone hair on their one end. These hairs have different length and thickness. Their calibration is performed by pressing them on the analytical balance scale till the hairs bend. The weight that is shown in that moment follows the power of irritation.

**Aim of work:** make sure that the skin possesses the touch sense; find out its density in different areas of skin.

**For work is needed:** hair esthesiometers (tactometers), carton stencil with the 1x1 cm perforations.

**Plan of work:** examine the skin surface of the finger tip and dorsal part of the forearm. The investigated person puts his arm on the table and look to another side. Researcher imposes the stencil on the examined skin surface and presses the skin with esthesiometer to its compressing. It is performed to the different spots inside the 1cm<sup>2</sup> area. Repetitive pressing should not be rhythmical. The hair should not move on the skin. Investigated person should say when he feels touch. The feeling occurs in case when the hair hits the touch spot. Define the density of the touch spots in different skin regions (number per 1cm<sup>2</sup>).

This experiment requires strong attention from both the researcher and investigated person. Using the set of calibrated Fei's hairs one can observe the subliminal level of pressure.

**Results:** From the 30 contacts inside the finger tip area of 1cm<sup>2</sup> it was determined \_\_\_\_\_ touch spots; on the volar forearm \_\_\_\_\_ spots and on the dorsal forearm \_\_\_\_\_ spots.

**Conclusions:**

1) Receptor density of was highest on the \_\_\_\_\_ skin surface. It was minimal on \_\_\_\_\_.

### Work 3. Investigation of cold and thermal skin sense in human

Thermoreceptors, which are cold and thermal, are localized in the skin deeper than touch receptors. They were discovered long time ago and there is no thought-wave concerning their morphology. Krause's bulbs are supposed to be receptors of the cold stimuli and free nerve endings are thought to be excited by the heat. The density of their localization is 10-13 for cold and 1-2 for heat receptors per 1cm<sup>2</sup>. There regions with lesser or more tight their location. This experiment is performed by using a thermoesthesiometer which is the glass cone with the metal rod with high thermoconductivity. The cone is filled with the hot or cold water and put on the cork tightly. The rod reaches a certain temperature and is imposed on the skin. This is the way to identify cold or thermal spots.

**Aim of work:** to make sure in the presence of thermal and cold receptors in the skin by identifying their localization, find out its density in different areas of skin.

**For work is needed:** thermoesthesiometer, ice water, water at a temperature 50-60 °C, carton stencil with 1cm<sup>2</sup> perforations.

**Plan of work:** thermoesthesiometer fill with the ice water and put on the cork. Impose the carton stencil and in one its perforation touch the palm skin with thermoesthesiometer. This procedure should be done 30 times. Estimate how many times investigated person felt the cold. Experiment should be repeated for a hands' back.

For examination of the thermal senses one needs the thermoesthesiometer with the hot water (50°C). Estimate how many times from 30 touches investigated person felt the warm. Experiment should be repeated for a hands' back.

**Results:**

Per 1 cm<sup>2</sup> of skin there were determined: 1) \_\_\_\_\_ cold spots on the palm, \_\_\_\_\_ on the back hand.

2) \_\_\_\_\_ thermal spots on the palm, \_\_\_\_\_ on the back hand.

**Conclusions:**

- 1) The density of cold receptors localization is greater on \_\_\_\_\_ but lesser on the \_\_\_\_\_.
- 2) The density of thermal receptors localization is greater on \_\_\_\_\_ but lesser on the \_\_\_\_\_.
- 3) On the certain part of skin the density of cold receptors is \_\_\_\_\_ than that of thermal receptors.

#### **Work 4. Investigation of pain sense of the human skin**

The skin has a pain senses. It is supposed that pain feeling evokes in case of special receptors irritation - damage receptors or nociceptors. These are high-threshold mechanoreceptors that are activated by mechanic stimuli of significant power which can destroy the tissue. Nociceptors include also chemoreceptors which are activated in response to pH change (during acidosis) that take place during thermal and chemical injure. The simplest and well dosed way of initiating the pain is the touching to skin with different intensity by needle.

**Aim of work:** to find out whether diffenent skin parts have the equal pain sensitivity.

**For work is needed:** carton stencil with  $1\text{m}^2$  perforations, sterile unused needles.

**Plan of work:** on the inner surface of the forearm the stencil is imposed. The investigated person puts his arm on the table and look to another side. In the space of one perforation the periodical pricks are applied to the different places. After each prick investigated person should tell about his feelings - prick or just touch. Researcher should calculate the number of pain feelings and the number of touch senses after 30 needle application. Then this experiment is performed on the outer forearm.

**Results:**

Per  $1\text{m}^2$  of skin there were determined: 1) \_\_\_\_\_ pain spots on the inner surface, \_\_\_\_\_ on the outer side.

**Conclusions:**

The density of pain receptors localization on the inner forearm is \_\_\_\_\_ than that of the outer side.

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

## **The literature**

### ***Basic***

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### ***Additional***

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### **FOR NOTES**

## Practical study 8.

### Studying of vision (optic sensory system) and of hearing (auditory sensory system)

#### 1. Theme urgency:

Optic system accepts more than 90% of the information that go from the distant stimuli to the brain. Due to brain a person perceive the shape, size, color and movements of the things and also their localization in the space, distance to them et al.

Knowledge about biophysical and physiological processes which are conducted in different portions of optic sensory system is of great importance for a doctor's professional work, namely for understanding the interaction of the organism with the environment and for the diagnostic of main or additional sensory structure failure.

Auditory sensory system has a second role in acceptance of distant stimuli. During evolution this system was specialized to interaction with acoustic signals which spread through the air. Important feature of this system is not only sounds perception but also detecting its properties and localization of sounds wave generator.

Knowledge about biophysical and physiological processes which are conducted in different portions of auditory sensory system is of great importance for a doctor's professional work, namely for understanding the interaction of the organism with the environment and for the diagnostic of main or additional sensory structure failure.

#### 2. Educational aims:

- *Explain the structure and functional organization of the optic sensory system.*
- *Illustrate schematically the optic sensory system organization.*
- *Characterize the processes those take place in different levels of the optic sensory system.*
- *Choose adequate methods for the research of main function of the optic system.*
- *Analyze peculiarities of the sensory system functions during human life.*
- *Explain the structure and functional organization of the auditory sensory system.*
- *Illustrate schematically the auditory sensory system organization.*
- *Characterize the processes those take place in different levels of the auditory sensory system.*
- *Choose adequate methods for the research of main function of the auditory system.*
- *Analyze peculiarities of the sensory system functions during human life.*

#### 3. Approximate pattern for independent work at preparation for practical study

##### 3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study

Term	Definition
visual acuity	ability to see two spots separately at their maximal approach
visual field	ability to see the large space in front of eyes
binocular vision	ability to see one object while the image of it is formed on the retina of each eye
color vision	ability to perceive and differentiate colors
accommodation	process that helps to enlarge bending of the lens while looking at the near objects
convergence	converging of optical axis while looking at the near objects
emetropia	image focusing on the retina

myopia	refraction abnormality - image focusing behind the retina, is corrected with concave lens
hypermetropia	refraction abnormality - image focusing before the retina, is corrected with convex lens
astigmatism, astigmatia	refraction abnormality when the iris curvature is not the same, is corrected with cylindrical lens
Presbiopia	the damage of the lens convexity during accommodation due to its less elasticity, is corrected with convex lens
Air conductivity of the sound	the ordinary conductivity of sound wave through all the additional structures to the organ of Corti
Bone conductivity of the sound	conductivity through the cranial bones to the bone cochlea and further due to perilymph, endolymph and basilar membrane fluctuations to the auditory receptors
Auditory acuity	by using the method of audiometry the hearing loss is determined for different frequencies comparatively to the standard threshold for each frequency that is taken as normal
Binaural hearing	the mode of hearing that allows to localize the sound source due to sound wave perception by hearing receptors of both ears

### 3.2.Theoretical questions

- 1) General outline of the visual sensory system and its portions.
- 2) Eye movement apparatus. Role of the eye movements in visual function. Binocular vision.
- 3) Convergence of the optical lines
- 4) Light conduction and image focusing. Accommodation. Pupil reflex
- 5) Photoperception and analysis. Retina receptive fields, visual acuity, visual field.
- 6) External geniculate bodies. Visual cortex
- 7) Perception of colors.
- 8) Methods of research of basic visual functions and their indexes (peripheral, central, colour stereopsis).
- 9) General physiology description of the auditory system and its departments.
- 10) Sound-conducting system, functions of auricle, transmission of voice vibrations by the channels of cochlea.
- 11) Sound perceptive apparatus, functions of receptor cells of spiral organ.
- 12) Electric phenomena in the cochlea. Electric activity of ways and centers of auditory analyzer.
- 13) Analysis of frequency of sounds, sounding intensity.
- 14) Basic voice feelings

### 3.3.Practical works

- 1) Research of central vision is by means of tables of Sivcev-Golovin.
- 2) Research of peripheral vision is by means of perimeter.
- 3) Research of stereopsis is by means of four-dot tes
- 4) Research of colour vision is by means of polychromatic tables.
- 5) Research of bone transmission of the sound.
- 6) Comparison of air and bone transmission of the sound.

## 4.Materials for individual work and self-control

### 4.1.Answer the question

- 1) Draw the chart of visual analyzer and specify its basic structures.

- 2) On the chart draw the imaginary cut of one of optical nerves in an area between a retina and crossing of optical nerves. How will an information transfer change after this in higher centers?
  - 3) On the chart of visual analyzer draw "disruption" of both visual areas of occipital brain cortex. What changes of functions of visual analyzer will take place after it? What functions will be saved?
  - 4) On the chart of visual analyzer draw the imaginary "cut" of fibres of visual nerve, which form crossing in the place of their intersection. How will an information transfer change from a retina to the centers of brain cortex? How will eyeshot change?
- 
- 5) Draw the chart of auditory analyzer and specify basic structures of it.
  - 6) Using a chart, to explain, which way pass the information from an auditory analyzer to the oculomotor centers in case of sudden voice stimulus.
- 
- 7) It is known that with age the range of audio-frequency which a man perceives changes. What changes should be in new-born, in a child at the age of 6, in a person at the age of 20 and at the age of 70 years?

#### ***4.2.Solve the task individually***

1.At artificial displacement of one eyeball aside we see objects doubled. Explain, why? What side will the second image be displaced in, if the line of sight is displaced in medial, lateral directions?

2.Dark star night, looking at the sky, in the center of eyeshot we see the a feww of bright large stars, and for peripheries - many stars of different size and brightness. Explain this phenomenon.

3.In darkness and at feeling of fear pupils broaden. Explain the mechanism of this phenomenon.

4. At determination of borders of eyeshot by means of perimeter and coloured test object the last one seems colourless, when is on periphery. As far as moving of test object to the middle of arc of perimeter the investigated begins to distinguish colors. Explain this phenomenon.

5. As a result of disease the structures of middle ear on both sides are damaged in a man. Can he perceive sounds?

6. There is such profession, as clincher. People of this profession can lose a hearing because of influence of very intensive sound during a long time. In clincher of 35 years old the range of perception of audio-frequency presents 9000-17000 Hertz. What structures of the auditory system here can be damaged? What range of frequencies is perceived by the healthy man of this age?

#### 4.2. Choose correct answer

1. Damage visual pathways from a right side resulted in complete blindness on the left eye; define the site of damage :

- A. visual nerve of the left eye
- B. visual nerve of right eye
- C. visual crossing
- D. tractus opticus
- E. genicular-spur pathway

2. The image is focused behind a retina; such violation of refraction has the name:

- A. emmetropia
- B. hypermetropia
- C. myopia
- D. astigmatism
- E. presbyopia

3. Horizontal cells of retina form local chains from:

- A. rods
- B. cones
- C. bipolar cells
- D. ganglionic cells
- E. amacrine cells

4. Amacrine cells of retina form local chains from:

- A. rods
- B. cones
- C. bipolar cells
- D. ganglionic cells
- E. by horizontal cells

5. A person who was looking through window began to read a book. Due to the change of

state of a certain organ refractive power of optical media increases. What organ is it?

- A. vitreum of eye.
- B. Cornea.
- C. Vitreous body.
- D. Pupil.
- E. Lens of the eye.

6. What process takes place during shifting one's gaze from near to far located things?

- A. Contraction of ciliary muscle.
- B. Increase of curvature of lens of the eye.
- C. Weakening of Zinn's ligament.
- D. Weakening of ciliary muscle.
- E. Increase of refractive ce of eyes.

