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## **ELECTROPHYSIOLOGY. PHYSIOLOGY OF EXCITABLE TISSUES**

Educational and methodical manual

Recommended by the Methodical Panel of the Institute of Biology and Biomedicine  
for students of NNSU

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Reviewer

prof. Veselov A. P.

The training manual contains materials for practical work in the course of human and animal physiology and test questions on the topic of the lesson. This training manual is intended for students specialising in the following areas:

31.05.01 "Medical work", 31.05.03 "Dentistry", 30.05.01 "Medical biochemistry",  
30.05.02 "Medical Biophysics", 30.05.03 "Medical Cybernetics",  
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## INTRODUCTION

Almost all of our knowledge in the field of human physiology is based on the results of laboratory experiments, thanks to which the information presented in textbooks and lectures was obtained. The experimental approach is used to solve many of the remaining mysteries in the body's work, and only experiment makes it possible to understand physiology as a science. In addition, physiology is the theoretical basis of medicine, its foundation, and, consequently, the physiological experiment is considered as an important stage of scientific clinical research. It is obvious that the laboratory workshop should be an integral part of teaching students the basics of human and animal physiology.

### *General objectives of the workshop:*

- demonstrate how the physiological processes studied in the theoretical course actually occur in a living organism;
- give a general idea of some of the physiological methods and devices used to observe physiological phenomena and measure their parameters;
- study the mechanisms that control the physiological functions of the body.

## TOPIC 1. BASICS OF THE PHYSIOLOGICAL EXPERIMENT

### **Ethics of physiological experiment**

Compliance with the rules of humane treatment of animals is a prerequisite for conducting physiological experiments. In 1984, International recommendations for conducting biomedical research using animals were approved. This document of the European research Council and the Advisory Committee on medical research sets out the most important principles for setting up a biomedical experiment.

In Russia, the procedure for using animals in an experiment is determined by a number of documents approved by the heads of all departments where this type of research can be conducted. The main document is the "Rules for working with experimental animals". This document stipulates that the researcher has the right to use animals in the experiment, but a number of provisions must be strictly observed:

- You can only conduct an experiment using animals in public institutions that have an appropriate experimental base.
- Setting up such experiments is allowed only in institutions where there is an equipped vivarium, served by staff who serve animals.
- Only people with higher education in biological, medical, veterinary and zootechnical field can conduct experiments with animals.
- The model of the experiment must meet the requirements of humane treatment of animals and in the case of any painful manipulations, it is necessary to use anesthesia.

- Compliance with the requirements of humane treatment of animals should be noted when presenting the methodology and results of the experiment in scientific publications or compiling reports.
- Healthy animals of the appropriate species should be selected for experiments, limited to the minimum number required to obtain scientifically reliable results.
- The next in order and degree of importance of the recommendations is the requirement of ethical treatment of animals. Researchers and other personnel should always treat animals as sensitive to various types of impacts and consider it their ethical duty to treat and use animals in such a way as to minimize the inconvenience and pain caused to them.

### **Measures for injuries, contact with blood and other biological materials**

If contact with blood or other fluids occurred with a violation of the integrity of the skin (prick, cut), the person must do the following:

- remove gloves with the work surface inside;
- squeeze the blood out of the wound;
- wash your hands under running water with soap, and then treat the damaged area with one of the disinfectants (70% alcohol, 5% tincture of iodine);
- apply a patch to the wound, put on a fingertip;
- if necessary to continue work - wear new gloves.

If the skin is contaminated with blood or other biological fluid without damage, you must:

- treat the skin with one of the disinfectants (70% alcohol, 3% chloramine solution);
- wash the contaminated area with soap and running water and re-treat with 70% alcohol.

If biological material gets on the mucous membranes:

- oral cavity - rinse with 70% alcohol;
- nasal cavities-drip a 30% solution of albucide;
- eyes - rinse with water (clean hands), drip a 30% solution of sulfacetamide. A 0.05% solution of potassium permanganate can be used to treat the nose and eyes.

If the biomaterial gets on the robe, clothing:

- disinfect gloves;
- remove clothing and soak it in a disinfectant solution (except for 6 % hydrogen peroxide, neutral calcium hypochloride, which destroy tissues) or place it in an autoclave bag;
- wipe the skin of the hands and other parts of the body with 70% alcohol under contaminated clothing, then rinse with soap and water and re-wipe with alcohol;

- clean contaminated shoes twice with a rag soaked in a solution of one of the disinfectants.

#### **First aid kit for emergency medical care:**

- finger pads (or gloves) at the rate of 1-2 per student per shift;
- adhesive tape - 1 coil;
- potassium permanganate in attachments of 0.05 g;
- potassium permanganate dilution tank;
- ethyl alcohol 70%;
- a tube-dropper of a 30% solution of sulfacetamide ;
- 5% iodine tincture and 3% hydrogen peroxide solution;
- rubber gloves - 3 pairs, glasses., plastic aprons, 4-layer masks;
- large plastic bag for collecting contaminated clothing;
- attachments of disinfectants: chloramine 30 g; 3 attachments (each stored separately);
- container for diluting disinfectants.

After reading the rules and receiving instructions on safety, the student signs in the "Journal of control sheets for instructing students on safety".

#### **Preparation of reports on practical work**

The accumulation of knowledge in any field occurs through active communication of scientists, which consists in publishing the results of experiments in scientific journals and presentations at conferences, congresses and symposiums. Therefore, the task of the workshop is not only to get acquainted with the basics of experimental work, but also to teach students the rules for presenting the results of scientific work in the form of written reports (protocols) and oral messages. The written report is proposed to be based on the same rules that are usually imposed on the publication of experimental materials by scientific journals. The report on practical classes includes the main sections that are present in the scientific article - "Introduction", "Methodology", "Results", "Discussion", "Conclusions" and "Literature".

**Introduction.** It contains a small amount of basic information about the problem under study, and sets out the goals of the experiment. The definition of the main physiological phenomena and concepts under study is given, and the expected results of experiments can be described. You must remember to correctly quote all the information sources used in this part of the report. Include in this part of the report only the information that is relevant to this work!

**Methods (methodology).** This includes a brief description of the object of research, materials, devices, equipment, substances and reagents, as well as methodological approaches used in the experiment. The description of the methods should be detailed enough for other researchers to repeat the experiment. At the same time, you should avoid excessive detail, and it is better to refer to the original literary source, where the methodological techniques are considered in detail. If you have made

any modifications to the experiment, this must be reflected in the description. Do not forget to specify the doses and concentrations of the drugs used.

**Result of work.** This section can be designed separately or together with the next section "discussion of results".

The results obtained in the experiment can be presented in the form of original recordings on the tape recorder, cardiograph or electroencephalograph. You must specify the speed of the tape, the parameters of the applied stimuli with accurate recording of the moment of application and termination of the stimulus (in the captions to the illustrations, appropriate explanations are given). If the registration was performed from the oscilloscope screen, on the scale of the pressure gauge, etc., then it is more convenient to present the results of the experiment in the form of a table. The table contains the obtained values of the studied parameters and their units of measurement.

If possible to identify the main regularities of the studied phenomena, graphs are built based on the obtained data. They should be neat and clear. You do not need to build each graph on an A4 sheet, but you should not reduce it to the size of a postage stamp. Graphs must have a title, parameter designations along the axes with units of measurement, number and explanations of the symbols used in it (legend); all experimental points and calculated parameters are entered in them.

**Discussion of results.** This is the most important section of the report that reveals the depth of understanding of the problem being studied and the ability to apply theoretical knowledge in explaining the results obtained in a real experiment. Discuss your results from the perspective of modern science concepts. Try to imagine the mechanisms underlying the observed phenomena. Explain the significance of the discovered method of regulation in the work of the whole organism. If the results obtained differ from the theoretically expected results, try to identify possible reasons for these discrepancies. When making assumptions, don't forget about the limitations that any measurement technique has.

**Conclusions.** They briefly list the main results and patterns found in the experiment. For example: "when the amplitude of the stimulus increases from ... mV to ... there is an increase in the amplitude of the muscle response. Further amplification of the stimulus does not change the muscle response." (It is not necessary to explain the mechanisms of the observed phenomena again – they are already set out in the "Discussion" section.)

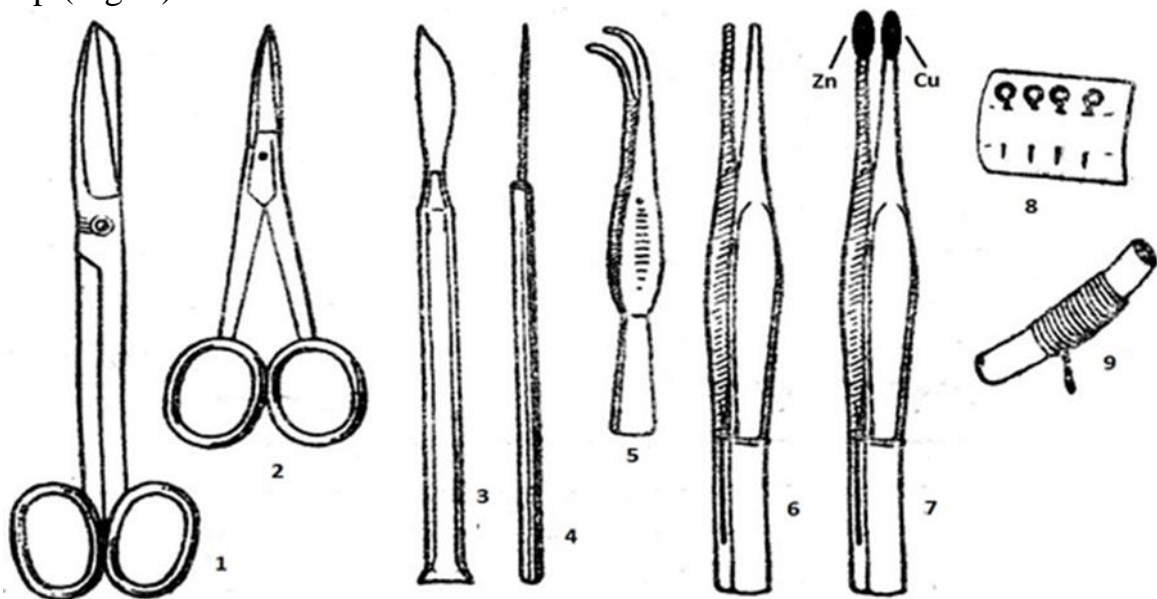
**Literature.** At the end of the work, all the literature sources that you used in the report design and referenced in the theoretical introduction should be listed in alphabetical order.

Thus, it is clear that the laboratory report (Protocol) should be brief and objective. The key point is the completeness and consistency of the above mentioned. A thoughtful approach to explaining discrepancies between the results of the experiment and the theory is much more correct than trying to ignore them! This will teach you, as future researchers, to be accurate and critical in evaluating the results obtained.

### **Tools for dissection**



The following set of tools can be used to perform the work described in the workshop (Fig. 1):



**Fig. 1. Tools for dissection (explanations in the text)**

Scissors are large with straight ends, one of which is sharp (1).

Small (eye) scissors for fine preparation, necessary for most work on the physiology of the nervous system and the physiology of blood circulation (2).

Tweezers: anatomical (6), ocular (5).

Preparation needle (4). Pins (mainly for attaching a frog to a plate). They should be at least four, and it is better not to scatter them in a box, but to give them fixed in a paper substrate (8).

The scalpel (3) is issued only for certain works, for example, for opening the eye, for operations to the experiment of Sechenov braking. Knife for Stripping contacts, electrodes, wires, etc.

Ligature or thread (9) (for convenience, wound on a rubber tube).

Galvanic tweezers (7) the Tweezers are made of surgical tweezers with cu and Zn plates on the branches.

Various clips and cannulas (issued when performing the relevant work and are not included in the permanent set of tools).