7. Which of the visual functions is violated most of all at the damage of rods?

- A. Light adaptation.
- B. Peripheral sight.
- C. Binocular sight.
- D. Central sight.
- E. Colour sight.

8. After the trauma of cerebrum a person lost his sight. The damage of what areas of cerebrum cortex can cause such a state?

- A. Frontal.
- B. Temporal.
- C. Parietal.
- D. Occipital.
- E. Temporal and parietal.

9. The action potential transmission through the optic chiasm is stopped because of tumor.



Which fields of vision(temporal or nasal) of the right and of the left eyes are kept and which are lost?

**A.** nasal parts of both eyes are kept, temporal parts of both eyes are lost.

**B.** temporal parts of both eyes are kept, nasal parts of both eyes are lost.

**C.** temporal and nasal parts of the left eye are lost, both ones of the right eye are kept.

**D.** Nasal part of the left eye and temporal part of the right eye are lost; temporal part of the left eye and nasal part of the right eye are kept.

**E.** temporal part of the left eye and nasal part of the right eye are lost; nasal part of the left eye and temporal part of the right eye are kept.

10. The action potential transmission through the optic nerve on the left side is stopped because of trauma. What fields of vision of the right and the left eyes are kept and what are lost?

**A.** nasal parts of both eyes are kept, temporal parts of both eyes are lost.

**B.** temporal parts of both eyes are kept, nasal parts of both eyes are lost.

**C.** temporal and nasal parts of the left eye are lost, both ones of the right eye are kept.

**D.** Nasal part of the left eye and temporal part of the right eye are lost; temporal part of the left eye and nasal part of the right eye are kept.

**E.** temporal part of the left eye and nasal part of the right eye are lost; nasal part of the left eye and temporal part of the right eye are kept.

11. Which determination most fully characterizes properties of basilar membrane of cochlea, where the organ Corti is located :

**A.** receptors on an apex perceive LFS of voice vibrations

**B.** a basilar membrane in bases is wider than apex

**C.** a basilar membrane in bases is more pliable of apex

**D.** high-frequencies cause the maximal vibrations of membrane near-by a helicotrema

**E.** a basilar membrane on an apex is more hard of that in bases

12. Auditory receptors develop depolarization (receptor potential) when their hair contact with an integumentary membrane due to oscillation:

**A.** integumentary membrane

**B.** basilar membrane

**C.** vestibular membrane

**D.** endolymph

**E.** perilymphs

13. Depolarization of auditory receptors is arisen due to:

**A.** diminishing of conductivity for the ions of potassium

**B.** increase of conductivity for the ions of sodium

**C.** increase of conductivity for the ions of calcium

**D.** to the increase of conductivity for the ions of potassium

14. Mesencephal animal the turn of the head and auricles toward a loud voice signal was observed. The greatest auditory centers which directly took part in the noted reaction is:

**A.** cochlear nuclei

**B.** nuclei of olive

**C.** overhead humps

**D.** bottom humps

**E.** medial genicular bodies

15. Endolymph has in the composition a greater concentration of ions :

**A.** sodium

**B.** potassium

**C.** magnesium

**D.** calcium

16. In experiment on an animal the cut of pathway was conducted, that resulted in the loss of hearing on the left ear. Where a damage was carried out:

**A.** cochlear nuclei

**B.** olive

**C.** bottom humps

**D.** medial genicular bodies

**E.** vestibulo-cochlear nerve

17. With the help of a tuning fork the patient's perception of sounds was examined at a patient. When a tuning fork was placed near the external ear the patient didn't hear the sound of tuning fork by his right ear. When legs of the tuning fork were placed on a papillary sprout a patient heard a sound. With the affection of what part of the auditory sensory system is it connected?

- A. Cochlear nerve.
  - B. Inferior colliculus tecti.
  - C. Medium ear.
  - D. Internal ear.
  - E. Medial genicular body
18. According to the data of audiometry a patient has got the imperception sounds of medium frequency. The damage of what organ can be the **reason** of it?
- A. Cochlear nucleus.
  - B. Tectum.
  - C. Spiral ganglion.
  - D. Middle **part** of tendrils.
  - E. Lateral genicular bodies.
19. At the experiment on an animal electric activity of neurons of spiral ganglion is registered. It allows to analyze afferent

impulsations from certain receptors. What receptors are these?

- A. Vestibular.
  - B. Cemicircular ducts.
  - C. Organ of Corti`s.
  - D. Vestibular.
  - E. Vestibular and organ of Corti`s.
20. Middle part of cochlear of internal ear was destroyed in animal while experiment. It will cause abnormalities of the sound perception of the following frequencies:
- A. High and low
  - B. No abnormalities
  - C. High
  - D. Middle
  - E. Low

### **Protocol of practical study №8. ” \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_\_\_\_**

#### **Work 1. Research of central sight by means of tables of Sivcev-Golovin**

Central sight is determined by ability to perceive the form of objects and distinguish their shallow details. A leading role in its forming is played by the photoceptors of yellow spot - functional center of retina. Here they are located most densely and unite in the smallest receptor fields. Therefore the image of certain object projected on them is analysed more detailed. The index of central sight is a acuity of sight, that is ability of man to see two dots separately at their maximal approaching. It is determined in relative units (a norm it is considered 1,0).

The size of image on a retina depends on the point of view, that is from a corner, which appears between light rays which effect the eye from two light points. Separate theirs perception is possible, when light rays from both light points fall on a retina on such distance one from other, which exceeds the diameter of one receptor field. At such condition between two excited receptor fields there is one it is not excited.

The minimal point of view, under which a man distinguishes two light points yet, is evened 1'. It relates to the distance of 4 μm between the projections of light points on a retina. The diameter of external segment of one cone in the center of yellow spot presents 0,3 MKM.

Thus, at the normal acuity of sight a man sees two light points under the corner of 1'. On this principle tables of Sivcev-Golovin had been built for the examination of the sight acuity. In these tables there are 12 lines of letters and signs as rings. They are drawn so, that width of every stroke of letter or sign evidently from certain distance under the corner of 1', and whole letter - under the corner of 5'. On left of table near every line distance is indicated, from what letter and signs recognize at normal sight. On a right side the acuity of sight of patient, which recognizes letters and signs of this line from distance a 5 m, is indicated.

**Aim of work :** to learn the method of central sight examination by an eidoptometry; to make sure in that the majority of inspected have normal central sight; explain, what structures` state and functions act on central sight and on acuity of sight.

**For work is needed:** standard tables of Sivcev-Golovin , pointer.

**Plan of work.** Hang on a wall the table of Sivcev-Golovin so that its bottom line must be at the level of eyes of inspected persons. The investigated sits down in the distance a 5 m from a table. Close one eye with a screen, and ask him to name the indicated letters (signs). Researches begin with an overhead line, where signs are largest, gradually passing to lower. Find a that line in which the inspected can not correctly name all letters (signs). Write down the index of acuity of sight. Investigate the second eye in the same manner.

**Results.**

- 1) Acuity of sight of right eye \_\_\_\_\_
- 2) Acuity of sight of the left eye \_\_\_\_\_

**Conclusions:**

( estimate the results, answer the question, whether the got indexes meet a standard, and what they testify to)

**Work 2. Research of peripheral sight is by means of perimeter**

Peripheral sight is characterized by ability to perceive the wide sector of space before an eye. While looking at the object it is fixed by an eye, and the image of it is designed on the functional center of retina - yellow spot. At the same time objects which surround this object on different distance from it are embraced by sight. The image of them is designed on the peripheral areas of retina, which area considerably exceed the yellow spot one. Thus and part of retina which is located outside a yellow spot carries out the function of peripheral sight. An exception is an area of visual nerve nipple, where photoreceptors are absent. A physiology blind spot appears here.

The index of function of peripheral sight are a form and size of its field, they are registered by the method of perimetry. This method consists at that in the immobile eye limit of vision white or coloured objects on a spherical surface is determined by means of the special device - eye perimeter. One can get the graphic image of form of eyeshot and sizes of it, shown in angular degrees after a few meridians. Every eye is inspected separately.

Basic part of an eye perimeter is a perimetric arc which is envisaged on horizontal wasp so, that can be revolved. In the center of arc a white dot is inflicted for fixing of sight, and on the edge of its angular degrees are marked.

On opposite part to the stand chin holder for fixing of the head. On its the support for an eye is added. Screen is added to the device for an exception from the stereopsis of the second eye. In a registration device the form-chart of eyeshot is inlaid, on which necessary dots are marked. The corner of turn of arc is deducted by means of pointer.

**Aim of work :** to learn bases of method of an eye perimetry; to make sure in that every eye has the its own eyeshot; estimate the state of peripheral part of retina.

**For work is needed:** eye perimeter, set of standard tests objects, screen, registration form-chart of each eyeshot.

**Motion of work.** Put a perimeter on a table in the place well lighted up. A perimetric arc is put under the corner of 20-30° to the horizontal plane. Insert the form-chart of eyeshot under a protective strap so that the hyphens of form chart and protective strap coincided. To fix the device in such position by the nut. To put a perimetric arc horizontally.

The inspected is seated before a perimeter by a back to the source of light. The height of chin holder is necessary to be proposed such, that a patient sat comfortably, and the bottom edge of eyecup of the investigated eye leaned against support. The uninspected eye is closed by the screen or palm. Inspected it is offered to look at a dot in the center of arc. To take a white test-object 3 mm in diameter and to begin to move it on a perimetric arc from periphery to the center. In that moment when a patient saw a test-object, to count of degrees on a perimetric arc, to move a recording device on a slat, set it on the size of the deducted degrees and do the puncture of form chart. The got size means the border of eyeshot on this material. Measuring repeat, each time returning the arc of perimeter on 30°. Because

of it get on a form chart the marks of borders of eyeshot after 12 meridians. To take out a form from a recording device. To connect marks lines. The got polygon shows the borders of eyeshot of чорно-білого vision. Determine the borders of eyeshot the same method, applying the coloured objects (yellow, dark blue, red and green) of tests here.

**Results.**

1) *Eyeshot of right eye :*

2) *Eyeshot of the left eye :*

**Conclusions:**

*(to answer the questions: is the eyeshots in inspected person normal and what it testifies to)*

### **Work 3. Research of stereopsis is by means of four-dot test**

A receptor part of the visual sensory system is a pair organ (two retinas). Therefore while looking at the object two monocular images are perceived simultaneously. They unite the visual system in one continuous perception. It takes place only then, when the image of object is designed on the so-called corresponding (identical) retinal points, that is possible due to the concerted function of all portions of oculomotor apparatus - both left and right. Character of sight is binocular thus. It is a norm.

If such co-ordination is impaired, then the image of object is designed on the disparate retinal points (unidentical). It is at the damage of separate external muscles of eye or oculomotor nuclei, that predetermines impairment of convergence of visual lines. At that rate a man perceives character of object doubled - two identical images, imposed on each other with some displacement. Such sight is named simultaneous.

The third form of sight is monocular vision. When it presents characteristic perception of image is only from one retina. From the second retina it is braked in the central portions of the visual system. Consider that it is a adaptive reaction which arose as protecting from the permanent doubling of image.

The methods of character of sight research are based on optical distribution of eyeshots by means of colour filters. Devices which contain polarization colour filters are named diplosopes, and devices with the colour filters of additional colors - four-dot test. The adopted devices allow simultaneously right and left eyes to produce separately physiologically equivalent tests.

Work is done by means of four-dot test, in the complete set of which there are colour glasses-filters of red and green colors. This wall device, structurally look like a lantern, on a front wall has four round opening, which are located as a letter of "T", which is returned on 90°. Two opening is closed by green colour filters, one - red, another - colourless. In the middle of corps there is a lamp for illumination of colour filters. Glasses have red glass for a right eye and green-for left. They divide eyeshot. Thus, green objects, when shine, a patient sees with the left eye, red - right. A colourless object he sees both eyes - right as red, left as green. Four-dot test is fixed on height of a 120 cm and plug illumination in a network.

**Aim of work :** to learn bases of method of stereopsis research ; to define character of sight; . explain physiological base of binocular sight.

**For work is needed:**four-dot test CT-1 with red-green glasses (by colour filters).

**Plan of work.** The inspected is seated on a chair in the distance by a 5 m from a device. For an acquaintance from four-dot test he it is offered to close one or the second eye. It is thus necessary, to name the colors of objects and specify their location. Colour glasses-filters put on and, recovering every eye, make sure in that the inspected distinguishes colors every eye: two- through red and three - through green glass.

Proceed to research of character of sight. Inspected is offered to define and name a location and color of objects which he sees through glasses. Answers can be different - depending on character of

sight inspected posses. In case of normal stereopsis he distinguishes four colors. Thus, if one eye leading, then a middle colourless test gets color that glass which is contained before a leading eye. If there is not a certain leading eye, both periodically the color of colourless test changes: he seems then red or green, and sometimes whitish.

At simultaneous sight the confluence of colors does not take place. The inspected distinguishes five colors: three green and two red. Thus depending on the type of cross-eye of correlation of tests will be different. At an convergent strabismus tests of red color will be on the right, and green - on the left. At a incongruous strabismus a red color will be on the left, and green - on the right.

At monocular sight the investigated distinguishes colors one eye: left -three green for vertical lines or right- two red for horizontals.

**Results:**

(Write down in protocol a report inspected about subjective perceptions of objects, located for horizontals and vertical lines)

**Conclusions:**

*(to answer a question, what character of sight does inspected have)*

**Work 4. Research of colour sight is by means of polychromatic tables**

Colour sight is determined on the basis of ability of the visual system to perceive the light waves of different length and form feeling of color. The index of it is the ability to distinguish three primary colors - red, green and dark blue.

Distinction of colors is the function of cones. There are three types of them. One of the first one react on a red color, second - on green, third - on dark blue. It is related to the properties of visual pigment which they contain. If all three types of cones are irritated by corresponding colors simultaneously and in an identical degree, then feeling white is arisen up.

One can investigate feeling of color by a pigmental method with the help of polychromatic tables of Rabkin. They are built on the so-called principle of pseudoisochromatism - unreal monochromaticity. Inspected is offered to look at a few pictures of different colors, but identical brightness. The investigated who distinguishes the row of colors only after their brightness will not be able correctly to name all colors, as all pictures seem to him identical. The polychromatic tables of Rabkin contain 25 coloured pictures, represented on a background other color. Both figures and background consist of the separate coloured groups. Those groups, which fold a figure or number, painted in the different tints of one color. Such colors are chosen which are badly differentiated by people with the impaired color feeling.

**Aim of work :** to master principle of method of research of colour sight; explain the base of colour sight.

**For work is needed:** polychromatic tables of Rabkin for research of color feeling.

**Plan of work:** Researches is conducted at certain illumination. Luminescent illumination is assumed. Tables are exhibited from the distance of 1 m from inspected person. He is sitting a back to the source of light so that tables are lighted up. Examination starts with contemplation of the coloured reproductions of pictures. They are given in pairs as a conditional original and his copy which is picted by an artist with the anomaly of colour sight. One should pay attention to disparity of some tones of original copy.

To revise all the tables of the first series, naming the recognized signs. One table is exposed no longer than 5 sec. The inspected must for this time confidently name the sign or number, that it is shown to him. If he names them correctly, it is considered that he sees this table. If he named a sign

wrong, read the "hidden" sign or can not read anything, it is considered that he does not see this table and he has an anomaly of colour sight.

Sometimes inspected names that which is represented on a table correctly, but does it after his careful contemplation (over 5 c). Then he is considered to have weakcolour sight.

**Results.**

(to write down in protocol, whether the inspected names colors correctly, and what it testifies to)

**Conclusions:**

(to answer if the normal coloured sight is and what it testifies to)

**Work 5. Research of bone conductivity of sound (experiment of Veber)**

Conduction of sound in an external ear to the ear-drum takes place through the air environment. Here its resonance strengthening in a range biologically meaningful frequencies (200-2000 Hertz) is observed and transmission of vibrations to the ear-drum. The last one together with otosteons, hammer, anvil and stapes compose the chain of anatomic structures. In this case sounds are passed to the basic membrane and endolymph of membranous channel. This is the third sound-conducting environment. It is located in an internal ear, participates in the irritation of receptors - hair cells together with basic and tectorial membranes. The system of stones of middle ear is needed for the concordance of different acoustic impedance of the air and perilymph.

Next to ordinary air conductivity of sound there is the second type of transmission of it to the internal ear - directly through the bones of skull. Research of bone conductivity of sound has a diagnostic value.

**Aim of work:** to make sure in the presence of bone realization of sound.

**For work needed:** tuning fork, rubber tube, cotton wool.

**Plan of work:** The inspected is seating on a chair and a tuning fork that sounds is imposed on top of his head. Inspected must hear the sound of identical force by both ears.

In one ear a cottonwool tampon should be inlay and experience is repeated. Inspected marks that now more loud sound is perceived by a that ear which is obstructed by cotton wool. It is explained by diminishing of loss of voice energy through an external acoustic duct. The like strengthening of sound takes place at the damage of sound-conducting apparatus of one ear.

To make sure that part of voice energy disperses during passing through external auditory motion, it is necessary to connect external auditory motions of two patients with rubber tube and to put to one of them tuning fork on a head. Thus the second patient will hear a sound because of distribution of sound-waves from the external acoustic duct of the first patient.

**Results.**

1) When a tuning fork is located on the middle of the head top, inspected hears the sound \_\_\_\_\_ of force on both sides.

2) In that case, when from one side external auditory channel is closed by cotton wool, and a tuning fork is located on the middle of the head top, the inspected hears a prepotent sound from \_\_\_\_\_ the side

**Conclusions:**

1) There is bone conductivity of sound, because when a tuning fork is located on the middle of the head top, inspected \_\_\_\_\_

2) Forces of sound at an osteophony is higher from a that side, where external auditory channel was closed by cotton wool which testifies to \_\_\_\_\_

**Work 6. Comparison of air and bone sound conductivity (experience of Rynne)**

Air conductivity of sound is a normal physiology process, and bone conductance is a concomitant process and for the perception of auditory information has a second-rate value.

**Aim of work :** to educe advantages of air realization of sounds. Compare air and bone conductivity.

**For work is needed:** a tuning fork.

**Plan of work:** The inspected is seating on a chair. Put a tuning fork which sounds, to the papillary outgrowth. The inspected must hear a sound which weakens gradually. As soon as a sound disappears, a tuning fork is carried to the ear. A sound appears again.

There is the reverse phenomenon at the damage of sound-conducting structures - the sound of tuning fork is not heard then, when it is located near external auditory channel, and becomes to hear after its transferring to the papillary outgrowth.

**Results.**

1) Inspected hears a sound, when a tuning fork is on a papillary sprout.

2) When a sound disappears at an osteophony, after transference of tuning fork to external auditory channel inspected \_\_\_\_\_

**Conclusions:**

(to answer such questions: what type of sound transmission is more effective; what type of sound transmission prevails in inspected person)

**Protocol revised** \_\_\_\_\_

(date, Preceptor's signature)

**The literature**

**Basic**

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

*Additional*

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2. Ganong's Review of Medical Physiology 25th ed. McGraw-Hill Education. 2015. – 750 p.
3. E.B. Babsky, B.I. Khodorov, G.I. Kositsky, A.A.Zubkov Human physiology. Mir Publishers Moscow, 1975, V.2, P. 169-214.

**FOR NOTES**



## SECTION 5. Nervous regulation of motor functions.

### Practical study 9.

#### ***Studying of the spinal cord's role in motor functions regulation of an organism***

##### **1.Urgency of the theme:**

The spinal cord is the first level of physiologic functions` regulation in the CNS, and particular in the moving functions. Here the nervous centres are located which are carried out with influences of the brain nervous centres. The brain nervous centres hand over the information through the descending leading pathways and provide the adaptative organism`s reactions. At the same time the nervous centres of brain receive the information through ascending pathways about the state of regulated parameters, which provides correction of parameters for adaptative reactions.

In the case of damage of conducting pathways of the spinal cord which provide its communications with the spinal cord centres, the character of spinal reflex reactions changes, or they are not carried out at all at damage of the spinal centres.

##### **2.Educational purposes:**

- *To make conclusions about the state of moving functions of an organism - a muscular tone, a pose, locomotions, moving reflexes after cross-section at different CNS levels and damages of moving structures.*
- *To analyze regulated parameters and mechanisms of receptor`s activation as the watching devices during the realization of moving reflexes.*
- *To make conclusions about the state of moving reflexes which are locked at different levels of CNS, and the structure of their reflex arches.*
- *To make conclusions about the role of conductive pathways of the CNS in maintenance of sensory and moving functions of an organism.*

##### **3.Approximate pattern for independent work at preparation for practical study**

##### **3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Spinal shock	The temporally absence of spinal reflex reactions, the local centres of which are situated below the place of the damage.
Tonic moving reflexes	They provide muscular tone support.
Phasic moving reflexes	They provide moving of kinematic pairs or kinematic chains thanks to muscles contraction.
Kinematic pair	These are two bones which are connected with a joint.
Kinematic chain	It is a set of several kinematic pairs (for example, extremities)
Myotatic reflexes or stretching reflexes.	These are reflexes which arise at a stretching of muscles` receptors - muscular spindles.
Neuromotor unit	It is a group of muscular fibers, which are innervated with one motoneuron.

##### **3.2.Theoretical questions**

- 1) The functions of spinal cord: sensory, reflex, conductive.
- 2) The neuronal structure of spinal cord. Neuromotor units.
- 3) The kinds of the sensory information which enter the spinal cord from organism`s receptors. Muscle spindles: the structure and mechanism of irritation.

- 4) The types of spinal reflexes. Tonic and phasic motor reflexes of the spinal cord, their physiological significance and the structure of reflex arches. The efficiency of tonic motor reflexes of the spinal cord in conditions of its autonomic activity.
- 5) Antigravity tone. The conception about a body pose and the conditions for its support. Motor reflexes and postural reflexes for maintaining body position.
- 6) Functional characteristics of spinal cord conductive pathways.
- 7) Medial and lateral motor systems for motor function regulation of an organism. The character of each of the ways of these systems influence on spinal  $\alpha$ -motoneurons with different functional meaning. The types of connection of fibers of descending ways with spinal  $\alpha$ -motoneurons.
- 8) Dependence of spinal reflexes on brain centers activity. The mechanisms and development of spinal shock.

### **3.3. Practical works**

- 1) The research of the spinal shock on a frog.
- 2) The research of a muscular tone on an experimental spinal frog.
- 3) The research of a pose on an experimental spinal frog.
- 4) The research of phasic skin-muscular moving reflexes on an experimental spinal frog.
- 5) Research of tendon reflexes on a person.

## **4. Materials for self-control**

### **4.1. Answer the question:**

- 1) What is the significance of the fact that in the process of animals' evolution the mostly part of fibers of descending pathways do not evenly end on  $\alpha$ -motoneurons of spinal cord (direct monosynaptic connection), but connected with them with help of interneurons (polysynaptic connection)?
- 2) Which of the descending pathways mainly activate flexor's motoneurons of spinal cord, and which of the extensor's? How can we explain the fact, that as a result of evolution the majority of descending pathways mainly activate flexor's motoneurons?
- 3) Is the duration of the spinal shock on a frog and on a monkey the same? What does it testify about?
- 4) How and why will the muscular tone of animals change after removal of brain? How does it influence on animals' ability to keep an antigravity posture?

### **4.2. Solve the task individually**

- 1) There is a patient in a hospital in a state of spinal shock. After the regular medical examination a doctor concluded that the patient began to recover from the spinal shock. What changes in the state of the patient were the base for such a conclusion? What are the mechanisms of these changes?
- 2) A woman complains to her doctor that sensitivity in her legs was diminished, and the right leg can "don't obey". Sometimes the woman even can't walk or move her right leg. When

the woman put her feet in hot water she noticed that she didn't feel pain in the "healthy" foot, but there are hot and painful feeling in "ill foot". After the medical examination the doctor recommended to her magnetic resonance tomography of the lumbar part of spinal cord. Explain the physiological reason of symptoms observed in the patient.

- 3) Patient had traumatic damage of spinal cord between Th1 and Th2 segments. As result he immediately lost ability of voluntary movement of muscles which have their motoneurons located below damaged segments. Name the mechanisms of areflexia. How long will it last? Will this patient be able to sit, walk, do voluntary movements by his arms, breath, chew, swallow? Will he be able to fine movements by his fingers? Will he have somatic sensitivity? Will he be able to defecation and urination? What changes and why will occur with this patient after 3 months?
  
- 4) Activity of spinal nervous centers was studied in experiment on a frog. All dorsal roots of spinal cord were cut on the left side and all ventral roots were cut on the right side. How will this manipulation influence on performance of protective withdrawal reflexes in response to pain stimulation of frog's pads?