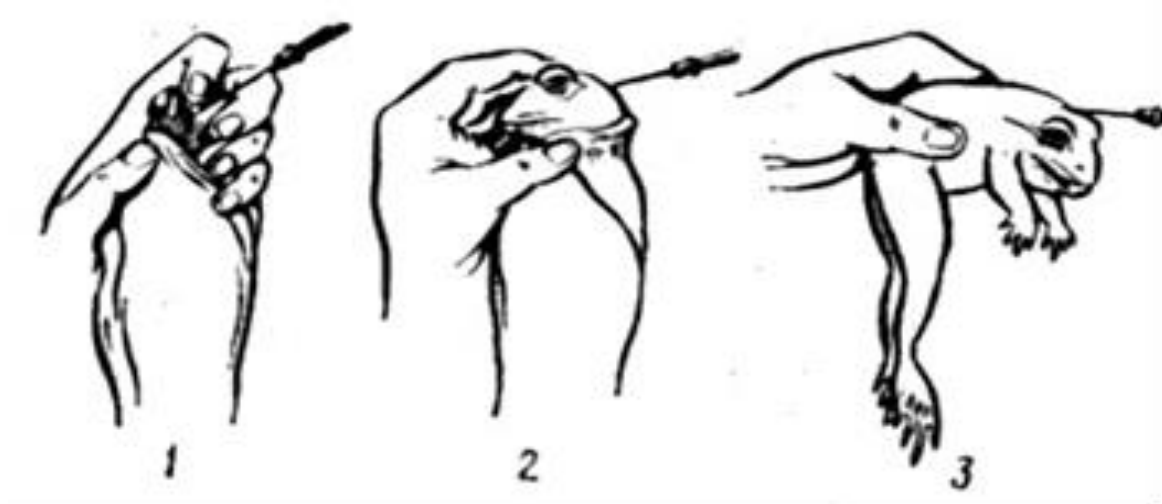
It is recommended that each student be given a set of tools that is necessary for this laboratory task.

### **Methods of immobilizing a frog**

In conducting a physiology workshop, it is necessary to immobilize the frog either by destroying the brain and spinal cord, or by anesthesia. Destruction of the frog's brain and spinal cord can be performed in the following ways:

**Destruction of the brain and spinal cord** (Fig.2). Take the frog in your left hand with your hand back up, so that your thumb is on its back. Place your index finger on the frog's upper jaw and tilt its head down. In this position, the location of the occipital fossa is clearly visible. Through the fossa between the occipital bone, insert the needle into the skull cavity and destroy the brain. Then turn the needle in the opposite direction

with the spine and insert it into the spinal canal, destroying the spinal cord with several turns of the needle. The General relaxation of the frog's muscles and the lack of reflex reactions indicate complete destruction of the brain and spinal cord. With this method of immobilizing the frog, very little blood is lost.



**Fig. 2. Scheme of destruction of the brain and spinal cord**

**Decapitation followed by destruction of the spinal cord.** Take the frog in your left hand, and with your right one, insert the lower blade of the scissors as deep as possible into the mouth under the back of the upper jaw behind the eyes. With a quick movement, cut off the upper jaw at the level of the rear end of the eardrums (save the lower jaw). Insert a dissecting needle into the opening of the spinal canal and destroy the spinal cord.

**The use of anesthesia** (ether, alcohol, urethane). Anesthesia is rarely used in the training workshop. To anesthetize the frog, a 10% solution of alcohol or a 2% solution of ether is used. The frog is released into the solution for 10-15 minutes. Muscle relaxation and lack of motor activity are good indicators of sufficient anesthesia action.

### **Fixing a frog**

In a number of works, the spinal preparation of a frog is used - a frog whose brain is destroyed and the spinal cord is preserved. When preparing the corresponding nerves and muscles and conducting research, the spinal frog must be fixed to the plate motionless. It is best to fix it on a cork (or paraffin) plate with a size of 20x10 cm.

When fixing a frog on a plate, it is important to stretch its limbs well so that they are stationary and do not interfere with the recording of responses. Pins must be inserted in the direction opposite to the movement of the limb: otherwise, the legs slide on the pin, and fixation is not provided.

## TOPIC 2. PHYSIOLOGY OF EXCITABLE TISSUES

### LESSON №1. ELECTRICAL PHENOMENA IN EXCITABLE TISSUES

#### Control questions on the topic of the lesson

1. Biological membranes, their structure and functions.
2. Ionic asymmetry between the external and internal environments of the cell.
3. Ion channels.
4. Membrane resting potential.
5. Membrane action potential, its phases.
6. Goldman-Hodgkin-Katz equation
7. Mechanism of change in ionic conductivity during generation of action potential.
8. Critical level of depolarization. Change in the critical level of depolarization. Depression Verigo.

#### Practical work № 1. Preparation of a neuromuscular preparation

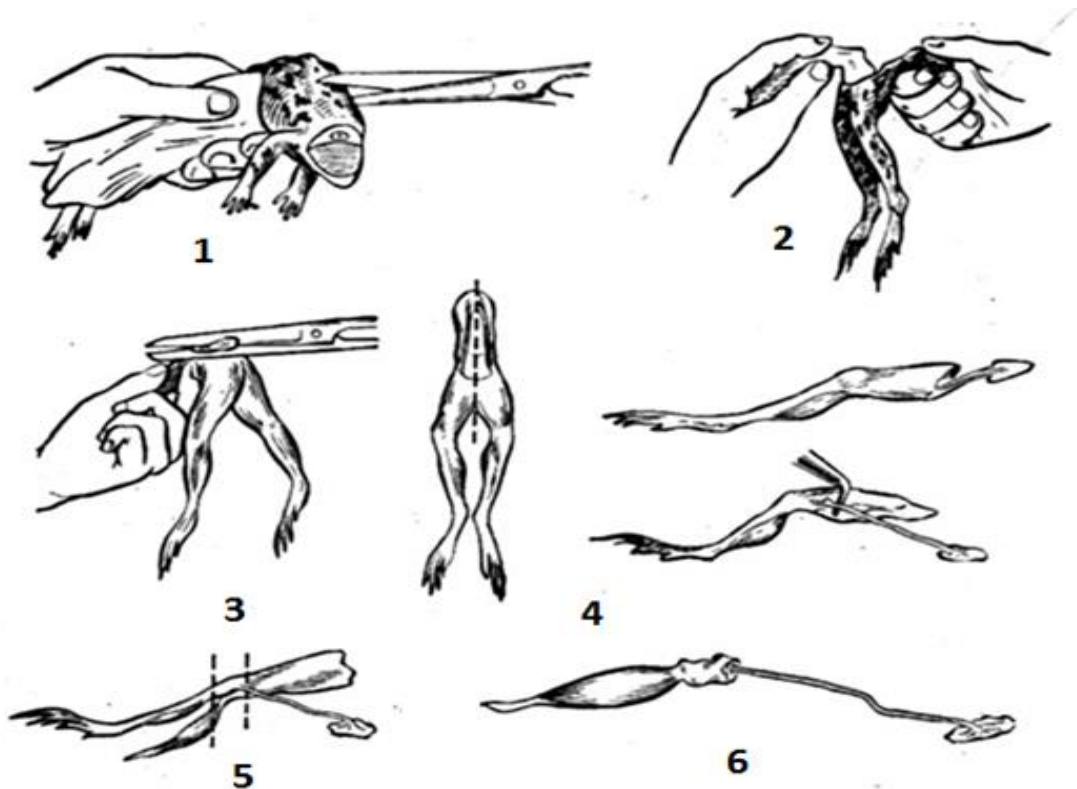
**The purpose of the work:** to master the technique of preparing a neuromuscular drug.

**For the work you need:** a frog, gauze napkins, tools for dissecting, a tablet for dissecting, a Petri dish, a 0.6% solution of sodium chloride.

#### **Progress of work:**

##### 1. Preparation of the preparation of the hind legs.

Take the frog, wrap it in a gauze cloth so that the frog's forelimbs are pressed against the body, and the head remains free (Fig. 3). Immobilize the frog by destroying the brain and spinal cord. After the destruction of the spinal cord, remove the needle from the spinal canal and check for reflexes. Take the frog by the hind legs so that its abdomen hangs down, cut the spine across, make two cuts to the right and left of the spine, cutting the skin along with the muscle to the symphysis (Fig.3.1). Cut off and remove the hanging entrails, as well as the skin and muscles of the abdominal wall so that the hind limbs remain with the sacrum, a piece of the spine and the sciatic nerves coming out of the preserved remnant of the spinal canal. Holding the spine with one hand, use the other to grab the edge of the skin with a napkin and remove it. The result is a preparation of the two hind legs of a frog (Fig.3.2).



**Fig.3 Preparation of a neuromuscular preparation (explanations in the text)**

2. Preparation of a rheoscopic foot.

From the back legs of the frog, take the spine and bend it so that the coccyx protrudes upwards. Cut the tailbone with scissors. Put the preparation with the abdominal side up (Fig. 3.3). trying not to touch the nerve stems of the sacral plexus, cut the spine along the middle line and separate the legs from each other. Holding the rest of the spine, select the sciatic nerve using glass hooks. Remove the pelvic bone by cutting it near the spine and hip joint (Fig. 3.4).

3. Preparation of a neuromuscular preparation.

The next stage of work is the preparation of the sciatic nerve and calf muscle. To dissect the nerve, the thigh is placed with the back surface up, the muscles are bled and dissect the sciatic nerve lying in the depth along its entire length. After lifting the nerve for the rest of the spine, you need to carefully cut the surrounding tissue with scissors. Cut the foot one and a half centimeters above the knee joint (Fig. 3.5). Remove any remaining thigh muscles. Put a pair of scissors under the Achilles tendon, separate it along the entire length and cut it below the sesamoid bone. Taking the tendon with tweezers, pull the calf muscle to the side, tearing the fascia that bind it to other tissues. Cut the foot below the knee joint. The result is a neuromuscular preparation of the calf muscle and the sciatic nerve (Fig. 3.6). Place the product in a Petri dish containing ringer's solution or 0.6% sodium chloride solution.

**Results of the work and their design.** Draw in the protocols of preparations got in stages.

## Practical work № 2. Galvani's first experience

**The purpose of the work:** to get acquainted with the experience of L. Galvani on the basis of which the question of the existence of "animal electricity" was first raised.

**For the work you need:** a frog, gauze napkins, tools for dissecting, a tablet for dissecting, a Petri dish, galvanic tweezers, a 0.6% solution of sodium chloride.

**Progress of work:** Use the preparation of the frog's hind legs to work. Place the drug on a glass plate. Touching the nerve plexus with the branches of a galvanic tweezer, observe the muscle contractions that occur (Fig. 3).

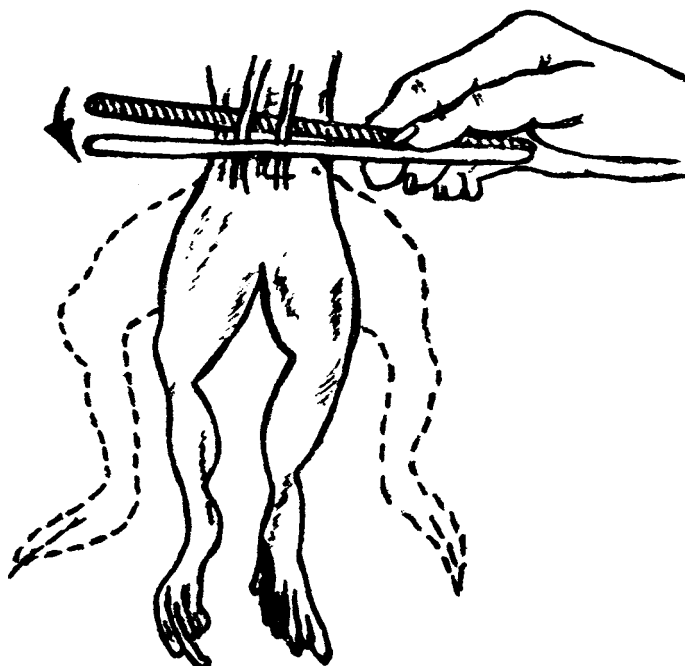


Fig. 3. Galvani's first experience

**Results of the work and their design.** Draw a diagram of the experience. Make a conclusion explaining what the source of electricity is and what causes muscle contraction.