#### 4.3. Choose the correct answer:

1. In the experiment on a frog a cross-section between medulla oblongata and the spinal cord was made. What character of muscular tone and what pose will be observed at a frog?
  - A. The tone is weakened, the pose is passive
  - B. The tone is strengthened, the pose is active
  - C. The tone does not change, the pose is passive
  - D. The tone is strengthened, the pose is passive
  - E. The tone is weakened, the pose is active
  
2. In the experiment on an animal the dorsal roots of the spinal cord were cut, as a result of this in the zone innervated by the dorsal roots the following changes took place:
  - A. Loss of motor functions
  - B. Weakening of muscles' tone
  - C. Strengthening of muscles' tone
  - D. Loss of sensitivity
  - E. Loss of sensitivity and motor functions
  
3. Which of the following pathways activates mainly spinal flexor's motoneurons:
  - A. rubro-spinal
  - B. vestibule-spinal
  - C. Spino-cerebellar ventral
  - D. Spino-cerebellardorsal
  - E. reticulo-spinal
  
4. In the experiment on an animal the ventral roots of the spinal cord were cut, as a result of which in the zone innervated by dorsal roots the following changes took place:
  - A. Loss of motor functions
  - B. Weakening of muscles' tone
  - C. Strengthening of muscles' tone
  - D. Loss of sensitivity
  - E. Loss of sensitivity and motor functions
  
5. Which of the following pathways activates mainly spinal extensor's motoneurons:
  - A. Rubro-spinal
  - B. Vestibule-spinal
  - C. Spino-cerebellar anterior

- D. Spino-cerebellar posterior  
E. Cortico-spinal
6. The painful and temperature sensitivity is absent in a person after spinal trauma. What conductive spinal pathways are damaged?  
A. Spino-thalamic  
B. Spino-cortical  
C. Reticulo-spinal  
D. Vestibulo-spinal  
E. Rubro-spinal
7. In a spinal frog the cutting of sciatic nerve leads to increasing of length of low extremity on the side of cutting. This is result of damage of reflex arch of:  
A. Phasic flexing reflex  
B. Phasic myotatic reflex  
C. Tonic myotatic reflex  
D. Tonic reflex of support  
E. Phasic extensive reflex
8. The changed character of knee reflex was found in a patient. These changes are the result of damage of the local nervous center in one of the spinal cord parts:  
A. The cervical  
B. The thoracic  
C. The lumbar  
D. the sacral  
E. the coccygeal
9. Reflex relaxation of muscle occurs in response to its strong fast contraction. This is result of irritation of such receptors:  
A. Muscle spindles  
B. tendon Golgi receptors  
C. Articulate Ruffini`s receptors  
D. Tactile Meissner`s receptors  
E. The free nervous endings
10. There are gamma-motoneurons which innervate intrafusal muscular fibers located in the gastrocnemius muscle. In the experiment these gamma-motoneurons were irritated with the electrical current. The result of it was:  
A. relaxation of this muscle  
B. Increase in the force of its contraction  
C. contraction of the opposite group of muscles  
D. nothing has changed

### **Protocol of practical study №9. “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_\_\_\_**

#### **Work 1. The research of a spinal shock at a frog.**

**The work purpose:** 1) to reveal the phenomenon of a spinal shock on a spinal preparation of a frog and to determine its duration.

2) explain mechanisms of spinal shock.

**The work course.** Prepare a spinal preparation of a frog, and start the stopwatch at the moment of decapitation. Hang quickly a preparation for the lower jaw on a support hook and put mechanical irritation with tweezers on a foot skin of back extremity. Repeat the irritations every 10 s until reflex response will appear. Note down the time when reflexes were restored.

#### **Results of the work:**

1) *The time since the moment of decapitation of a frog till moving spinal reflexes appearance is \_\_\_\_\_ seconds*

#### **Conclusions:**

1) *The temporary absence of spinal reflexes after cutting between brain and spinal cord testifies about \_\_\_\_\_ phenomena that is observed in an initial stage of transition of a spinal cord on a mode of independent activity.*

2) \_\_\_\_\_

#### **Work 2. The research of a muscular tone of a spinal frog.**

**The work purpose:** to reveal the reflex nature of a muscular tone.

**The work course:** Hang a spinal preparation of a frog for the lower jaw on a support hook and pay attention to the angle of its back extremities flexing in knee joints. Prepare the sciatic nerve on

one side at a place of its exit from a spinal cord and cut. After that compare angles of flexing in knee joints of denerved and intact extremity and compare their length.

**Results of the work.**

1) Back extremity of a spinal preparation of a frog are flexed in knee joints approximately at an angle \_\_\_\_\_

2) After the nerve cutting on the right side the angle of back extremity flexing in a knee joint makes \_\_\_\_\_

**Conclusions:**

1) The reason of back extremity flexing in knee joints is the tone of \_\_\_\_\_ muscles of back pads of spinal frog which is caused by \_\_\_\_\_ spinal reflex, because after a nerve cutting from the one side \_\_\_\_\_

2) The scheme of the reflex arch of spinal tonic \_\_\_\_\_ reflex which arises as a result of \_\_\_\_\_ receptors stretching

**Work 3. The research of a pose of a spinal frog.**

**The work purpose:** : to state whether the spinal centers at their independent activity can maintain antigravity posture.

**The work course.** Place a spinal preparation of a frog after restoration of its motor reflexes on a desk and compare position of a trunk, extremities and lower jaw with the same ones in intact frog.

**Results of the work.**

1) The pose of a spinal frog differs from a pose of an intact frogs \_\_\_\_\_

\_\_\_\_\_.

**Conclusions** (answer the question: can the coordination mechanisms of spinal cord in the mode of its independent activity provide the antigravity posture of animals?)

**Work 4. The research of phasic skin-muscular moving reflexes of a spinal frog.**

**The work purpose:** reveal at a spinal preparation of a frog the character of reciprocal moving reflex reactions at To study on spinal frog different types of reflectory responses to irritation of one lower extremity: protective withdrawal reflex, reflex of reciprocal extension, homolateral and contralateral reflexes of upper extremities, wiping reflex.

**The work course.** Hang a spinal preparation of a frog from the lower jaw on a support hook. Irritate a frog's skin with 01 % solution of sulfuric acid. Irritate such sites of a skin: 1) foots of back extremities; 2) upper extremities; 3) on the back; 4) on the thorax. Observe the character of moving reaction after each irritation and then wash off the acid, putting the spinal preparation into a cup with

water up to the place of cutting. Then place a filtering paper moistened of 0,3 % solution of sulfuric acid on the skin of the thorax and observe a response. After that cut a spinal cord with scissors below the corner of shovels and repeat all procedures.

**Results of the work.**

(To describe protective reflex reactions of a spinal frog)

**Conclusions** (*answer the question: what kinds of spinal phasic skin-muscular moving reflexes are inherent in a frog?*)

**Work 5. The research of tendon reflexes at a person.**

**The work purpose:** find out myotatic reflexes on a person. Analyze mechanisms of its formation.

**The work course.** 1. *The research of knee-jerk reflex.* The student being tested sits down on a chair, putting leg on leg so that the shin hangs down freely. For decreasing of inhibitory influence from the brain structures on the spinal centers it is possible to ask the student being tested sits to take hands in the lock and to stretch them. Put a strike with a neurological hammer on the tendon of quadriceps femoral muscle (below a patella). Repeat the same procedure on other extremity. Observe the character of reflex moving reaction. 2. *The research of Achilles reflex.* Ask the student being tested sits to put knees on a chair or a couch so that his feet hang down freely. Strike with a neurological hammer on Achilles tendon at first on one leg, and then on other leg. Observe the character of reflex moving reaction.

**Results of the work.**

1) *After the strike with a neurological hammer on the tendon below the patella on one extremity, and then on the other one we observe \_\_\_\_\_*

2) *After the strike with a neurological hammer in the place of skin projection of Achilles tendon on one extremity, and then on the other extremity we observe \_\_\_\_\_*

**Conclusions:** (*answer the questions: what receptors do the myotatic reflexes begin on? Why do the myotatic reflexes arise? To draw the schemes of reflex arches of the researched reflexes.*)

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

## **The literature**

### ***Basic***

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### ***Additional***

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**FOR NOTES**

## Practical study 10.

### **Studying of brain stem role in motor functions regulation of an organism**

#### **1.Urgency of the theme:**

The hindbrain and midbrain belong to the brain stem. Hindbrain consists of medulla oblongata and pons and forms the segmental portion of CNS. It contains motor and parasympathetic nuclei of cranial nerves. Midbrain has a suprasegmental structure and contains motor nuclei and nuclei for regulation of visceral functions.

Brainstem lesions can impair both motor and visceral functions of the body.

#### **2.Educational purposes:**

- *To analyze mechanisms of influence of brain stem structures on the activity of spinal cord's motor systems.*
- *To make conclusions about the state of moving functions of an organism - a muscular tone, a pose, locomotion, moving reflexes which take place after cross-section at different levels of CNS and damages of moving structures.*
- *To make conclusions about a role of conducting ways of CNS in providing the moving functions.*

#### **3.Approximate pattern for independent work at preparation for practical study**

##### **3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Antigravitation pose	It is a pose with the increased tone of muscles—extensors of extremities and trunk due to which animals or human support their body against gravity.
Decerebrate rigidity	It is an increase in tone of extensor muscles of extremities and trunk after brainstem cross-section between hindbrain and midbrain.

##### **3.2.Theoretical questions**

- 1) Types of sensory information entering hindbrain and midbrain. The vestibular apparatus, conditions for irritation of otolithic and ampullary vestibuloreceptors.
- 2) The reticular formation of the brainstem, mechanisms of maintaining its constant tonic activity. Ascending and descending pathways of reticular formations and their influences.
- 3) The role of hindbrain in maintaining body posture. The phenomena of decerebrate rigidity. Neck and vestibular postural reflexes. The significance of these reflexes and the role of hindbrain in it.
- 4) Motor reflexes of the midbrain. The role of midbrain in maintaining body posture and organism's orientation in the environment.

##### **3.3.Practical works**

- 1) The research of the vestibular apparatus role in providing motor functions of an organism.
- 2) The research of brainstem's vestibular static and statokinetic reflexes on guinea pig.
- 3) The research of statokinetic reflexes in rotation on humans.

#### **4.Materials for self-control**

##### **4.1. Give answers to the questions:**

- 1) How can we prove that decerebrate rigidity is caused by excessive gamma-strengthening of spinal myotatic reflexes?



- 2) At which level of CNS the centers which provide maintaining of body equilibrium in cats and dogs are located? What phenomenon testifies about this?
  
- 3) How do the statokinetic reflexes provide maintaining of stable equilibrium of the body?
  
- 4) What tone of muscles-extensors will be in a “mesencephalic” cat in comparison with intact cat and decerebrated one? What is the reason of extensors` tone violation which is observed in a mesencephalic animal?

#### **4.2. Solve the tasks individually**

- 1) Powerlifters when lifting the bar move their head back straining the muscles of the neck. An ordinary person does the same thing if he has to lift up something heavy. Explain which reflexes are triggered in this case?
  
- 2) A student was returning from the library at dusk, didn't notice a stone on the road, triped over it but didn't fall. Due to what reflex could the student keep the balance? Explain why this reflex is often not effective at night.
  
- 3) A three month old baby was lying on his bed. From the gust of wind the window got shut and made a loud noise. Describe the reflex which appeared in the baby in these conditions. What is its physiological significance?
  
- 4) According to the data of World Health Organization, stroke takes the third place among the reasons of premature death. The most lethal is medullar stroke, the least – the stroke of cortex of large hemispheres. What are the physiological reasons of such differences?

#### **4.3. Choose the correct answer:**

1. During a sea voyage, a passenger had signs of sea sickness (nausea, vomiting). Which structures were most irritated?

- A. Vestibular receptors
- B. Auditory receptors
- C. The nuclei of the vagus nerves
- D. Proprioceptors of the head

muscles

- E. Exteroreceptors of the head skin

2. The vestibular apparatus of a frog has been ruined on the right side, the result of that became the weakening of muscles' tone of:

- A. extensors on the right side
- B. extensors on the left side
- C. flexors on the right side
- D. flexors on the left side
- E. extensors on both sides

3. The red nuclei of an animal has been ruined, which resulted in the loss of one of the types of reflexes:

- A. statokinetic
- B. abdominal
- C. neck tonic
- D. spinal myotatic
- E. tendon

4. In an experiment on an animal with decerebrate rigidity this conditions disappeared after ruining of one of the brain structures. Which structure was ruined?

- A. vestibular nuclei
- B. red nuclei
- C. substantia nigra
- D. reticular nuclei
- E. olivary nuclei

5. An animal lost orienting reflex on light irritant after ruining one of the brain stem structures, namely:

- A. superior colliculus of quadrigeminal bodies
- B. inferior colliculus of quadrigeminal bodies
- C. red nuclei
- D. vestibular nuclei
- E. substantia nigra

6. In a patient the act of swallowing is violated as a result of the damage of one of the structures, which is located in:

- A. spinal cord
- B. medulla oblongata
- C. cerebellum
- D. thalamus
- E. substantia nigra

7. In an animal after damage of quadrigeminal bodies in the midbrain the absence of one of the reflexes will take place:

- A. myotatic
- B. righting
- C. orienting
- D. statics
- E. statokenetic

8. After the end of rotation of a person in the Barany's armchair the nistagmus of the eyeballs was observed. The center of this reflex is located in:

- A. medulla oblongata
- B. pons
- C. mid brain
- D. diencephalon
- E. cerebellum

9. In a cat there is a reflex weakening of the tone of muscles-extensors of the front extremities and straightening of back extremities which is resulted in the head tilting down. It takes place due to what reflexes:

- A. vestibular static postural
- B. static righting
- C. statokinetic
- D. myotatic
- E. supporting (foothold)

10. A cat was falling from a support with its head down, but landed with its head up. It was promoted by irritation of receptors:

- A. visual
- B. skin of the foot
- C. muscle spindles
- D. otolithic vestibuloreceptors
- E. ampullary vestibuloreceptors

### **Protocol of practical study №12 (10). " \_\_\_\_\_ " \_\_\_\_\_ 20\_\_**

#### **Work 1. The research of the vestibular apparatus role in motor functions of an organism.**

**The work purpose:** to determine the role of the vestibular apparatus of an animal in maintenance of equilibrium pose.

**The work course.** Make the unilateral ruining of a frog's vestibular apparatus and observe how its pose will be changed in comparison with an intact frog. Place the researched frog in an aquarium with water and observe its pose and movements.

**Results of the work:**



*Pose of the frog after ruining of right vestibular apparatus*



1) After one of labyrinths ruining in a frog we observe \_\_\_\_\_

**Conclusions:**

1) The head and body of the frog are turned to the side opposite to destroyed vestibular receptors, that testifies about \_\_\_\_\_ the tone of extensor muscles on the side of destruction of the labyrinth because of \_\_\_\_\_ of descending influences \_\_\_\_\_ on the spinal motor neurons

**Work 2. The research of brain stem's vestibular static and statokinetic reflexes on guinea pig.**

**The work purpose:** To establish the types of postural reflexes in a guinea pig and to analyze, at what receptors irritation they arise and what adaptive significance they have.

**The work course:**

1) Place a guinea pig on a plate and, declining a plate forward, backward, to the sides in order to change head's position in space, and observe the changes of muscles' tone on the side of the inclination.

2) Change the position of the guinea pig on the table surfaces, putting it on its back. Observe the stages of pose restoration.

3) Move a plate with the guinea pig quickly upwards, and then – downwards, observe how the muscles' tone of extremities will be changed at the moment of a start of motion in a vertical plane with acceleration.

4) Place the guinea pig on a platform rotating in a horizontal plane and observe the pose change at rotation, especially at the beginning and at the end of movement.

**Results of the work.**

1) When a plane with the guinea pig was declined forward or backward, to the right or to the left it was observed that \_\_\_\_\_

2) After the guinea pig has been put on its back, it was observed that \_\_\_\_\_

3) When quick moving upwards of a plate with a guinea pig it was observed that \_\_\_\_\_

When quick moving of a plate with guinea pig from top to bottom it was observed that \_\_\_\_\_

4) By the rotation of a guinea pig in a horizontal plane it was observed \_\_\_\_\_

**Conclusions:** (Answer such questions: What are the adjusting postural reflexes which have been found in a guinea pig called; what is the role of each of these reflexes in maintenance of body equilibrium?)

1)

2)

3)

4)

**Work 3. The research of statokinetic reflexes in rotation on humans.**

**The work purpose:** To establish the types of tonic reflexes at a person by its rotation on a horizontal plane.

**The work course.** 1) the person being tested sits down in Barany's armchair and inclines head downwards on 30°. Close the lock of the fixing device and rotate an armchair 10 turns for 20 seconds in any direction. Quickly stop the armchair and ask the person being tested to walk on an imaginary straight line. Observe the accuracy of the movement along the straight line.

2) Repeat the experiment rotating the armchair with the same speed, but now ask the researched student to lift his head at the moment the armchair stops and at this moment observe the movements of the eyeballs.

**Results of the work.**

1). \_\_\_\_\_ was observed in the person being tested after rotation in Barany's armchair.

2) The person being tested could not properly take some steps along the imaginary straight line after the rotation and the armchair's stop, and deviated from the straight line \_\_\_\_\_ (mark the side) because \_\_\_\_\_

**Conclusions:**

1) Statokinetic reflexes of angular acceleration which were observed in the researched person, led to eyeballs' nistagmus and to increase of muscles' tone (what muscles, from what side) – \_\_\_\_\_ that has significance in \_\_\_\_\_

Protocol revised \_\_\_\_\_  
(date, Preceptor's signature)

## The literature

### *Basic*

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### *Additional*

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**FOR NOTES**

**FOR NOTES**

## SECTION 6. Nervous regulation of visceral functions.

### Practical study 11.

#### ***Studying of nervous regulation`s mechanisms of visceral functions of an organism***

##### **1.Urgency of the theme:**

The nervous regulation of visceral function is carried out with the help of the autonomic nervous system and posses some particularities in reflex arch construction, in mediatory mechanism of signal transmission in synapses, in the regulatory role of the higher integrative centers.

The knowledge about mechanisms of visceral function regulation by the autonomic nervous system is important in the physician professional work because the visceral dysfunctions are the most frequent reason of addressing to a doctor.

##### **2.Educational purposes:**

- *To make explanation of the mechanism of autonomic nervous system influence on visceral functions of an organism.*
- *To make analysis of the alteration in visceral function after activation of sympathetic or parasympathetic nerves.*
- *To make interpretation of the mechanisms of changing in visceral functions after the blockade of the information transmission though the ganglionic and neuro-effector synapses of the autonomic nervous system.*

##### **3.Approximate pattern for independent work at preparation for practical study**

##### **3.1. The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Visceral function	The functions of inner organs and the physiological processes that supply the linear growth of the body, physical, psychical and sexual development, the adaptive responses of the organism and homeostasis
Preganglionic neuron	The autonomic neuron the soma of which is located in the CNS and its fiber pass to the autonomic ganglion
Postganglionic neuron	The autonomic neuron the soma of which is located in the autonomic ganglion and information pass though the axon to the effectors that are visceral organs and blood vessels.
Metasympathetic or enteric nervous system	The system of neurons that are located in the wall of the luminary muscular organs (e g gastrointestinal tract) and provide the local regulation of its functions by the local reflexes

##### **3.2.Theoretical questions**

- 1) General outline of the autonomic nervous system. Sympathetic, parasympathetic and metasympathetic systems.
- 2) Features of the reflex arch structures of central and peripheral autonomic reflexes.
- 3) Synapses of the autonomic nervous system: neurotransmitters, receptors and antagonists
- 4) Sympathetic, parasympathetic and metasympathetic effects on visceral functions.
- 5) Role of the different parts of CNS in the regulation of visceral functions.

##### **3.3.Practical works**

- 1) Investigation of the pupil reflex in man
- 2) Research of the neural mechanisms of the pupil reflex
- 3) Investigation of the heart rate after the standard physical exercising

**4. Materials for individual work and self-control**

**4.1. Answer the question:**

- 1) Give an explanation to the expansion of pupils that is observed when a hard pain or hypoxia occurs.
  
- 2) How pharmacological agents can simultaneously exclude the influence of the sympathetic and parasympathetic systems on all organs and structures of organism?
  
- 3) What drugs can be applied for the inhibition of gut motility and why?
- 4) What is the main difference between the role of spinal or brainstem centers and the role of forebrain centers in the regulation of visceral functions?
  
- 5) During the experiment, the peripheral segment of the transected vagus nerve is irritated in the cat. What changes will be observed?

**4.2. Solve the tasks individually:**

1. Write the differences between the autonomic nervous system and the somatic one.

	Autonomic nervous system	Somatic nervous system
1. Functions		
2. Organs-effectors		
3. Segmentarity of distribution		
4. Location of nervous centres		
5. Afferent way		
6. Type of efferent fibres		
7. Efferent way		
8. Synapses		

2. To state the accordance

The effector link of reflex can be:

Autonomic

Skeleton muscles

Smooth muscles

Somatic

Secretory glands of digestive system



Epithelial cells of skin

Endothelial cells of vessels

**3. To state the accordance**

The part of autonomic nervous system : Has the following morphological signs:

Sympathetic nervous system Efferent nervous are always located only in the intramural ganglions and innervate only the internal organs which have their own moving rhythm (heart, interstine, others)

Parasympathetic nervous system Efferent way can be represented by cortoco-, rubro-, vestibule-, reticulospinal pathways or by the axon of spinal motoneuron ;

Metasympathetic nervous system Efferent way consists of two neurons wherein the axon of the first neuron (preganglionic) is longer than the other one;

Somatic nervous system Efferent way consists of two neurons the first of them is located in thoracal or lumbal segments of spinal cord, and the other one in pre- or paravertebral ganglions.

**4.3. Choose the correct answer:**

- In the acute experiment on the dog there was a necessity of pharmacological blockade of the entire autonomic nerves. What substance from stated below can be used?
  - atropine
  - benzozeksoniy
  - phentolamine
  - obsidan
  - aminasine
- In a victim of the car accident during the inspection the increased heart rate, arterial pressure and expansion of pupils and dryness of mucus shell of mouth cavity were observed. Name the system of regulation that caused such changes.
  - vago-insular
  - parasympathetic
  - sympatho-adrenal
  - metasympathetic
  - hypothalamo-pituitary-adrenal
- In the acute experiment the peripheral end of the cut right vagal nerve in dog is irritated with the electrical current. What of the listed changes in visceral functions will be observed?
  - increase of the respiratory rate
  - increase of the heart rate
  - enlargement of the bronchiole lumen
  - decrease of the heart rate
  - down regulation of the intestinal motility
- Two drops of atropine were administered into the right rabbit eye and after the half an hour the pupil expansion was observed. This happens because of atropine influence on:
  - muscarinic acetylcholine receptors in neuroeffector synapses
  - nicotinic acetylcholine receptors in ganglionic synapses
  - $\beta$ -adrenoreceptors in neuroeffector synapses
  - $\alpha$ -adrenoreceptors in neuroeffector synapses
- Among the mushrooms that were gathered in the forest the poisonous ones were found. After eating they cause some symptoms of muscarinic poisoning. Name these symptoms:
  - the expansion of pupil
  - narrowing of pupil
  - bronchodilation
  - hypertension
  - tachicardia
- In the acute experiment on the dog the nerves that regulate gut motility with the help of CNS were cut. Some time later intestinal motor function renewed because of the reflexes of...
  - sympathetic nervous system

- B. parasympathetic nervous system  
 C. metasympathetic nervous system  
 D. viscerovisceral origin  
 E. somatic nervous system
7. The patient was treated by the antihypertensive drug. Choose one of the possible effects of this substance:
- A. stimulation of  $\beta$ -adrenoreceptors  
 B. blockade of  $\alpha$ -adrenoreceptors  
 C. stimulation of  $\alpha$ -adrenoreceptors  
 D. blockade of the muscarinic acetylcholine receptors  
 E. blockade of  $\beta$ -adrenoreceptors
8. In the acute experiment on the dog the increase of arterial pressure accompanied with the deeper and faster breathing, increased heart rate and diminishing of the secretion and motor function of the stomach occurred after the total cut of the vagal nerves due to the activation of the ..... reflexes:
- A. somatic  
 B. metasympathetic  
 C. sympathetic  
 D. viscerovisceral
9. During irritation of the sympathetic nervous centers their effect on visceral organs was registered. In what part of the CNS these centers are located?
- A. medulla and sacral segments of spinal cord  
 B. metencephalon and sacral segments of spinal cord  
 C. ventral horns of the thoracic and lumbar segments of the spinal cord  
 D. lateral horns of the thoracic and lumbar segments of the spinal cord  
 E. brainstem and sacral segments of spinal cord
10. In the experimental irritation of the parasympathetic centers bradycardia, enhancing of the stomach secretion and motility, hyperemia of the pelvic organs were observed. Choose the location of primary parasympathetic centers:
- A. brainstem and lateral horns of the sacral spinal segments  
 B. metencephalon and lateral horns of the thoracic and lumbar segments of the spinal cord  
 C. medulla and the ventral spinal horns  
 D. medulla and metencephalon

**Protocol of practical study №11. “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_\_\_\_**

**Work 1. Examination of the pupil reflex.**

Pupil reflex is a pupil narrowing that result as a contraction of circular muscle fibers of the iris. This reflex is of great defensive and adaptive purpose. Firstly it allows avoiding of the rodopsine exceeding destruction in the retina. Secondly, this reflex helps to maintain the visual orientation in case of potent lighting.