## Practical work № 3. Galvani's second experience

**The purpose of the work:** to get acquainted with the experience that shows the irritating effect of the current that occurs directly in the tissues.

**For the work, you need:** a frog, gauze napkins, tools for dissecting, a tablet for dissecting, a Petri dish, galvanic tweezers, a 0.6% solution of sodium chloride.

**Progress of work:** Use the frog's rheoscopic foot to work. Dissect the sciatic nerve to the knee joint. Keeping the nerve, cut off the thigh in its lower third. Quickly throw the nerve (holding it by the remains of the spine) on the remaining thigh muscles so that it simultaneously touches the damaged (transverse) and intact (longitudinal) surface of the muscle (Fig. 4.1). The lower leg muscles contract (Fig. 4.2).

## DO NOT WET THE DRUG WITH RINGER'S SOLUTION

Experience is obtained only if the nerve has retained high excitability, and the thigh muscle has just been cut.

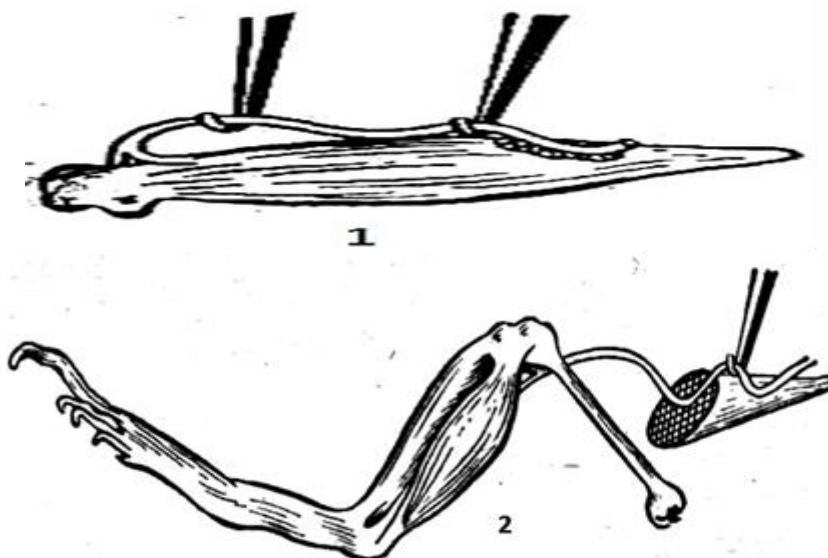


Fig. 4. Neuromuscular preparation - Galvani's second experience

**Results of the work and their design.** Draw a diagram of the experience. Make a conclusion explaining the fundamental difference between Galvani's first and second experience.

### Practical work № 4. Secondary tetanus (the experience of C. Matteucci)

**The purpose of the work:** to make sure that bio-currents (action potentials) occur when the muscle tissue is excited.

**For the work, you need:** a frog, gauze napkins, tools for dissecting, a tablet for dissecting, a Petri dish, galvanic tweezers, an electrical stimulator, fork electrodes, electric wires, and a 0.6% solution of sodium chloride.

**Progress of work:** Two rheoscopic feet are used for operation. Having strengthened the legs in a tripod or placed on a dry glass plate, place the nerve of the second drug longitudinally on the calf muscle of the first leg.

The nerve of the first drug is irritated by a weak, but sufficient (the duration of the current pulse is 1 MS, the frequency of repetition of the pulses is 20-30 pulses per second, the amplitude is 1-2 volts) which causes a distinct contraction of the leg muscles, with a rhythmic current using an electrostimulation (Fig. 5). In this case, the muscles of the second leg also begin to contract.

**Results of the work and their design.** Draw a diagram of the experiment. In the conclusion, explain the occurrence of action currents. Experience is obtained only if the nerve has retained a high excitability.

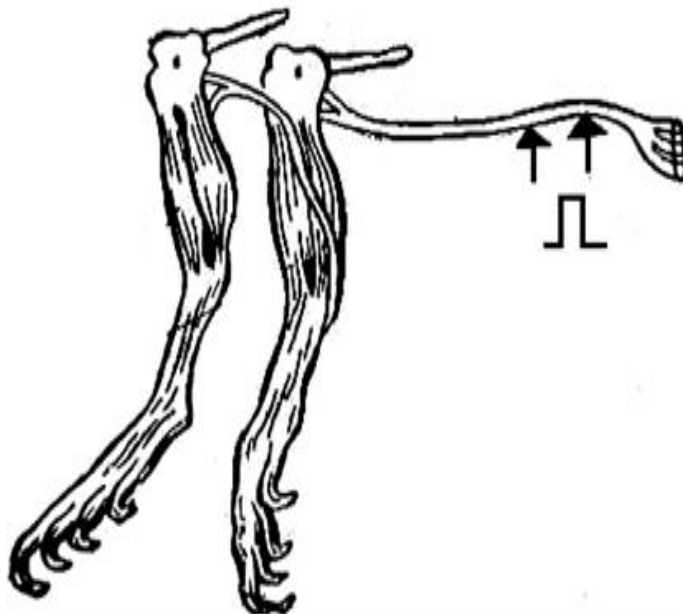


Fig. 5. Scheme of K. Matteucci's experience (secondary tetanus)

**Practical work № 5. Determination of the threshold of excitability of the neuromuscular drug in direct and indirect irritation**

**The purpose of the work:** to explore the concept of "power threshold of irritation", to compare the threshold force of the irritant upon direct irritation of the muscles and stimulation of its motor nerve.

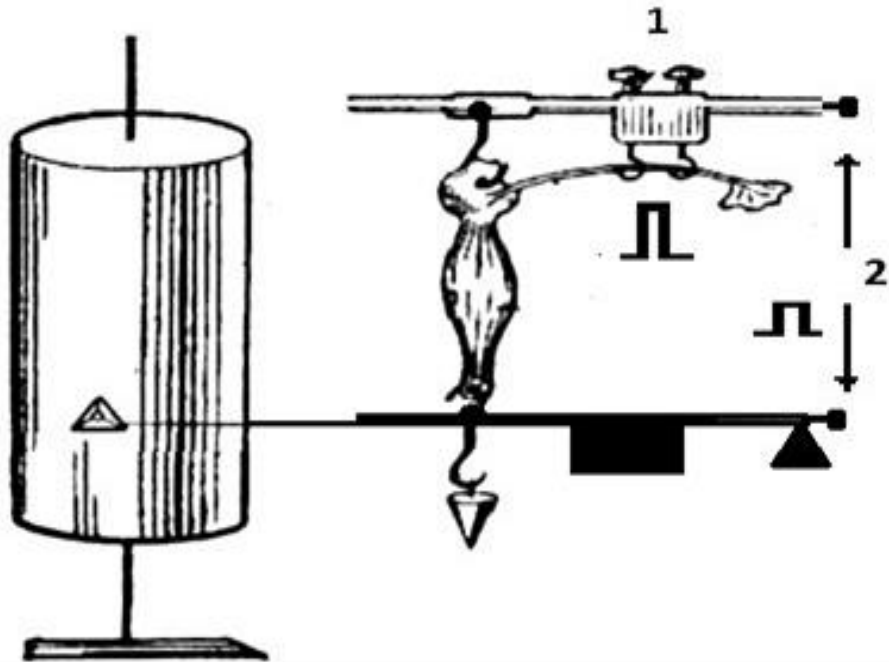
**For the work, you need:** a frog, gauze napkins, tools for dissecting, a tablet for dissecting, a Petri dish, galvanic tweezers, an electrical stimulator, fork electrodes, electric wires, and a 0.6% solution of sodium chloride.

**Progress of work:** Use a neuromuscular preparation for work. The prepared neuromuscular preparation is attached to the femur in the clamp. After piercing the Achilles tendon with a hook, attach it to the writing lever. Place the nerve on a substrate. Carefully, without violating the integrity of the drug, bring the thymus electrodes connected to the terminals of the electrostimulator to the nerve (Fig. 6).



Fig. 6. The neuro-muscular preparation with the femoral bone

For research, you can use the installation diagram shown in Fig. 7.



**Fig. 7. Installation diagram for determining the threshold of excitability of a neuromuscular drug in direct (2) and indirect irritation (1)**

Set the pulse duration adjustment knob to 1 MS, set the pulse frequency knob to 1 pulse per second, and set the pulse amplitude adjustment knob to 0. Turn on the electrical stimulator.

Threshold of excitability of the nerve and muscle (Fig. 7) is determined using the current from the electrical stimulator as an irritant. The amplitude of the stimulator pulses is regulated in three ranges: from 0 to 0.15 V; from 0 to 1.5 V; from 0 to 15 V. this depends on which of the three positions (0.01, 0.1 or 1) the switch of the amplitude range multiplier is.

Determining the excitability threshold should start with the minimum voltage, therefore, put the range switch in the 0.01 position and turn the "amplitude" knob to the right until the muscle begins to contract. If the muscle does not contract even at the extreme right position of the handle, return it to the 0 position, set the range switch to 0.1, and increase the amplitude again to the value at which the muscle first contracts. If there is no effect in this case, set the range selector to position 1 and repeat the definition. Thus, the minimum voltage at which excitation occurs in the nerve will be found.

Then transfer the electrodes to the muscle and in the same way find the excitability threshold for direct irritation of the muscle.

**Results of the work and their design.** Draw a diagram of the experience. Write down the results. In the conclusions, compare the obtained irritation thresholds for the nerve and muscle. What has a higher excitability nerve or muscle? What is the relationship between the thresholds of irritation and excitability?



## LESSON № 2. MUSCLE PHYSIOLOGY

### Control questions on the topic of the lesson

1. Structure of myofibrils.
2. The mechanism of muscle contraction and relaxation.
3. Single muscle contraction and its characteristic.
4. Correlation of action potential phase with phases of excitability change and single contraction cycle.
5. Motor units.
6. Work and muscle strength.

### Practical work № 1. Dependence of the amplitude of muscle contraction on the force of irritation

**The purpose of the work:** to make sure that the amount of contraction of the frog's calf muscle depends on the force of irritation.

**For the work, you need:** frog, gauze, tools, preparation, plate preparation, Petri dish, electroplated tweezers, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.6% sodium chloride solution.

**Progress of work:** Assemble a unit consisting of a kymograph, vertical myograph and an electric stimulator (Fig. 8).

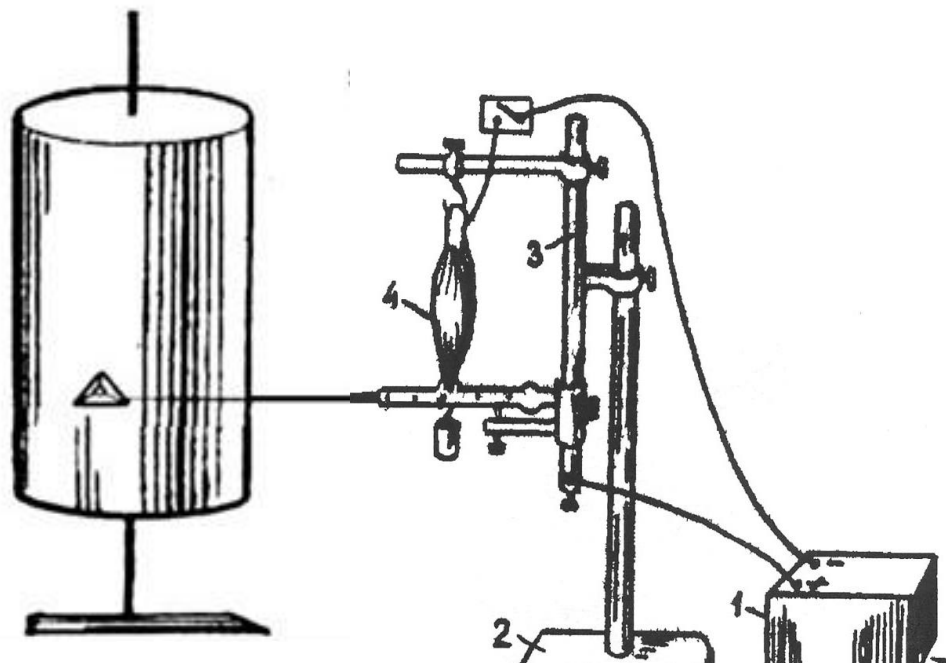


Fig. 8. Setting for recording frog skeletal muscle contractions. 1 - electric stimulator, 2, 3 - vertical myograph, 4 - muscle

Prepare a drug isolated frog calf muscle without sciatic nerve. The muscle is suspended in the vertical myograph and irritate it with pulses of increasing strength, starting from the threshold, each time increasing the value of the pulse amplitude from the threshold by 1 division, turning the stimulator on and off with each new value of the amplitude. Record contractions on the stopped cymograph, turning the drum at each new recording by about 0.5 cm. under each contraction of the muscle, write the value of the voltage in volts at which it is received (Fig. 9).