Circular muscle fibers of the iris belong to smooth muscles and are innervated by the parasympathetic fibers of the oculomotor (III cranial) nerve. Pupil narrowing in response to a bright light is a visceral parasympathetic reflex of the autonomic nervous system. Pupil dilation in the case of dull light is a sympathetic reflex of the autonomic nervous system during which the radial iris muscles are activated by sympathetic nerves.

Parasympathetic nature of this reflex can be revealed by provoking this response after atropine administration. Atropine is the antagonist of muscarinic acetylcholine receptors in neuroeffector parasympathetic synapses.

**Aim of work:** to find out the changes of pupil's diameter after the eye lightening, explain the mechanisms.

**Materials and equipments:** a lamp with a reflector.

**The work course.** Close one eye by hand for 3-5 seconds. Then rapidly open and light the eye with a lamp. Notice the change of iris diameter.

**Results of the work:**

After the lightening the iris diameter \_\_\_\_\_

**Conclusions:**

- 1) Pupil \_\_\_\_\_ in response to light is reflectory developed. This is an autonomic from the retina receptors.
- 2) The reflex arch of pupil reflex:

### Work 2. Investigation of the neural mechanism of pupil reflex.

The parasympathetic origin of the iris reflex can prove by using atropine - muscarinic acetylcholine receptor antagonist.

**Aim of work:** to prove that pupil narrowing in response to the light is a parasympathetic reflex of the autonomic nervous system.

**Materials and equipments:** a lamp with a reflector, rabbit, atropine sulfate solution (1:1000), pipettes.

**The work course:** Light rabbit eye by a lamp. Close this eye by your hand for 3-5 sec. Then rapidly open and light the eye once again. Make sure that the pupil reflex takes place. Drop the eye with atropine and after 3-10 min try to evoke the reflex by lighting this eye.

#### Results of the work.

- 1) After the lightening the eye where the atropine have been put the iris diameter \_\_\_\_\_;
- 2) In response to the light the pupil diameter of the intact eye \_\_\_\_\_.

**Conclusions:** (why the pupil reflex can not develops after the atropine administration)

Show with the arrow on the diagram in work No.1 the place of action of atropine.

### Work 3. Examination of the heart rate after standard physical exercise.

**Aim of work:** to elucidate the effects of the autonomic nervous system that influence on heart rate during physical activity, explain the mechanisms

**Materials and equipments:** stop-watch.

**The work course.** record the pulse rate on radial artery per 1 min. Perform 20 squats for 30 sec and just after that calculate the pulse rate (per 1 min) once again.

#### Results of the work.

At rest the heart rate per 1 min is \_\_\_\_\_

After the standard physical exercise pulse rate per 1 min is \_\_\_\_\_

#### Conclusions:

- 1) After the standard physical activity the pulse rate per 1 min \_\_\_\_\_ that is the result of \_\_\_\_\_ reflector influence on cardiac pacemaker. (Draw the reflex arch)

Protocol revised \_\_\_\_\_  
(date, Preceptor's signature)

### **The literature**

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#### ***Additional***

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**FOR NOTES**

## SECTION 7. Humoral regulation of functions.

### Practical study 12.

#### *Studying of humoral regulation of functions of an organism*

##### 1.Theme urgency:

Visceral function regulation is performed not only by the autonomic nervous system but also with the help of humoral mechanisms, for example hormones. Knowledge of the mechanisms of humoral control of visceral function is essential for the physicians' work because the visceral dysfunctions are the most frequent reason of addressing to a doctor. But only if a doctor is able to use the modern evidence about hormone-receptor mechanisms and is able to determine the hormonal control loop of some parameters he can work professionally.

##### 2.Educational aim:

- to explain a term "humoral control of visceral functions".
- to describe factors of humoral control and be able to compare them.
- to differentiate basic mechanisms of hormone action on the target cells.
- to analyze the control loop of humoral regulation and be able to draw this loop.

##### 3.Approximate pattern for independent work at preparation for practical study

##### 3.1. *The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study*

Term	Definition
Target cells	the cells that are acted on selectively by a specific agent (as a virus, drug, or hormone)
Second messengers	the intracellular substances (as cyclic AMP, cyclic GMP, inositol trisphosphate, diacylglycerol and calcium) that mediates cell activity by relaying a signal from an extracellular molecule (as of a hormone or neurotransmitter) bound to the cell's surface

##### 3.2.Theoretical questions

- 1) General view about humoral regulation and its main differences from the nervous one.
- 2) Factors of humoral control. The properties of hormones.
- 3) Mechanisms of hormone action on the target cells.
- 4) Main mechanisms of the endocrine glands regulation.
- 5) Humoral regulation loop.
- 6) Age particularities of neuroendocrine control of the organism functions.

##### 3.3.Practical works

- 1) Investigation of the mechanism action of epinephrine on the heart rate.

#### 4.Materials for individual work and self-control

##### 4.1. *Answer the question:*

1. At subcutaneous injection of epinephrine solution the constriction of the skin vessels occurs. How to state in the experiment what type of adrenergic receptors` activation leads to vasoconstriction?
2. Will the cortisol influence on the target cells if to block their membranes receptors? Explain your answer.

3. Draw the chart, demonstrating the mechanisms action of epinephrine on target cells (the typical cardiomyocytes of heart ventricles).

**4.2.Solve the task individually:**

1. Write the differences between nervous (autonomic) regulation and the humoral one.

Characteristics	Nervous regulation	Humoral regulation
Functions supplement		
Accuracy of transmission		
Carrier of information		
The way for transmission		
The speed of transmission		

2. All membrane receptors are blocked in the cell. What hormones actions are kept and why? Write hormones and endocrine glands which secrete them.

3. To state the accordance:

Groups of hormones

Mineralocorticoids

Glucocorticoids

Sexual hormones

Contain

Hydrocortisone, cortisol, corticosterone

Androgens, estrogens, progesterone

Aldosterone, desoxycorticosterone

Hydrocortisone, corticosterone, adrenocorticotropin

Androgens, oxytocin, progesterone

**4.3.Choose the correct answer:**

1. Factors of humoral control that are secreted by specialized and unspecialized cells and have mainly distant or local effect are all of the listed besides of.....

- A. gastrin
- B. prostaglandin
- C. histamine
- D. insulin
- E. somatostatin

2. Lipid-soluble hormones are carried by the blood to target organs:

- A. In free form
- B. In combination with blood cells
- C. In combination with specific proteins of plasma (transcortin or testosterone-estrogen-binding globulin)
- D. In combination with specific plasma proteins (albumin)
- E. In combination with plasminogen.

3. The mechanism of negative feedback, in the system of neurohumoral regulation, which is carried out by the pituitary gland is:

- A. The stimulative effect of the tropic hormones of the anterior pituitary gland on the peripheral gland' hormones
- B. The inhibitory effect of the tropic hormones of the anterior pituitary gland on the peripheral gland
- C. The stimulation of the production of the tropic hormones of the anterior pituitary gland by action of peripheral gland hormones
- D. The inhibitory effect of peripheral gland' hormone on the production tropic hormones by the pituitary gland
- E. The inhibitory effect of the hormone of peripheral gland on target organs

4. Choose the hormone that binds with the membrane receptors:
- thyroxine
  - cortisol
  - aldosterone
  - epinephrine
  - testosterone
1. Choose the messengers of vasopressin action on the target cell:
- diacylglycerol
  - inositol triphosphate
  - cAMP
  - phospholipase C
  - cGMP
6. Residents of mountain regions are required to eat iodinated salt or sea products that are rich in iodine. The purpose of this recommendation is to avoid of the.....
- thyroid gland hyper function
  - adrenal hyper function
  - thyroid gland
  - hyper function of anterior pituitary
  - hypo function of posterior pituitary
7. Which of hormones listed below increases the cellular cAMP concentration?
- aldosterone
  - testosterone
  - estradiol
  - glucagon
  - cortisol
8. During the examination a ten year old child the physical and psychical retardation was observed. The deficit of what hormone leads to such symptoms?
- calcitonine
  - thyroxine
  - insulin
  - parathyroidal hormone
  - gonadotropine
9. After the eating of the carbohydrate-rich meal the blood analysis shows the glucose level up to 8,0 mmol/l. Secretion of what hormone will be increased in this case?
- glucagone
  - epinephrine
  - vasopressin
  - insulin
  - cortisol
10. What of the hormones listed below interacts with the cytoplasmic receptors?
- epinephrine
  - vasopressin
  - cortisol
  - glucagone
  - thyroxine

### Protocol of practical study №12. “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_

#### Work 1. Investigation of epinephrine effect on the heart.

**Aim of work:** to determine the changes of the frog's heart rate under the epinephrine. To find out the type of receptors that mediates epinephrine effect on myocardial cells.

**Materials and equipments:** preparation set, 2 glass cups, Ringer solution for the cold-blooded, epinephrine solution (1:1000), 0,1% solution of anapriline, frog.

**The work course.** By metal bore destroy in frog the brain and spinal cord. Put it on the board on its back. Cut the thorax and pericardium. Isolate the heart holding near the aortic arch and put it into the cup with Ringer solution. Calculate the heart beatings (per 1 min) in control conditions. Insert into the cup 1-2 drops of epinephrine and record the heart rate again. Remove the heart to another cup and add the new Ringer solution. Wash the heart from epinephrine. Calculate the heart beatings and add 1-2 drops of 0,1% solution of anapriline. Record the heart rate and than add 1-2 drops of epinephrine and calculate the heart rate again.

#### Results of the work:

Stage of the experiment	Heart rate per 1 min
1. Heart in the Ringer solution	
2. + epinephrine solution (1:1000)	
3. washed from epinephrine	
4. + 0,1 % solution of anapriline	

5. + epinephrine solution (1:1000)	
------------------------------------	--

**Conclusions:**

- 1) The heart rate after epinephrine administration is \_\_\_\_\_
- 2) The heart rate under epinephrine after applying of the beta-antagonist anapriline

\_\_\_\_\_ that is the evidence of  
 \_\_\_\_\_ effect of epinephrine on the cardiac cells that is mediated via  
 \_\_\_\_\_.

**Protocol revised** \_\_\_\_\_

(date, Preceptor's signature)

**The literature****Basic**

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.
2. E.N.Marieb, K.Koehn. Anatomy and Physiology. 10-th edition by Person Education Ltd,London, 2016. P.615-654.

**Additional**

1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P. 159-181.
2. H.M.Goodman. Basic medical endocrinology. 4-th edition by Elsevir Inc.,USA, 2009. – 344p.
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**FOR NOTES**



**FOR NOTES**

**Practical study 13.****Studying of hormones` role in growth, physical, mental and sexual development****1.Theme urgency:**

The group of hormones which supply the psychical development, physical development and linear growth of the body and also the sexual maturation require a special attention in professional training of a doctor. Because the opportune diagnosis of hyper- or hypo function of endocrine glands can give a possibility to improve or normalize named functions.

**2.Educational purposes:**

- *to analyze the regulated parameters and make a conclusions about the state of regulatory mechanisms involving hormones of linear growth of the body, physical, psychical and sexual development.*
- *to conclude about the level of physiological functions of the organism and its systems after the alteration in concentration of anterior pituitary hormones (ST) and thyroid hormones ( $T_3$ –  $T_4$ ).*
- *to analyze the age peculiarities of organism functions which are connected with the endocrine glands activity.*

**3.Approximate pattern for independent work at preparation for practical study****3.1.The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study**

<b>Term</b>	<b>Definition</b>
Endocrine gland's hypo function	the diminishing of glandular hormone secretion into the blood that leads to the decrease of blood hormone concentration
Endocrine gland's hyper function	the enhancing of glandular hormone secretion into the blood that causes the increase of blood hormone concentration

**3.2.Theoretical questions**

- 1) Role of the hypothalamo-pituitary system in the control of endocrine glands function.
- 2) Role of the anterior pituitary hormone somatotropin in physical development and linear growth of the body.
- 3) Role of the thyroid hormones in physical and psychical development, metabolism regulation and control of visceral functions.
- 4) Role of the sex hormones in the control of physical development and sexual maturation and reproductive functions of the organism.

**3.3.Practical works**

- 1) Research of the thyroid hormones influence on linear growth, physical and psychical development and metabolism intensity in experimental conditions (a film)
- 2) Experimental investigation of thyroid hormones exceeding secretion (a film)

**4.Materials for individual work and self-control****4.1.Answer the question:**

- 1) What hormones supply the psychical development of the child? Can we reveal their deficiency and avoid the mental retardation?
- 2) What hormones provide the physical development and linear body growth? Is it possible to reveal their deficiency and prevent the consequences of their absence?

- 3) Why pygmy are so small? Find the possible reasons.
- 4) Which of the reproductive hormones predominate in women? Determine the role of these hormones.
- 5) Which of the reproductive hormones predominate in men? Determine their role.

#### 4.2. Solve the tasks individually:

1. Describe the main stages of the synthesis and draw the regulatory scheme of the secretion for the thyroid hormone. What is the importance of control the level of TSH in the blood during the thyroxine therapy?
2. Choose all correct answers (the answer should be explained). Iodothyronines:
  - A. They are synthesized in hypophysis.
  - B. They interact with internal cells` receptors
  - C. They stimulate  $\text{Na}^+/\text{K}^+$ -ATP-ase
  - D. In high concentrations they increase catabolic processes.
  - E. They take part in adaptation at hypothermia.
3. Experimental animal was injected with somatostatin.  
How will be change the rate of somatotropin secretion by the cells of the anterior pituitary gland? Draw the contour regulation of somatotropin secretion.
4. Select the appropriate statements
 

<ul style="list-style-type: none"> <li>✓ Concomitant pathology in acromegaly can be:               <ol style="list-style-type: none"> <li>1) diabetes mellitus;</li> <li>2) nanism;</li> <li>3) myxedema;</li> <li>4) hyperthyroidism.</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>✓ Functions of Somatotropin               <ol style="list-style-type: none"> <li>1) stimulates proteins synthesis;</li> <li>2) stimulates lipolysis;</li> <li>3) depresses proteins synthesis;</li> <li>4) stimulates glucagon secretion;</li> <li>5) suppresses glucagon secretion.</li> </ol> </li> </ul>
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5. To state the accordance:

- A. Graves`s disease
- B. Myxedema
- C. Endemic goiter
- D. Cretinism
- E. Autoimmune thyroiditis

#### 4.3. Choose the correct answer:

1. Pygmies have a normal mental and physical development but they are too small. This is the result of the deficiency of:

- A. Somatoliberins
- B. Somatostatins
- C. Somatomedin (ilgf)
- D. STH
- E. TTH

2. A 40 year old man notes that his hands and feet enlarged significantly. The most probable reason is the increase secretion of ...:

- A. Somatoliberins
- B. Somatostatins
- C. Somatomedin (ILGF)
- D. STH
- E. TTH

3. A woman of 30 years old has noticed that she has lost weight, has a fast pulse, even little things irritate her. The reason for this may be primarily an increase in secretion

- A. Adrenaline
- B. Dopamine
- C. Glucagon
- D. Thyroxine
- E. Somatostatin

4. In postmenopausal women there are often limb fractures, especially in winter, because it decreases bone strength due to the lack of :

- A. Thyroxine
- B. Somatotropin
- C. Thyreocalcitonin
- D. Estreogens
- E. Progesterone

5. During the examination of a patient who complains for the tachycardia. It was found that the heart rate is 120 beats per min at the resting conditions. Blood analysis showed the increased concentration of thyroid hormones which cause the tachycardia due to the direct increase of..... in the pacemaker cells of heart.

- A. the sodium permeability

1. It is accompanied with proteoglycans and water accumulation in skin.

2. It appears at hypofunction of thyroid gland at an early age.

3. It is the consequence of the formation of immunoglobulin which imitates the action of thyrotropin

- B. the calcium permeability
- C. the number of adrenoreceptors
- D. the amount of adenylate cyclase
- E. the protein synthesis

6. Progesterone is synthesized:

- A. in the adrenal cortex
- B. in the medulla adrenal glands
- C. in the ovaries
- D. in the pituitary gland
- E. in testicles

7. Luteinizing hormone stimulates:

- A. Follicle development
- B. Uterine hyperplasia
- C. Ovulation
- D. Lactation
- E. Contractile activity of the uterus

8. The first half of the menstrual cycle is controlled by the hormone:

- A. Luteinizing
- B. Somatotropic
- C. Progesterone
- D. Follicle-stimulating
- E. Prolactin

9. The hormone controls the second half of the menstrual cycle:

- A. Luteinizing
- B. Somatotropic
- C. Follicle-stimulating
- D. Progesterone
- E. Oxytocin

10. In a child, bone development lagged behind chronological age, due to the lack of ossification of the epiphyseal cartilages with a deficiency:

- A. Somatostatin
- B. Somatomedin
- C. Somatotropin
- D. Thyroxine
- E. Insulin

**Protocol of practical study №13. “ \_\_\_\_\_ ” \_\_\_\_\_ 20 \_\_\_\_****Work 1. Experimental investigation of the thyroidal hormones role in linear growth, physical and psychical development and metabolism intensity. (a film)**

**Aim of work:** to determine the effect of thyroxine and T<sub>3</sub> hormone on the linear growth, behavior and metabolism intensity.

**Plan of work:** in the film the investigation of kid's behavior, linear growth, pulmonary ventilation and oxygen consumption are shown in normal conditions and after the thyroid gland extirpation.

**Results of the work:** the film shows that the kid after thyroidal extirpation has some particularities comparatively to the normal kid. These are: 1) growthretardation, 2) it was stiff and inert, 3) has a reduced pulmonary ventilation and oxygen consumption

**Conclusions:** \_\_\_\_\_  
(in conclusions explain the mechanisms of detected symptoms)

**Work 2. Experimental research of the exceeding thyroid hormones production. (a film)**

**Aim of work:** to determine the effect of increased thyroid hormones concentration on metabolism intensity.

**Plan of work:** hens were fed with the bird's dusty thyroid gland that caused the elevation of blood concentration of T<sub>3</sub> and T<sub>4</sub>.

**Results:** the exceed blood concentration of thyroid hormones lead to the increased metabolic intensity that resulted in early moulting.

**Conclusions:** \_\_\_\_\_  
(in conclusions explain the mechanism of metabolic changes under thyroid hormones)

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

**The literature****Basic**

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.
2. E.N.Marieb, K.Koehn. Anatomy and Physiology. 10-th edition by Person Education Ltd,London, 2016. P.615-654.

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1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P.182-196, 258-301.
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**FOR NOTES**

**FOR NOTES**

## Practical study 14.

### ***Studying of hormones` role in homeostasis regulation and organism`s adaptation to stressful factors***

#### **1.Theme urgency:**

Group of hormones which provide control of homeostasis parameters and reaction of unspecific adaptation to the stress factors influence require considerable attention in professional preparation of a doctor, because exactly the constancy of such homeostasis parameters, as a sodium, calcium, potassium ions and phosphates concentration in the internal environment are crucial for such properties, as excitability and conductivity, contracting muscles, state of bones of the locomotor system and a lot of others. Concerning the role of hormones in unspecific adaptation of organism, the modern state of life is accompanied with stress factors affects on the organism that can result in different displays in an organism functioning, including some alteration being caused by hormones action on target cells on the different stages of unspecific adaptation of organism.

#### **2.Educational aims:**

- *to analyze the regulated parameters and make conclusions about the function of homeostatic control mechanisms by hormones.*
- *to make conclusions about the physiological functioning of the organism, its systems and organs after hormones concentration changes which supply homeostasis control.*
- *to explain the mechanisms of hormonal control of unspecific adaptation response of the organism.*

#### **3.Approximate pattern for independent work at preparation for practical study**

##### ***3.1.The list of the basic terms, parameters, characteristics which a student should acquire at preparation for practical study***

<b>Term</b>	<b>Definition</b>
Stress factors	the changes in external or internal environment which cause the work strain (stressed state) of the organism that is followed by the activation of hypothalamic-pituitary-adrenal hormones secretion that provide unspecific adaptation response
Unspecific adaptation of the organism	a state of the organism that is characterized by the increased concentration of hypothalamic-pituitary-adrenal hormones that results in energetic and defensive resources mobilization under stress conditions

##### ***3.2.Theoretical questions***

1. Role of pancreatic hormones in the homeostasis maintenance and in control of physiological functions.
2. Role of calcitonin, parathormone and calcitriol in the maintenance of calcium and phosphate blood concentrations.
3. General review of unspecific adaptation of the organism to stress conditions. Role of hormones in development of the unspecific adaptation.
4. Role of sympathetic-adrenal system in the unspecific adaptation response.
5. Role of pituitary-adrenal system in the unspecific adaptation reactions. The main effects of glucocorticoids and mineralocorticoids.

##### ***3.3.Practical works***

- 1) Investigation of physical exercising as a stress factor on the organism functions.

**4. Materials for individual work and self-control**

**4.1. Answer the question:**

- 1) What hormones maintain  $\text{Na}^+$  and  $\text{K}^+$  concentration in the internal environment of an organism? What factors stimulate these hormones secretion into blood?
  
- 2)  $\text{Ca}^{2+}$  ions concentration was diminished in blood. What hormones will take part in the maintenance of the constancy of concentration of this homeostatic parameter? Draw the chart of regulatory contour.
  
- 3) What hormones regulate the constancy of glucose concentration in the internal environment of the body? How does the lack of the hormone insulin affect the function of brain neurons? Why?
  
- 4) What hormones provide the rapid adaptation to stressors?
  
- 5) What hormones of the hypothalamic-pituitary-adrenal system provide a long-term non-specific adaptation of the body to the action of stress factors? Name its characteristic signs.
  
- 6) Explain the reasons and displays of steroids withdrawal syndrome.
  
- 7) Draw the chart of the contour of biological regulation of glucose concentration constancy in blood, write name of hormones, taking part in the regulation.

**Draw a regulation loop of the:**

- 1) The constancy of  $\text{Na}^+$  and  $\text{K}^+$  concentrations in blood with hormones participation.
- 2) The constancy of  $\text{Ca}^{2+}$  concentration in blood with hormones participation
- 3) The constancy of glucose concentration in blood with hormones participation
- 4) Cortisol secretion

**4.2. Solve the tasks individually:**

1. Write the hormones which

Decrease the glucose level in blood	Increase the glucose level in blood
1.	1.
	2.
	3.
	4.
	5.

2. Fill in the table



Hormone	The structure and place of synthesis	The stimulus for secretion	Target cell or organs	Mechanisms of humoral signal conduction	Metabolic changes in target cells
Insulin					
Glucagon					
Cortisol					
Epinephrine					

3. Write the stages of insulin synthesis. Explain what reasons can lead to insulin deficiency. Why is the concentration of C-peptide in blood essential for diagnostics.