**Fig. 9. Record the size of the contraction of the frog's calf muscle from the force of irritation**

The reduction in threshold voltage will be minimum, then it increases and at some value of the stimulus (it should be noted) reaches its maximum, i.e. when a further increase in the pulse amplitude will increase the amplitude of contraction.

**Results of the work and their design.** Insert the received myograms into the Protocol. Compare the parameters of the irritating pulses that produce the minimum, average, and maximum amplitude reductions.

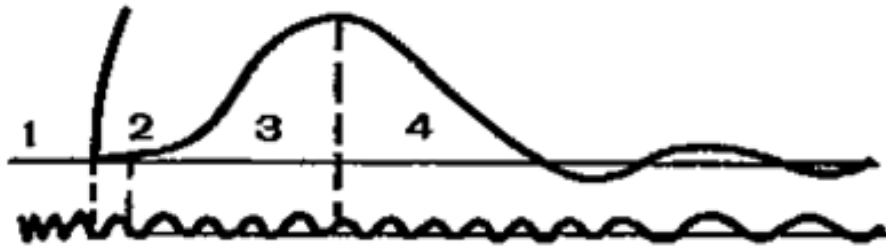
In the conclusions formulate the dependence of the amplitude of contraction of the isolated muscle on the force of irritation ("ladder" dependence). Explain the difference in response to the increasing stimulus of a single muscle fiber and an entire muscle.

### **Practical work № 2. Recording and analyzing a single muscle contraction curve**

**The purpose of the work:** to study the features of the contractile response of the striated muscle to a single stimulus.

**For the work you need:** frog, gauze, tools, preparation, plate preparation, Petri dish, electroplated tweezers, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.6% sodium chloride solution.

**Progress of work:** Prepare a preparation of the frog's calf muscle without a nerve. Strengthen the drug in the myograph. Under the influence of the current shock, the muscle contracts, and the myograph writer draws a detailed curve of muscle contraction on the moving plate (Fig. 10).



**Fig. 10. Single muscle contraction Curve**

1-contact closing time, 2-latency period, 3-shortening phase, 4-relaxation phase

**Results of the work and their design.** Draw the resulting curves.

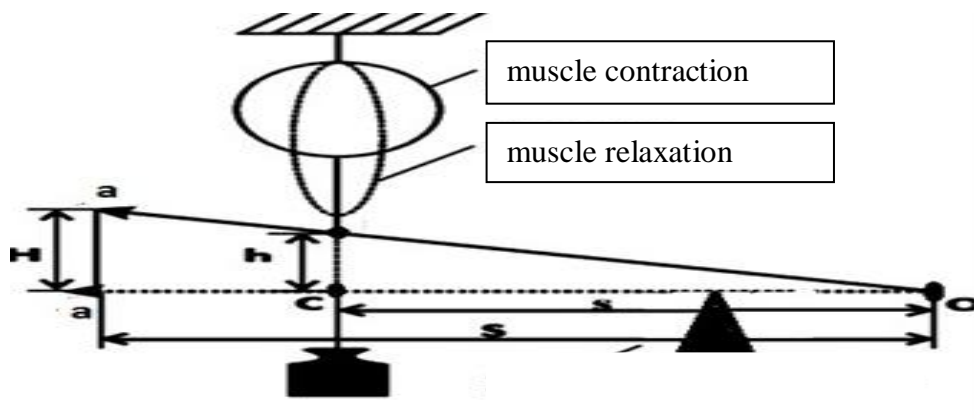
In the conclusions, describe the conditions under which a single muscle contraction develops. What processes occur in the muscle in different phases of contraction (from the point of view of the theory of muscle contraction)?

**Practical work № 3. Work of the muscles. Dependence of the amount of work on the load**

**The purpose of the work:** to establish the dependence of the amount of muscle work on the amount of load. Pay attention to the average load rule.

**For the work you need:** frog, gauze, tools, preparation, plate preparation, Petri dish, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.6% sodium chloride solution.

**Progress of work:** Reducing and lifting the load, the muscle performs a certain work, which can be calculated by knowing the weight of the load and the amplitude of muscle contraction by the formula:  $A = P \times h$ . The Work is expressed in kg / m or g / cm; where P is the weight of the load, h is the value of shortening the muscle **Fig. 11**.  $h = (H \times s) / S$ , where H is the height of Piscina in cm and record on the drum kymograph; S – length of Piscina from the point of rotation (O) until the end of Piscina (a); s is the length of Piscina from the point of rotation (O) to the point of attachment of the muscle and the load (S).



**Fig.11 Diagram of the study of the amount of muscle work dependence on the amount of load**

The dependence of the amount of muscle activity on the amount of load can be experimentally proved and expressed in the form of a graph. To assemble the system for the registration of muscle contraction (Fig. 8).

Suspend various loads directly under the muscle to the lever (10, 20, 50, 100, 200, 300, 400g), each time causing irritation to the muscle using an electrical stimulator. Record the height of the muscle contraction on the drum of the stopped kymograph.

**Results of the work and their design.** Calculate the work performed by the muscle and plot the dependence of the amount of work on the amount of loads, marking the load on the abscissa axis, and the work on the ordinate axis (g / cm).

In the conclusion formulate the rule of average loads and average rhythms of Ukhtomsky.

#### **Practical work № 4. Dynamometry. Study of maximum muscle effort and strength endurance of the hand muscles**

**The purpose of the work:** to master the method of studying the maximum muscle effort and strength endurance of the hand muscles.

**For the work you need:** a hand dynamometer.

**Progress of work:** The subject in the standing position withdraws the outstretched arm with a dynamometer (Fig. 12) to the side at right angles to the body.



**Fig. 12. Hand dynamometer DC0100**

The second free hand is lowered and relaxed. At the signal, the subject performs the maximum force on the dynamometer twice. Muscle strength is evaluated by the best result. Then the subject performs the maximum effort 10 times with a frequency of once every 5 seconds. The results are recorded and determine the performance of the muscles according to the formula:

$$P = (F1 + F2 + FZ + \dots + Fb) / b, \text{ where}$$

P-health level;

F1-Fb-dynamometer indicators for individual muscle efforts;

b - the number of attempts.

These results are used to determine the index of decreased muscle performance according to the formula:

$S = [(F1 - Fmin) / Pmax ] \times 100$ , where  
S-indicator of decreased muscle performance;  
F1 - the value of the initial muscle effort;  
Fmin - minimum amount of muscle effort;  
Fmax - the maximum amount of muscle effort.

**The results of the work and design.** Calculate and record in the Protocol the strength, performance level, and rate of decrease in muscle performance based on the results of 10-fold measurements. Build a graph of the decrease in muscle performance: on the abscissa axis, set aside the ordinal numbers of efforts, on the ordinate axis-the dynamometer indicators for each effort. Compare the results of several subjects.

In the conclusion give the concept of strength to the muscle. Note the factors that determine muscle strength.

### LESSON № 3. NERVE MUSCULAR TRANSMISSION

#### Control questions on the topic of the lesson

1. The laws of excitement in the nerves.
2. Nerve-muscular connection - synapse.
3. Structure of electric synapses.
4. Structure of chemical synapses.
5. Potential of the end plate.
6. Optimum and pessimus in neuromuscular preparation.
7. Fatigue in nerve, isolated muscle, neuromuscular structure.

#### **Practical work № 1. Recording the tetanic contraction of skeletal muscle.** **Optimum and pessimum of frequency of irritation in tetanus**

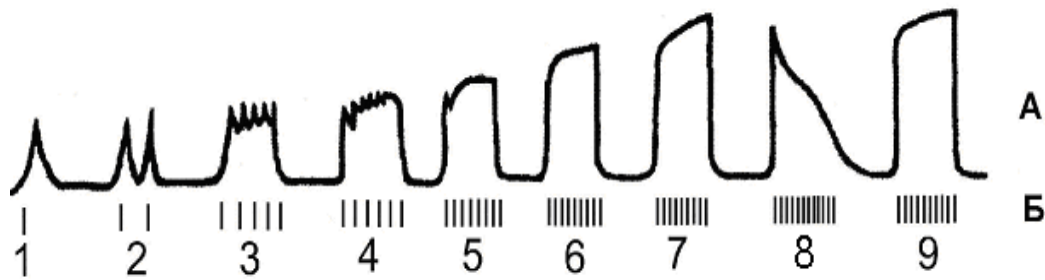
**The purpose of the work:** to record various types of skeletal muscle contractions.

**For the work you need:** frog, gauze, tools, preparation, plate preparation, galvanic tweezers, Petri dish, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.6% sodium chloride solution.

**Progress of work:** a neuromuscular preparation fixed in the myograph is used for work (Fig. 7).

The nerve of the drug is placed on the electrodes from the stimulator. Set the frequency of irritation to 1 Hz, pulse duration to 1 MS. and find the threshold of excitability (smooth rotation of the amplitude knob) for single pulses. Make the current a little more than the threshold, use the cymograph drum and record single muscle contractions. Then increase the frequency of irritation: switch the "frequency" knob by one division each time you make a record. Before increasing the frequency, the stimulator must be turned off every time. Record jagged and smooth tetanus (Fig. 13). Find the optimal frequency of stimulation to which the muscle responds with a smooth tetanus of the highest height-optimum (approximately 40-50 Hz). Record the optimum

for 4-5 seconds, and then dramatically increase the frequency of stimuli to 100 or more Hz and record the pessimum of the frequency. After 5 seconds, reduce the frequency of stimulation to the optimal level and re-record the tetanus (it should be optimal).



**Fig. 13. Recording of muscle contractions when the stimulus acts with a certain frequency**

A-registration of muscle contraction; B-frequency of stimulus action.

1-single muscle contraction; 2-summation of two contractions; 3, 4 - formation of a toothed tetanus; 5, 6-formation of a smooth tetanus; 7, 9-optimum; 8 – pessimum.

**Results and their design.** Paste the resulting curves into the Protocol. Note: single muscle contraction, jagged, smooth tetanus, optimum and pessimum of the frequency of stimulation, as well as the frequency of stimuli at which they are received.

The conclusions explain the mechanisms of various types of skeletal muscle contractions. Analyze the conditions for the transition of the muscle from the optimum state to the pessimum state. Note that the pessimum is not an expression of muscle fatigue, but reflects the development of the block of excitation in the synapse or presynaptic terminals.

## **Practical work № 2. Localization of fatigue in the neuromuscular preparation**

**The purpose of the work:** to determine the localization of fatigue in the neuromuscular preparation.

**For the work you need:** frog, gauze, tools, preparation, plate preparation, Petri dish, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.6% sodium chloride solution.

**Progress of work:** Use a neuromuscular preparation for work. Strengthen it in the clamp and connect it to the myograph (Fig. 7). By suspending a small load (100g) on the shoulder of the lever, irritate the nerve (indirect muscle irritation) with single stimuli with a current strength sufficient to contract the muscle until complete fatigue occurs (the muscle does not respond to the irritation). Then transfer the electrodes to the muscle and produce direct irritation. In this case, the muscle begins to contract.