4. Fill in the table

Hormone	The place of synthesis	Stimuluses	The mechanisms of action	Target organs	Effects
Antidiuretic hormone					
Aldosterone					
Atrial natriuretic peptide					

5. Fill in the table.

Hormone	The place of synthesis	Stimuluses	The mechanisms of action	Target organs	Effects
PTH					
Calcitonin					
Calcitriol					

6. Finish writing in the scheme of the processes which take place during non-specific prolonged adaptation of an organism to stressors action

Stressor ----- receptors` irritation -----hypothalamus

Hypophysis

Adrenal glands

Mineralocorticoids

glucocorticoids

**4.3. Choose the correct answer:**

1. A patient with a joint inflammation was treated with cortisol during a long time that lead to the inhibition of a certain hormone secretion trough negative feedback loop. Choose this hormone:
  - A. ST
  - B. TTH
  - C. ACTH
  - D. FSH
  - E. LH
7. Aldosterone exceeding secretion is usually followed with such changes:
  - A. hypernatremia
  - B. hypokalemia
  - C. increased hydrogen secretion
  - D. hypertension
  - E. all mentioned before
3. Somatostatin that is released from delta cells of pancreatic islets inhibits the secretion of.....:
  - A. cortisol
  - B. aldosterone
  - C. epinephrine
  - D. insulin
  - E. tyrotropine
4. A 70 year old man heard from a TV about the usefulness of combined vitamin D3 and calcium consumption. Exceeding consume of such complex resulted in hypercalcemia. What hormones should be prescribed to normalizing of calcium blood level?
  - A. parathyrine
  - B. calcitriol
  - C. calcitonin
  - D. epinephrine
  - E. glucagone
5. Vitamin D3 as a hormone is produced under PTH influence in the:
  - A. liver
  - B. kidneys
  - C. skin
  - D. gut
  - E. adrenal glands
6. After kidney transplantation the host reaction is suppressed by administration of:
  - A. epinephrine
  - B. aldosterone
  - C. vasopressin
  - D. cotrisol
  - E. insulin
7. Under stress conditions the blood analysis revealed hyperglycemia which was developed as a result of gluconeogenesis and glycogenolysis. These processes were activated by:
  - A. cortisol
  - B. aldosterone
  - C. vasopressin
  - D. insulin
  - E. angiotensin
8. A certain hormone is able to increase the number of receptors on target cell membrane and regulate its own effects this way. What is this hormone?
  - A. thyrotropin
  - B. somatotropin
  - C. ACTH
  - D. thyroxine
  - E. epinephrine
9. Choose the hormone concentration of which is maximal in early morning due to circadian rythm:
  - A. epinephrine
  - B. glucagone
  - C. insuline
  - D. cortisol
  - E. vasopressin
10. In women after climacteric period the frequency of bones fracture

- dramatically increases that is due to the lack of ..... control on calcium balance.
- A. androgens  
B. estrogens  
C. cortisol  
D. insulin  
E. calcitriol

**Protocol of practical study №14. “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_**

**Work 1. Investigation of standard physical activity effect as the stressor on the organism.**

**Aim of work:** to determine the heart rate alterations after standard physical exercise comparatively to the rest condition, explain their mechanisms

**Plan of work:** Each student calculates its own heart beating rate at a rest. After that performs 20 squats for 30 s and immediately after finishing records pulse rate during the 1st, 2nd and 3rd minutes of resting till the heart rate will be normalized.

**Results of the work:**

Heart rate per 1 min	At a rest	After physical exercise		
		1st min	2nd min	3rd min

**Conclusions:** \_\_\_\_\_

**Protocol revised** \_\_\_\_\_  
(date, Preceptor's signature)

**The literature**

**Basic**

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

**Additional**

1. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Physiology. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, P. 197-257.
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**FOR NOTES**

**FOR NOTES**

## Control lesson 15.

### **Practical skills in general physiology**

#### **1.Educational aims:**

The control of mastering part №1 “General physiology and higher interactive functions” in accordance to concrete aims of the current sections №1-7 permits to display student’s successfulness in the realization of the following end aims of the discipline:

- *To analyze the regulated parameters and make the conclusions about the mechanisms of nervous and humoral regulation of the organism’s physiological functions and its systems.*
- *To interpret the mechanisms and regularities of functioning of organism’s excitable structures*
- *To analyze the state of sensory processes in the providing human vital activity*
- *To explain the physiological bases of the methods of organism’s functions research.*

#### **2.The basal level of preparation**

Students have practical skills from the previous studying disciplines:

The previous disciplines	Received skills
Human anatomy	<i>To analyze the information about structure of a human body, its systems, organs and tissues</i>
Histology, cytology, embryology	<i>To interpret microscopic and submicroscopic structures of the cells</i>
Medical biology	<i>To explain the regularities of the vital activity of a human organism on molecular-biological and cell levels</i>
Medical and biological physic	<i>To treat the general physical and biophysical regularities lying in the base of a human vital activity</i>

#### **3.The task for independent work during the preparation for the control lesson**

##### **3.1.Theoretical questions**

##### **Section 1. Introduction into physiology.**

1. Physiology as a science. The conception about its functions. The methods of physiological research.
2. Establishment and development of physiology in XIX century
3. The contribution of the works by I.M. Sechenov, I.P. Pavlov, P. K. Anochin, P.G. Kostuk into the world physiology development
4. Ukrainian physiological school.

##### **Section 2. General physiology of the excitable structures.**

1. Resting potential, the mechanisms of origin, its parameters, physiological role.
2. Action potential, the mechanisms of origin, its parameters, physiological role.
3. Excitability. Firing level (the critical level of depolarization), the threshold of depolarization of the excitable cell.
4. Changes of cell’s excitability during the single action potential development.
5. The meaning of the parameters of electrical stimuli for the excitation appearance.
6. The mechanisms of excitation transmission along nervous fibres.
7. The regularities of excitation transmission along nervous fibres.
8. The mechanisms of excitation transmission through the nervous-muscular synapse.
9. Excitation-contraction coupling. Mechanisms of sceletal muscles` contraction and relaxation
10. The types of muscles` contraction: single and tetanic, isotonic and isometric.

##### **Section 3. Biological regulation.**

1. Biological regulation, its kinds and meaning for an organism. Counturs of biological regulation. The feedback mechanism role in regulation.
2. The conception about reflex. The structure of the reflex arch, and the functions of its links.
3. Receptors, their classification, the mechanisms of excitation.

4. Proprioceptors, their types, functions. The structure and functions of the muscle spindles.
5. Mechanisms and regularities of the excitation transmission in the central synapses.
6. The types of central inhibition. The mechanisms of presynaptic and postsynaptic inhibition development.
7. Summation of excitation and inhibition by the CNS's neurons.

#### **Section 4. Sensory systems.**

1. Sensory systems, their structure and functions.
2. Taste sensory system, its structure and functions, methods of research.
3. Smell sensory system, its structure and functions.
4. Somato-sensory system, its structure and functions.
5. Physiological mechanisms of pain.
6. Opiate and unopiate antinociceptive systems of an organism, their significance.
7. Physiological mechanisms of anaesthesia.
8. Auditory sensory system, its structure and functions.
9. The functions of external and middle ear. Internal ear, frequency analyzes of sound signals.
10. Visual sensory system, its structure and functions.
11. The main visual functions and methods of their research.

#### **Section 5. Nervous regulation of motor function.**

1. Motor reflexes of spinal cord., their reflex arches, physiological significance.
2. Conductive function of spinal cord. Dependence of spinal reflexes on brain centers activity. Spinal shock.
3. Motor reflexes of hindbrain, decerebrate rigidity.
4. Motor reflexes of midbrain, their physiological significance.
5. Cerebellum, its functions, the symptoms of a damage.
6. Thalamus, its functions.
7. Limbic system, hypothalamus, their functions.
8. Basal nuclei, their functions, the symptoms of a damage.
9. Sensory, associative and motor zones of brain cortex, their functions.
10. Interaction between different CNS's levels in motor functions regulation. Locomotions, its regulation. Functional structure of arbitrary movements. Age changes of motor functions.

#### **Section 6. Nervous regulation of visceral functions.**

1. General structure of autonomic nervous system. Visceral reflexes, their reflex arch.
2. Synapses of autonomic nervous system, their neurotransmitters, cytoceptors and block of excitation transmission in the synapses.
3. The action of sympathetic nervous system on the visceral functions.
4. The action of the parasympathetic nervous system on the visceral functions.
5. The role of the metasympathetic nervous system in visceral functions' regulation.
6. The unity of sympathetic and parasympathetic systems in functions' regulation.

#### **Section 7. Humoral regulation of functions.**

1. Humoral regulation, its differences from the nervous one. Characteristics of factors of humoral regulation.
2. Hormones' qualities, their actions. Mechanisms of hormones' actions on the target cells.
3. Countours of humoral regulation. Regulation of hormones secretion by the endocrine glands.
4. Hypothalamo-hypophysal system's role in endocrine glands' functions regulation.
5. Growth hormone, thyroxine and triiodtyponine, insuline role in the regulation of linear growth of body and physical and mental development of an organism.
6. Calcitonine, parathormone (paratyryne), calcitriole (vitamine D3-hormone) role in regulation of calcium and phosphates constancy in the blood.
7. Pancreatic hormones' role in organism's functions regulation
8. Thyroid hormones' (T3, T4) role in organism's functions regulation
9. Physiology of female sexual system, its functions, sexual hormones' role.
10. Physiology of male sexual system, sexual hormones' role.

11. General conception about unspecific adaptation of an organism to stress situation. Hormones` role in unspecific adaptation.
12. Sympatho-adrenal system`s role in unspecific adaptation`s regulation of the organism to stress situation.
13. Hypothalamo-hypophysal system`s role in unspecific adaptation`s regulation of the organism to stress situation. The main influences of glucocorticoids and mineralocorticoids on an organism.
14. Regulation of calcium homeostasis and its role in ensuring the normal condition of the maxillofacial area.

### 3.2. Practical skills.

1. To calculate parameters of functions and to display graphically the processes taking place in the excitable structures.
2. To draw diagrams and explain the structure and mechanisms:
  - a. *Counturs of biological regulation, reflex arches of motor reflexes,*
  - b. *Development of excitation and inhibition in CNS, processes of summation and reflex coordination,*
  - c. *Reflex arches of motor reflexes on all CNS levels and conducting ways, which provide coordination of different CNS`s levels.*
  - d. *Reflex arches of visceral reflexes, which provide visceral functions` regulation, hormones` action on target cells and their secretion regulation, counturs of visceral functions regulation with the participatio of hormones .*
3. To estimate the state of sensory systems under their functions` parameters.
4. To draw the diagrams of the structure of specific channels for the information transmission in the sensory systems and to explain the mechanisms of formation of suitable feelings and images of external reality.

### 5. The regulations of control lesson

The duration of a control lesson is 2 academical hours.

The control of student`s level of preparation during the control lesson is spend according to the following regulations:

1) Computer`s test control (during 45 minutes: consists of fulfillment of 60 tests in which a student has to chose only one right answer).

2) During the left time a student decides situational tasks, draws the diagrams, grafs and counturs of regulation, other integrative tasks in which the student can display abilities to analyze and to interpret preposed situational tasks and to make right based conclusions.

Some integrated situational tasks are proposed to a student, which permits to display the successful mastering of parte 1. The check up of studying tasks is fulfilled by a teacher during the control lesson as far as they fulfilled by a student. The tasks are standartized and are directed on the control of end aims of discipline during the semantic sections studying.

**Protocol of control lesson № 15. “ \_\_\_\_\_ ” \_\_\_\_\_ 20\_\_\_\_**

**Computer`s test control:**

**Solve the tasks:**

*Protocol revised* \_\_\_\_\_  
(date, Preceptor's signature)

## **The literature**

### ***Basic***

1. Guyton and Hall Textbook of medical physiology. John E. Hall, 13<sup>th</sup> ed. Elsevier Inc. 2016. – 1168 p.

### ***Additional***

1. Physiology. V.M.Moroz, O.A.Shandra, R.S.Vastyanov, M.V.Yoltukhivsky, O.D.Omelchenko. Vinnytsia: NOVA KNYHA PUBLISHERS, 2011, – 912 p.
2. Ganong's Review of Medical Physiology 25th ed. McGraw-Hill Education. 2015. – 750 p.
3. Human Physiology. Fox I., 8<sup>th</sup> edition. By the McGraw-Hill Companies, USA, 2004. – 727 p.
4. Human Physiology: The Mechanism of Body Function. Vander et alls, 9<sup>th</sup> edition, 2004. – 800 p.
5. Human physiology. E.B. Babsky, B.I. Khodorov, G.I. Kositsky, A.A.Zubkov Mir Publishers Moscow, 1975, V.1, P. 7-53; V.2, P. 7-83, 92-134, 140-165, 169-214, 222-296, 300-317, 329-409.

## **FOR NOTES**



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*Educational edition*

**Tamila A. Alieva, Ph.D.**  
**Ighor M. Karvatsky, Ph.D.**  
**Ludmyla O. Klymenko, Ph.D.**  
**Tetiana S. Lagodych, Ph.D.**  
**Ivan V. Leschenko, Ph.D.**  
**Iryna A. Lukyanenko, Ph.D.**  
**Olena Yu. Scherbak**  
**Iryna G. Strokina, Ph.D.**  
**Olena O. Vinogradova-Anik, Ph.D.**

*Translated by I.G.Strokina, Ph.D., O.O.Vinogradova-Anik, Ph.D.*

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Комп'ютерна верстка та дизайн – *І.М.Карвацький*

**Practical works in physiology.** Edited by I.M.Karvatsky. Manual for practical studies and individual work of stomatological faculty students. 2-th Vol. – Kyiv. Книга-плюс, 2021. V.1 – 106 p.

Формат 70×100/16. Папір офсетний. Друк офсетний. Ум. друк. арк. 8,8.  
Підписано до друку 29.03.2021 р. Зам. №19-124. Наклад 100