**Results of the work and their design.** Paste the fatigue curve into the report. Indicate reduction in direct and indirect irritation.

In the conclusion indicate signs of fatigue. Note where fatigue is localized. Explain the causes of fatigue.

### Practical work № 3. Parabiosis and its phases

**The purpose of the work:** to reproduce the phenomenon of parabiosis, to investigate the regularity of its development.

**For the work you need:** frog, gauze, tools, preparation, plate preparation, Petri dish, electrostimulator, electric wires, kymograph, vertical myograph, pens, ink, 0.1% procaine, 0.6% sodium chloride solution.

**Progress of work:** Use a neuromuscular preparation for work. Assemble the device for registering muscle contractions (Fig. 7). By irritating the nerve with rhythmic pulses of threshold, average, and maximum strength, record myograms corresponding to each stimulus force.

To create a parabiotic focus, apply cotton wool soaked with 0.1% novocaine to the nerve area (below the location of the electrodes). Every 2-3 minutes (starting from the moment the substance is applied to the nerve, and then throughout the entire experiment), check the nature of muscle contractions, irritating the nerve with threshold, average and maximum stimuli. In the course of the experiment, it is necessary to catch the moment of the onset of the equalizing, paradoxical and inhibitory phases of parabiosis and record myograms for all three types of irritation. Usually, the signs of development of parabiosis appear after 8-10 min.

**Results of the work and its design.** Paste the myograms obtained in the experiment into the Protocol. Record the time of onset of the first and subsequent phases of parabiosis.

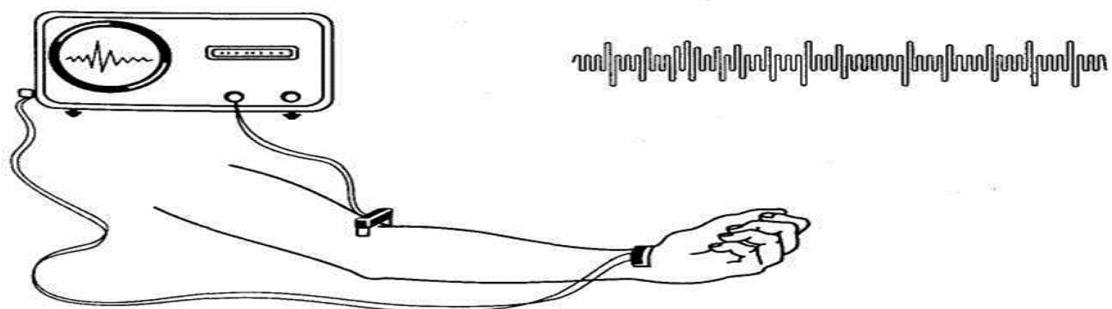
In the conclusion give the concept of parabiosis. Describe the mechanisms of occurrence of the equalizing, paradoxical, and inhibitory phases of parabiosis.

### Practical work № 4. Electromyography

**The purpose of the work:** to study the functional state of skeletal muscles and peripheral nerve endings using electromyography.

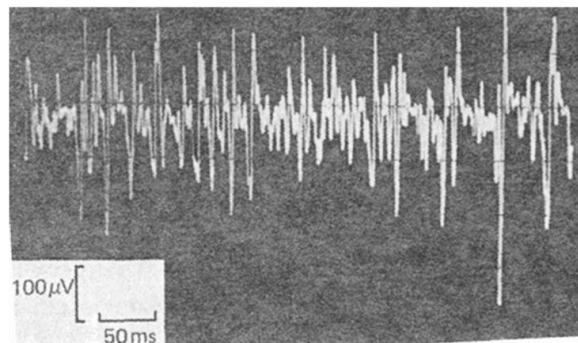
**For the work you need:** "Axion" electrocardiograph, conductive gel, alcohol, cotton wool, electrodes, hand dynamometer.

**Progress of work:** On the distal parts of the test subject's forearms, the skin is degreased with a cotton swab moistened with alcohol. Then a conductive gel is applied to these places and the red and yellow electrodes (I – lead electrodes) are applied to the right hand, and the black (earth) is applied to the left hand of the "axion" electrocardiograph (Fig. 14).



**Fig. 14. The arrangement of electrodes**

On the cardiograph, set the I-th lead, filter F, recording speed 25 mm / s, and the amplitude is 10 mm-1 millivolt. Then we ask person to use the dynamometer to compress the brush 10, 20, 30 kg, while recording the myogram (Fig. 15).



**Fig. 15. Recording a normal electromyogram**

Then repeat the manipulations for the left hand, placing the red and yellow electrodes (I – lead electrodes) on the left hand, and the black (ground) on the right hand. Normally, the maximum amplitude for 30 kg should be about 1 mV. The reduction of oscillations can be observed in the primary pathologies: scoliosis, or progressive degeneration of muscle tissue.

The reduction of oscillations is typical for total damage to the peripheral nervous system. Their complete absence indicates massive destruction of nerve fibers.

Spontaneous activity ("palisade rhythm") is registered in hereditary pathology of spinal cord neurons.

Myotonic syndromes (too slow muscle relaxation after contraction) are manifested by high-frequency bioactivity, and myasthenic ones (muscle weakness, increased muscle fatigue) - by an increasing decrease in oscillations.

In parkinsonism, there are periodic bursts of activity, so-called "volleys", the frequency and duration of which depend on the localization of the pathological focus.

After the end of the recording, remove the electrodes and remove the remnants of the conductive gel with cotton soaked in alcohol.

**The results of the work and design.** Attach the resulting myogram to the report, then make an analysis of it, calculating the maximum amplitude and frequency for 1 second. Conclude.



## TOPIC 3. PHYSIOLOGY OF THE NERVOUS SYSTEM

### LESSON № 1. REFLEX AND REFLEX ARC

#### Control questions on the topic of the lesson

1. The concept of reflex. Classification of reflexes. The main components of the reflexive arc.
2. Physiological properties and functions of neurons.
3. Reflex time, factors influencing the reflex time. Receptive field of reflex.
4. Somatic reflexes.
5. Autonomic Nervous System.
6. Structure plan and basic physiological properties of the Autonomic Nervous System.

#### Practical work № 1. Analysis of reflex arc

A reflex is a response of the body to irritation, which is carried out with the participation of the central nervous system. The structural and functional basis of the reflex is the reflex arc. The reflex arc consists of five links: the receptor, the afferent pathway, the central nervous system, the efferent pathway, and the effector. A reflex reaction can only be carried out if all the links in the reflex arc are intact. If at least one of them is violated, a reflex reaction is impossible.

**The purpose of the work:** To establish the role of each section of the reflex arc in the occurrence of the reflex. Prove the need for the integrity of all links reflex arc in the implementation of a reflex reaction.

**For the work you need:** a tripod with a clip and a stopper, a glass of water, a set of tools for dissecting, 0.5% sulfuric acid solution, 0.1% novocaine solution, filter paper, a frog.

**Progress of work:** Prepare a spinal frog, i.e. a frog with a destroyed brain and preserved spinal cord (Fig. 16A). Hang it on a tripod, pinning the lower jaw to the hook in the cork, clamped in the holder (Fig.16B).

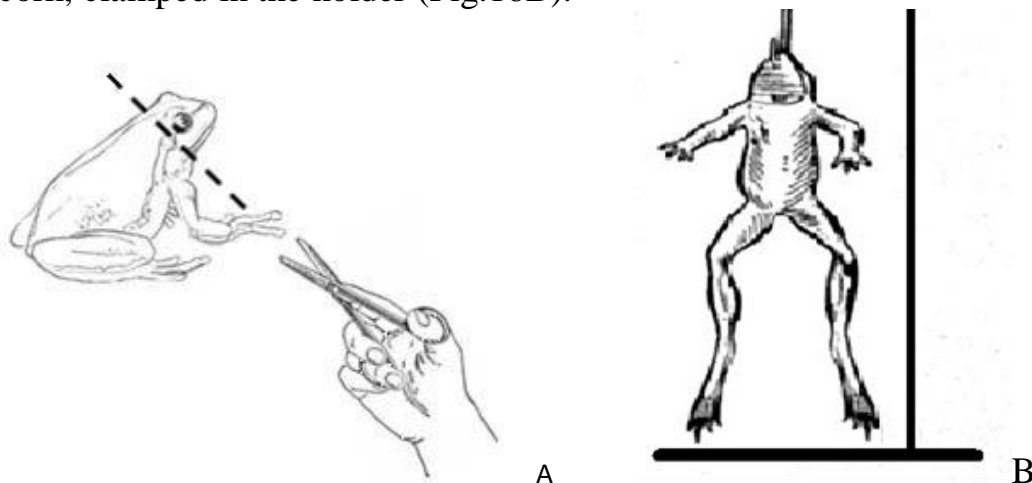


Fig. 16. Dorsal (decapitated) frog fixed in a tripod

On the right foot along the thigh, the sciatic nerve is dissected and a ligature is placed under it. Carefully pinch the skin of the foot with tweezers.

If the frog responds to the irritation, do the following:

1. Establish the role of the receptor in the implementation of a reflex reaction, for which:

A. Put a piece of filter paper moistened with 0.5% sulfuric acid solution on the skin of the lower leg of the right foot. Note the reflex response to irritation of the skin. After each irritation, the acid is washed off in a glass of water;

B. On the lower leg of the same foot, a piece of skin is cut out. A filter paper moistened with acid is carefully placed on the exposed area of the muscle. Making sure that the acid does not get on the skin. Skin receptors are removed-there is no reaction. The absence of a reflex reaction is explained by the fact that muscle receptors, unlike skin receptors, do not respond to a weak acid solution.

2. Establish the role of the afferent pathway, for what:

A. wash off the acid from the muscle, check the preservation of the reflex reaction to skin irritation;

B. observe a reflex reaction of the same (right) foot (with a prepared sciatic nerve) when lowering the fingertips into acid. There is a good motor reaction;

B. Carefully lifting the prepared nerve, put cotton wool under it, moistened with novocaine, which violates the nerve's conductivity, and first the afferent fibers are turned off, and then the efferent ones.

After applying novocaine to the nerve, the presence of a reflex reaction to the irritation of the foot with acid is checked every minute. The disappearance of the reflex reaction indicates the loss of conductivity of afferent fibers.

3. Establish the role of the efferent pathway, for what:

A. immediately after the reflex disappears, when the right foot is irritated, the left foot is irritated and the right foot responds. Then a piece of paper moistened with acid is applied to the skin of the back. Note that in both cases, two legs participate in the reflex reaction. This suggests that the conductivity of the motor fibers of the right foot is still preserved. Remove the acid from the skin of the back with a cotton swab dipped in water;

B. continue to observe, noting the moment of disappearance of the reflex reaction of the right foot.

4. Establish the role of the central nervous system, for what:

A. Irritate the left paw with acid or tweezers and observe a reflex response;

B. Destroy the spinal cord and observe the complete disappearance of reflex reactions.

**Results of the work and their design.** Analyzing the experiment, they provide evidence of participation in the reflex reaction of all the links of the reflex arc. Draw a diagram of the reflex arc.

## **Practical work № 2. Receptive field of the reflex**

A receptive field is a part of the skin (or any other part of the body) that produces a certain reflex when irritated.

**The purpose of the work:** To investigate the occurrence of certain reflexes when irritating certain receptive fields.

**For the work you need:** a frog, a tripod with a clip and a cork, a glass of water, a set of tools for dissecting, a 0.5% solution of sulfuric acid, filter paper, a neurological hammer.

**Progress of work:** Prepare a spinal frog (i.e. a frog with a destroyed head and preserved spinal cord), hang it on a tripod, pinning the jaw to a hook in a cork clamped in the holder (Fig. 16). Waiting for the frog to go through shock.

Spinal reflexes are examined when various receptive fields of the frog's skin are irritated.

The flexion reflex of the hind limb occurs when the back surface of the foot or lower leg is irritated (by squeezing with tweezers or applying a filter paper moistened with sulfuric acid).

The posterior limb extension reflex occurs when the plantar surface of the foot or lower leg is irritated. If the sole is slightly irritated with tweezers or a brush, only the toes of the foot are unbent.

A protective reflex. Apply a piece of filter paper moistened with 0.5 % sulfuric acid solution to the outer surface of the thigh. There is a protective reflex of dropping a piece of paper with a paw that is irritated. Repeat the experiment on the other foot. Then place the filter paper on the lower part of the stomach or on the back of the frog. The frog drops it with both legs. Intervals between irritations should be at least 2-3 minutes, after setting each of the experiments, the frog should be washed with water to remove the acid solution from the skin surface.

To determine the location of the receptive field of the croaking reflex, take an intact male frog with two fingers behind the back. In response to mechanical irritation of the skin of the back, a croaking reflex occurs.

The rubbing reflex occurs when different areas of the skin are irritated. If a filter paper moistened with a solution of sulfuric acid applied to the outer surface of the thigh or near the anal opening, a rubbing reflex of the hind limbs occurs. With the same irritation of the side of the torso, a rubbing reflex occurs of the limb closest to which the irritation is located. The rubbing reflex of the forelimbs occurs when the skin of the abdominal surface of the body is irritated between the legs.

Explain the observed phenomena. The results of experiments and conclusions are recorded in a notebook.

**The results of the work and design.** The results are recorded in a notebook.

## **Practical work № 3. Determining the reflex time. The ratio between the force of the stimulus and the time of the reflex**

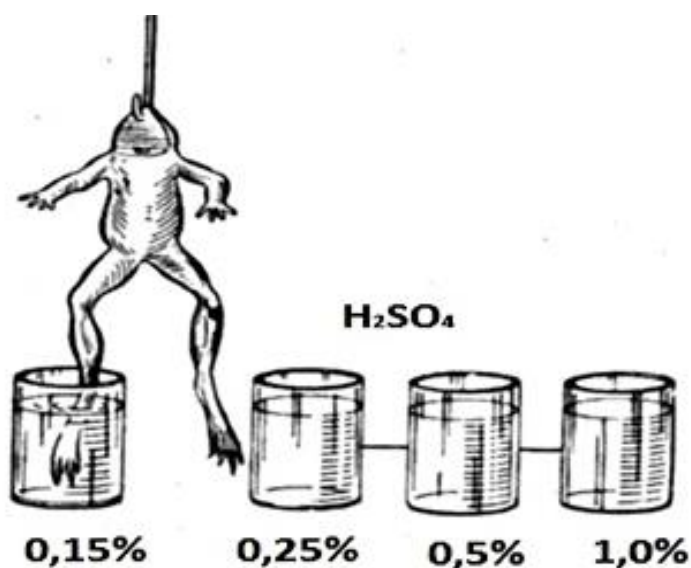
Reflex time is the time from the moment of irritation to the appearance of a response. The central time of the reflex is called the time of excitation in the central

nervous system. It is a more complex reflex (the more intermediate neurons are involved in its implementation, the more synaptic switching occurs). The time of the reflex depends on the strength of the stimulus.

**The purpose of the work:** to establish the dependence of the reflex time on the strength of the stimulus.

**For the work you need:** a tripod with a clip and a stopper, a set of tools for dissecting, a stopwatch, a glass of water, 0.1%, 0.3%, 0.5% solutions of sulfuric acid, a frog.

**Progress of work:** Prepare a spinal frog and hang it on a tripod. Use a stopwatch, setting it to a frequency of 60 beats per minute. Immerse the fingertips of one of the frog's legs in a Cup with 0.1% hydrochloric acid solution and count the time from the moment the foot is immersed in acid until a response to irritation occurs (Fig.17).



**Fig. 17. Determining the reflex time of a frog (by Turk)**

Thus, the reflex time is determined in seconds. Repeat the determination of the reflex time 2-3 times, after each irritation, do not forget to wash the foot with water. Repeated determination is carried out in 2-3 minutes. consider the average reflex time.

Establish a relationship between the strength of the stimulus and the time of the reflex. To do this, determine the average time of the reflex, using as an irritant solutions of sulfuric acid of a higher concentration- 0.3%, 0.5%. Determining the time of the reflex, immerse the same foot in acid to a certain level. The received data is put in the table.

**Results of the work and their design.** Draw a diagram of the experience. Record the reflex time for different stimulus strengths. Draw up the conclusion.

#### **Practical work № 4. Surface sensitivity research**

**The purpose of the work:** study of tactile sensitivity.

**For the work you need:** a set of weights of different weights.

**Progress of work:** For the study of tactile sensitivity, a set of weights of different weights are alternately superimposed on the same place of the subject. The person is asked which weight is heavier, and find out the smallest discernible difference. Then calculate how much of the larger weight is the difference (or more simply, how many percent).

In a healthy person, depending on the area of the body, this difference ranges from 1/40 to 1/10 (2.5-10 %) and even higher.

If this difference increases significantly, we can talk about a decrease in tactile sensitivity, about tactile hypesthesia. Hypersensitivity indicates tactile hyperesthesia.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion about tactile sensitivity.

### **Practical work № 5. The study of skin and autonomic reflexes**

**The purpose of the work:** to study the functional state of the sympathetic and parasympathetic parts of the autonomic nervous system by studying the skin-vegetative reflexes.

**For the work you need:** spatula, neurological hammer.

#### **1. Research of local dermography.**

**Progress of work:** Using a blunt object (a spatula, a handle of a neurological hammer), stroke irritation of the skin is carried out, and it is necessary to dose the strength of the irritation, taking into account the duration of the latent period of the reaction, its severity and duration. After 5-20 seconds, a white stripe (white dermographism) or a red stripe (red dermographism) appears in the area of irritation. The white stripe disappears after 8-12 seconds, and the red stripe disappears after 3 minutes. An intensely pronounced and long-lasting white stripe indicates increased activity of the sympathetic part of the autonomic nervous system. A pronounced and long-lasting red stripe is a sign of an increased parasympathetic reaction, and if a broad red stripe appears with a white edematous roller and a red border in the middle (towering dermographism), this also indicates a high permeability of the vascular wall.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations.

#### **2. Pilomotor reflex.**

**Progress of work:** This reflex is most clearly manifested when the back of the neck is irritated by rapid cooling (a piece of ice, cold water) or mechanical action (tingling of the skin, friction). In response, there is a reaction in the form of «goose bumps» in the area of irritation or throughout the irritated half of the body, associated with the contraction of the hair muscles. This reflex is spinal, i.e. the nerve center of this reflex is located in the spinal cord. In pathological cases, when the skin area is irritated below the level of the affected segment of the spinal cord, the pilomotor reflex, spreading upwards, reaches only the border of the pathological focus.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

### **Practical work № 6. Study of tendon reflexes**

**The purpose of the work:** to master the method of studying the simplest spinal reflexes and analyze the mechanisms of their occurrence.

**For the work you need:** neurological hammer.

#### **1. Knee reflex.**

**Progress of work:** A neurological hammer is struck on the tendon of the quadriceps (below the kneecap) - the lower leg is unbent. The muscles of the examined limb should be relaxed.

Compare the reflexes of both limbs. If the knee reflex is weakened, then the subject should firmly interlock the fingers of both hands, strongly stretch them to the sides. In this case, the knee reflex will significantly increase – the inhibitory effects of the cortex on the motor centers of the spinal cord are removed.

The reflex arc of the knee reflex passes at the level of three spinal segments: 2-o, 3-o, 4-o lumbar, with the main role played by the 4th lumbar segment.

#### **2. Achilles reflex.**

**Progress of work:** irritation of the achilles tendon causes contraction of the calf muscle. The person kneels on the table, and with a neurological hammer, the examiner deals a light blow to the achilles tendon of the calf muscle in the lower third (at the heel bone). There is a reflex extensor movement of the foot, which occurs due to the contraction of the triceps muscle of the lower leg.

Compare the reflexes on both legs.

The arch of the achilles reflex passes through the first and second sacral segments, and the main role belongs to the first sacral segment.

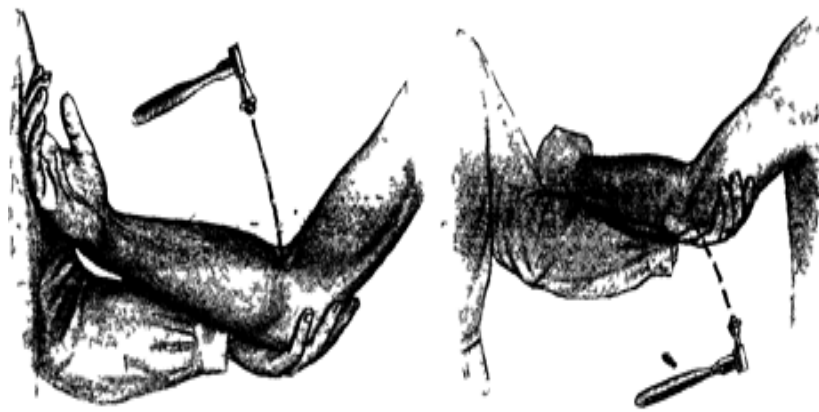
The achilles reflex is also one of the most permanent. It is similar to the knee reflex that every healthy person has, and its absence should be considered a pathological phenomenon.

In the protocol, draw and describe the reflex arcs of proprioceptive reflexes (knee and achilles), noting their features. Specify in which segments of the spinal cord the centers of these reflexes are located.

**3. The reflex of the biceps muscle** consists in the contraction of this muscle from a blow to its tendon (Fig. 18).

**Progress of work:** Supporting the elbow of the person's hand with the left hand, the right hand is struck with a neurological hammer on the tendon of the biceps muscle – the forearm is bent.

Its reflex arc passes through the fifth and sixth cervical segments.



**Fig. 18. Biceps (left) and triceps (right) reflexes**

4. The reflex of the triceps consists in the contraction of this muscle from a blow to its tendon (Fig.18).

**Progress of work:** Strike a neurological hammer on the tendon of the triceps muscle, the forearm is unbent.

The reflex arc passes through the sixth and seventh cervical segments.

**Results of the work and their design.** Specify in which segments of the spinal cord the centers of these reflexes are located.

### **Practical work № 7. Study of visceral reflexes**

#### 1. Cold test

**The purpose of the work:** to study the reflex response to a thermal stimulus

**For the work you need:** a bath of cold water, the blood pressure monitor.

**Progress of work:** the hand of the subject is immersed in cold water (from the tap). At this time, blood pressure is measured on the other hand:

1. before diving;
2. immediately after the dive;
3. after 1-2-3-5 min.

Normal systolic pressure is increased to 15-25 mm of mercury.art. with sympathicotonia, the pressure increases by more than 25 mmHg. st.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

#### 2. Goering's Reflex

**The purpose of the work:** to study some features of cardio-respiratory synchronism.

**Progress of work:** The student-subject, who is in a sitting position, counts the pulse. Then another research student asks him to take a deep breath and hold it. At this time, the pulse is counted again. Normally, there is a slowing of the pulse by 4-6 beats / min. with vagotonia, there is a slowing of the pulse by 8-10 beats / min or more.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion, explain the phenomenon of vagotonia.

## LESSON № 2. CENTRAL NERVOUS SYSTEM INTEGRATION PROCESSES

### Control questions on the topic of the lesson

1. Excitation in the central nervous system.
2. Inhibition in the central nervous system.
3. Central nervous system summation and irradiation.
4. Structure and functions of the spinal cord.
5. Functions of the posterior brain.
6. Functions of the middle brain.
7. Cerebellar functions.
8. Functions of the intermediate brain.
9. Functions of subcortical nuclei.

### Practical work № 1. The phenomenon of summation in nerve centers

**The purpose of the work:** to observe the phenomenon of summation of excitation in the frog's spinal cord.

**For the work you need:** electric stimulator, wires with bare ends, a tripod with a clip and a cork, a glass of water, a set of tools for dissecting, 0.5% sulfuric acid solution, 0.1% novocaine solution, filter paper, a frog.

**Progress of work:** Prepare a spinal frog and to suspend her for the bottom jaw on a hook of the tripod. On the skin of the thigh, apply a piece of filter paper moistened with a weak solution of sulfuric acid of sub-threshold concentration (Fig.19).

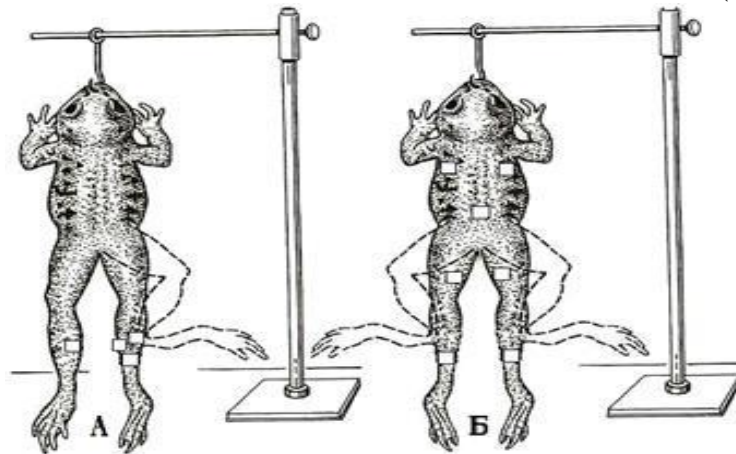


Fig. 19. Spatial summation

Then, on the receptive field of the same reflex, sequentially, at intervals of 10-15 seconds, apply the second, third, and so on filter papers moistened with the same acid solution until the corresponding reflex appears.

**Results of the work and their design.** Draw up the results and conclusions.

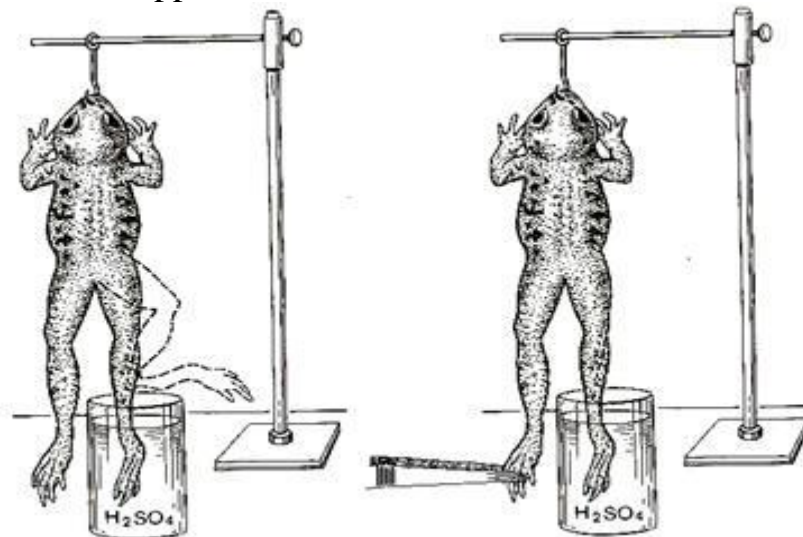
### Practical work № 2. Mutual inhibition of spinal reflexes



**The purpose of the work:** to make sure that one of the conditions for the occurrence of inhibition of spinal reflexes is the simultaneous stimulation of two different receptive fields.

**For the work you need:** a frog, a set of tools for dissecting, a metronome, a tripod with a clip and a stopper, a Hoffman clip, 0.3% solution of sulfuric acid, a glass of water.

**Progress of work:** The experiment is carried out on a spinal frog, which is suspended by the lower jaw on a tripod hook. Immerse the frog's foot in a 0.5% solution of sulfuric acid, determine the time of the flexion reflex. Repeat the experiment 2-3 times at intervals of 15-20s. then simultaneously with the immersion of the foot in acid, squeeze the other foot with tweezers. In this case, the flexor reflex to acid irritation is either absent, or its time is dramatically lengthened (Fig. 20). If you stop strong mechanical irritation of the opposite foot, the reflex to acid is restored.



**Fig. 20. Mutual inhibition of spinal reflexes**

<https://www.ok-t.ru/studopediaru/baza12/148650893311.files/image018.jpg>

Instead of squeezing the foot with tweezers, you can tie it tightly with a strong thick thread.

**Results of the work and their design.** Draw up the results and the conclusion.

### **Practical work № 3. Irradiation of excitation in nerve centers**

The process of arousal that occurs in the Central nervous system radiates (spreads). The irradiation of excitation depends on the strength and duration of the stimulus; with increasing strength and duration of the stimulus, the irradiation of excitation increases. Outwardly, this is expressed in the fact that new muscle groups are involved in the response and the movement increases. If the force or duration of the irritation is excessive, braking may occur.

**The purpose of the work:** to observe the irradiation of excitation depending on the strength of mechanical stimulation.

**For the work you need:** a frog, a set of tools for dissecting, a tripod with a clip and a cork, 0,3% sulfuric acid solution, a glass of water, filter paper.

**Progress of work:** Prepare a spinal frog and to suspend her for the bottom jaw on a hook of the tripod. Apply a mild irritation (for example, squeeze with tweezers) to the hind leg in the receptive field of the flexor reflex. There is a local reflex. Produce repeated, more severe irritation of the foot. This will cause flexion not only in the ankle, but also in the knee and hip joints. With a further increase in the force of irritation, the movement of the opposite hind leg will appear, then - in the IPSI-and contralateral front legs of the frog.

**Results of the work and their design.** Draw up the results and the conclusion.

#### **Practical work № 4. The dominant principle**

**The purpose of the work:** to study the most important properties of the dominant in its natural manifestation.

**For the work you need:** a frog, a set of tools for dissecting, a tripod with a clip and a cork.

**Progress of work:** Hang an intact frog on a tripod hook by the lower jaw. Observe the movement of the frog, aimed at releasing the hook (reflex removal from the hook). As soon as the frog calms down, apply mechanical irritation to various areas of the skin. Each time, in response to the stimulus, there are movements aimed at releasing the hook, regardless of the reflexogenic zone on which the irritation is applied. This experience was first described by A. A. Ukhtomsky. An example of a dominant is the grasping reflex in spring male frogs (during spawning). Stroke the male frog's chest with your finger. With its front paws, it will grip your finger so tightly that it can hang on it. At this time, apply mechanical irritation to the skin of one of the hind legs (for example, with tweezers). Note that it is not the flexor reflex of the corresponding foot that will occur, but the strengthening of the grasping reflex.

**Results of the work and their design.** Draw up the results and the conclusion.

#### **Practical work № 5. Study of the simplest reflexes implemented by certain cranial nerves in humans**

**The purpose of the work:** to master the method of studying the cranial reflexes in humans.

**For the work you need:** rubber bulb, reflex hammer

##### **1. Study of the labial reflex.**

**Progress of work:** Carry out beating in the area of the circular muscle of the mouth. There is a contraction of this muscle, leading to the extension of the lips in the form of a groove (V-VII pair of cranial nerves).

##### **2. Study of the conjunctival reflex.**

**Progress of work:** From a rubber pear, a stream of air is directed to the sclera, while there is a closing of the eye gap. The sensitive core of this reflex is the V, motor VII pair of cranial nerves.

3. Study of the auditory-blinking reflex.

**Progress of work:** Suddenly clap your hands behind the subject's back. In this case, there is a closing of the eyelids. This reflex is carried out by the nuclei of the auditory and facial nerves.

4. Study of the brow reflex.

**Progress of work:** Use a neurological hammer to perform tapping on the inner edge of the brow arch. In this case, there is a closing of the eyelids. This reflex is carried out by the nuclei of the trigeminal and facial nerves.

5. The study of the naso-ciliary reflex.

**Progress of work:** Use a neurological hammer to perform light tapping on the tip of the nose. This marks the closing of the eyelids. For this reflex, the V pair of cranial nerves is sensitive, and the motor pair is the VII pair of cranial nerves.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

**Practical work № 6. The study of extrapyramidal (striopallidary) system**

**The purpose of the work:** to determine the status of striopallidarnoy system.

**Carrying out the work does not require the use of equipment and tools.**

a) A symptom of excessive flexion of the arm.

**Progress of work:** Passive flexion of the student's arm in the elbow joint is performed. Normally, the forearm fits loosely to the shoulder, with the defeat of the striopallidar system, the forearm is tightly, throughout, adjacent to the shoulder;

b) A symptom of a falling hand.

**Progress of work:** The student-subject stretches out his hands, resting his palms on the palms of the student-researcher, the muscles of the test subject's hands are relaxed. The research student suddenly and abruptly removes his hands. In the normal subject occurs a reflex saving initial position of outstretched arms, in disease striopallidarnoy system hands falling fast;

c) A symptom of a flabby hand.

**Progress of work:** The student's hands are freely lowered. Take one of the hands by the shoulder and shake it sharply without warning. In this case, if there are violations of the functions of the striopallidar system, there is a "dangling" movement of the forearm and hand. Normally, this does not happen due to an instant increase in muscle tone of the hand;

d) Gordon's Symptom.

**Progress of work:** The student-subject is called knee reflex tapping on the tendon of the quadriceps femur. Normally, the lower leg immediately assumes its former flexor position after extension. In pathology of the striopallidar system, the quadriceps femur is in a state of tonic contraction for some time, which causes the tibia to stiffen in the extensor phase of the knee reflex.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

## **Practical work № 7. Study of the state of cerebellar functions in humans**

**The purpose of the work:** to master the method of research of some reflexes that allow detecting cerebellar lesions.

**Carrying out the work does not require the use of equipment and tools.**

a) the Romberg sample.

**Progress of work:** The student-subject becomes in the Romberg pose: standing, hands lowered, socks and heels of the feet shifted. In cerebellar pathology, there is a swaying of the torso, which increases if: a) the subject stretches his hands forward; b) closes his eyes; C) puts one foot in front of the other (in one line); d) stands on one leg; e) stands up on his toes. Normally, all this is not observed. With gross violations, the subject cannot stand even with his legs wide apart.

b) Finger-nose test.

**Progress of work:** The person is asked to move his hand to the side, and then touch the tip of the nose with his index finger (the test is performed alternately with the right and left hands with open and closed eyes). Normally, the person gets a finger exactly into the tip of the nose. On the side of the lesion of the cerebellum, there is a miss, sometimes combined with trembling of the hand and finger, which increases as the finger approaches the nose, especially when performing the test with closed eyes.

c) Heel-knee test.

**Progress of work:** The person is asked to slide the heel of one foot down the Shin from the knee to the foot of the other foot, and then up to the knee. When the cerebellum is affected, the heel jumps off the knee and tibia on the affected side.

d) Test mimoradna.

**Progress of work:** The person is asked to get the finger of an outstretched hand into the stationary finger of the researcher (the test is performed with open and closed eyes in the horizontal and vertical planes). When lesions of the cerebellum on the side of the injury, there is a miss.

e) Diadochokinesis.

**Progress of work:** The person is asked to stretch out his hands with spread fingers and perform opposite (supinator and pronation) movements at a rapid pace. When the cerebellum is affected, the movements are awkward, sweeping, and more pronounced on the side of the injury.

f) Investigation of gait.

**Progress of work:** The person is asked to walk in the same line forward and back, as well as to the sides (flanking gait). When the cerebellum is affected, there are signs of a "drunken gait": the person walks with his legs wide apart, staggering in different directions, and the flank gait is sharply disturbed.

g) Test for asynergia.

**Progress of work:** The researcher and the subject face each other at arm's length. The researcher holds his hands (palms forward) in front of him at the level of the shoulder girdle of the subject, who, with his hands, as it were, leans on the examiner, i.e., transfers a small part of his weight to him, sufficient to maintain balance. When

the researcher's hands are suddenly removed from the bottom, the subject tries to maintain the balance of the body.

Normally, the subject successfully maintains balance while remaining stationary, or leans back slightly. In a sick person, performing the test leads to an obvious forward tilt of the torso (with or without a step).

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

### LESSON № 3. PSYCHOPHYSIOLOGICAL METHODS OF STUDYING THE PROCESSES OF THE CENTRAL NERVOUS SYSTEM

#### Control questions on the topic of the lesson

1. Structural and functional organization of the crust of large hemispheres.
2. Characterization of cortical fields (functional and cytoarchitectonic).
3. Electrical phenomena in the cortex of large hemispheres.
4. Conditional and unconditional reflexes.

#### Practical work № 1. Tapping test

**The purpose of the work:** to acquaint students with the psychophysiological method of research of power indicators in the activity of the central nervous system.

**For the work you need:** a sheet of white paper, a pencil, a stopwatch.

**Progress of work:**

1. Draw a sheet of white paper into six identical rectangles. The test subject should use a pencil to apply points at the maximum speed in the first square for 10 seconds, then in the second, third, and so on. The total testing time is 60 seconds.

1	2	3
6	5	4

2. Calculate the number of points in each rectangle and create a scale using the following scheme:

Time (s)	Quantity of points
10	

20	
30	
40	
50	
60	

### Processing of results

Processing includes the following procedures:

- 1) count the number of points in each square;
- 2) build a graph of health, for which you can set aside 5-second time intervals on the abscissa axis, and the number of points in each square on the ordinate axis.

The coefficient of strength of the nervous system (CSNS) is calculated using the following formula:

$CSNS = ((x_2 - x_1) + (X_3 - x_1) + (x_4 - x_1) + (X_5 - x_1) + (X_6 - x_1)) : x_1$  and multiply by 100%, where

X1 – sum of taps in the first five-second segment,

X2-sum of taps in the second five-second segment

X3-the sum of taps in the third five-second segment, etc.

**Calculate the coefficient of functional asymmetry** for the health of the left and right hands, getting the total values of the health of the hands by adding all the data for each of the rectangles. The absolute difference in left and right hand performance is divided by the sum of the performance, and then multiplied by 100%:

$KFa = ((\Sigma R - \Sigma L) : (\Sigma R + \Sigma L))$  multiply by 100%, where

$\Sigma R$  - the total sum of points set by the right hand,

$\Sigma L$  - the total sum of points set by the right left

### Analysis and interpretation of results

The strength of nerve processes is an indicator of the performance of nerve cells and the nervous system as a whole. A strong nervous system can withstand a greater load in size and duration than a weak one. The method is based on determining the dynamics of the maximum rate of movement of the hands. The experiment is performed sequentially first with the right hand and then with the left hand.

The resulting variants of the maximum rate dynamics can be divided into five types:

- convex (strong) type: the rate increases to the maximum in the first 10-15 seconds of work; later, by 25-30 seconds, it may fall below the initial level (i.e., observed in the first 5 seconds of work). This type of curve indicates that the subject has a strong nervous system;

- smooth (medium) type: the maximum tempo is kept approximately at the same level for the entire time of operation. This type of curve characterizes the subject's nervous system as a medium-strength nervous system;

- descending (weak) type: the maximum tempo decreases from the second 5-second segment and remains at a reduced level throughout the work. The difference

between the best and worst result is more than 8 points. This type of curve indicates the weakness of the subject's nervous system;

- intermediate (medium-weak) type: the work rate decreases after the first 10-15 seconds. The difference between the best and worst results does not exceed 8 points. In this case, it is possible to periodically increase and decrease the rate (wave-like curve). This type is regarded as intermediate between the average and weak strength of the nervous system — the medium-weak nervous system;

- concave type: the initial decrease in the maximum tempo is then replaced by a short-term increase in the tempo to the initial level. Due to the ability to short-term mobilization, these subjects also belong to a group of people with a medium-weak nervous system (Table.).

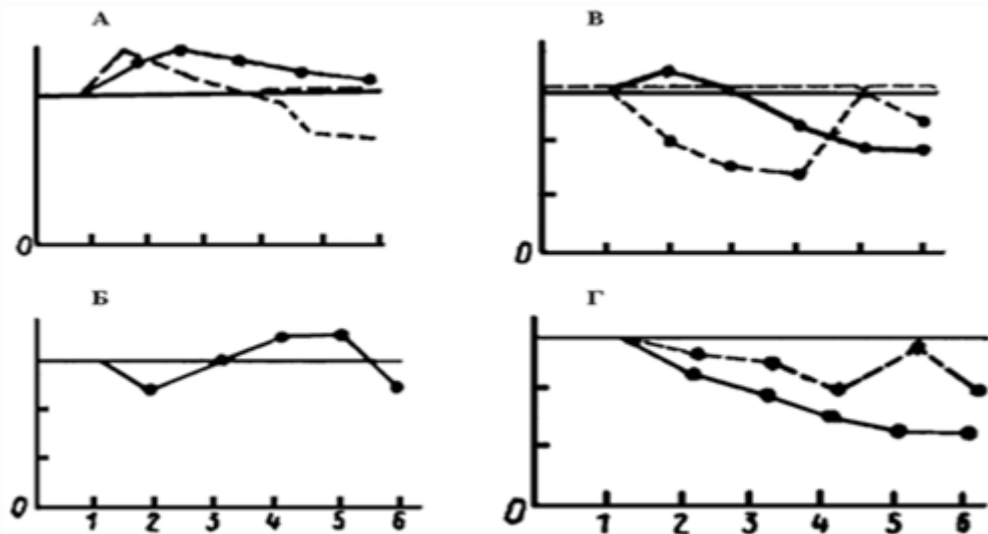


Fig. 21. The dynamics of the maximum rate of movements

Graphics:

A-convex type;

Б-level type,

В-intermediate and concave types,

Г-top-down type.

**Types of strength (weakness) of the nervous system**

Coefficient		Points	Diagnostic
>	≤		
56	more	25	Very high degree of strength or weakness of the nervous system (5)
52	56	24	
48	52	23	
44	48	22	
40	44	21	
37,2	40	20	High degree of strength or weakness of the nervous system (4)
34,4	37,2	19	
31,6	34,4	18	
28,8	31,6	17	
26,0	28,8	16	

23,8	26,0	15	Average strength or weakness of the nervous system (3)
21,6	23,8	14	
19,4	21,6	13	
17,2	19,4	12	
15	17,2	11	A slight degree of strength or weakness of the nervous system (2)
13,2	15,0	10	
11,4	13,2	9	
9,6	11,4	8	
7,8	9,6	7	
6,0	7,8	6	
4,8	6,0	5	The average nervous system (1)
3,6	4,8	4	
2,4	3,6	3	
1,2	2,4	2	
0,0	1,2	1	

**Draw up the results of the work.** Briefly describe the progress of the work and the results of observations. Basing on the results, draw a conclusion about the strength and stability of the excitation process.

### **Practical work № 2. Study of functional asymmetry of the brain**

**The purpose of the work:** to determine the lateral phenotype of a person using functional samples.

**For the work you need:** stopwatch, dynamometer, sheet of paper.

**Progress of work.** Students take two at a time to perform the following tests to assess sensorimotor asymmetry.

<b>Samples</b>	<b>Assessment methodology</b>
1. Taking a pen from the table.	The leading hand is the hand that the subject takes the object with.
2. Without visual control, circles, squares, and triangles are drawn simultaneously with two hands.	The leading hand is considered to be the hand that moves more effectively.
3. The intertwining of the fingers.	The thumb of the leading hand is placed on top.
4. Napoleon's pose (crossing his arms over his chest).	The leading hand starts moving first and places the hand on the opposite forearm.
5. Dynamometry.	The compression force of the dynamometer is determined three times with each hand. Average values are determined. Great strength is revealed in the leading hand.



6. Applause.	The leading hand is considered to be more active in the movement.
7. Test arm's length. With your eyes closed, both hands stretch out in front of you.	The leading hand is considered to be raised above.
8. Throwing a leg over a leg.	The leading leg is located on top.
9. Bouncing on one leg.	The leading leg is considered to be a push leg.
10. Approaching the door, backtracking	The leading leg begins to move.
11. Sample with a stopwatch.	The lead is considered to be the ear that the subject brings closer to the stopwatch.
12. Sample with a stopwatch.	The leading ear is the one that hears the clock ticking louder.
13. A sample of the "Hole in the map". The subject fixes the object through a small hole in a piece of paper. Then alternately closes the right and left eyes	Closing the leading eye causes the object to disappear from view.
14. Alternate squinting of the eye.	The leading eye is the first to squint.

2. Students enter the results of the tests in the protocol.

Protocol of the experiment for determining the lateral phenotype:

<b>The number of samples</b>	<b>The right limb</b>	<b>The left limb</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

Based on functional samples, the lateralization coefficient is determined using the formula:  $(P-L)/(P+L) \cdot 100\%$ , where P is the number of right-hand signs, L is the number of left-hand signs.

Based on the lateralization coefficient, the motor phenotype (samples 1-10), the sensory phenotype (samples 11-15), and the General sensorimotor phenotype (for all samples) are determined.

The leading hemisphere in motor and sensory activity is determined by the lateralization coefficient (positive - right - sided, negative-left-sided).

### **Practical work № 3. Study of the functional state of the brain by registering its bioelectric activity (EEG)**

**The purpose of this work** is to use an electroencephalograph to register a human electroencephalogram and perform its analysis.

**For the work you need:** electroencephalograph, a set of electrodes, conductive gel, alcohol, cotton wool.

**Progress of work:** 1. Preparing for registration

#### **1. Connecting a Digital wireless 2-channel bio-potential amplifier, BIO RECORDER 2.**

1.1. Connect the power supply (2) to the amplifier (1).

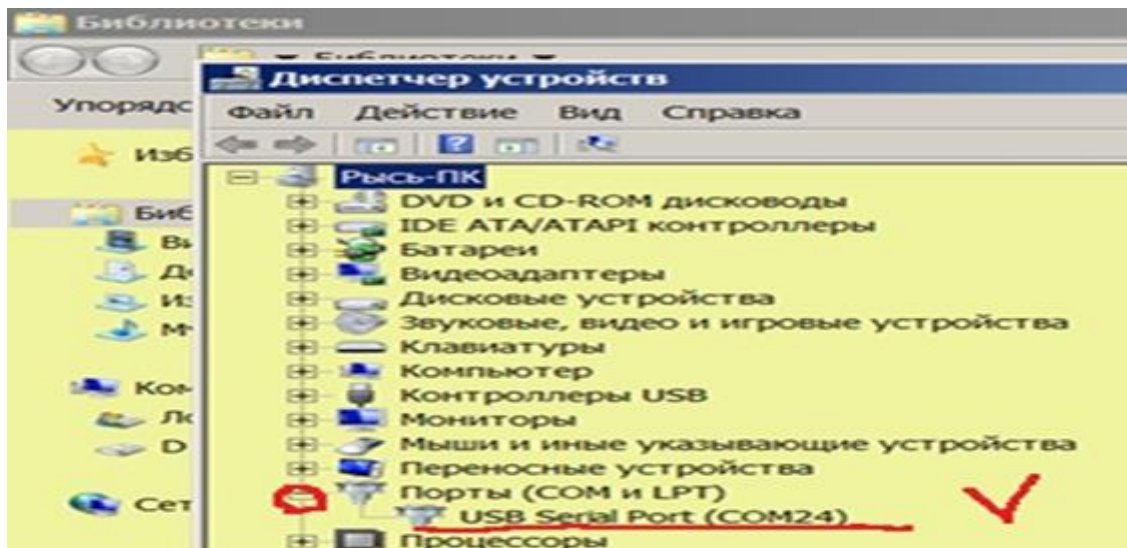
1.2. Insert the Bluetooth (5) transmitter into the USB connector. A blue diode should light up on the amplifier housing. (if it does not light up, change the polarity of the connector).

1.3. If it is not lit, the power supply must be recharged using the adapter (4) for the USB connector.

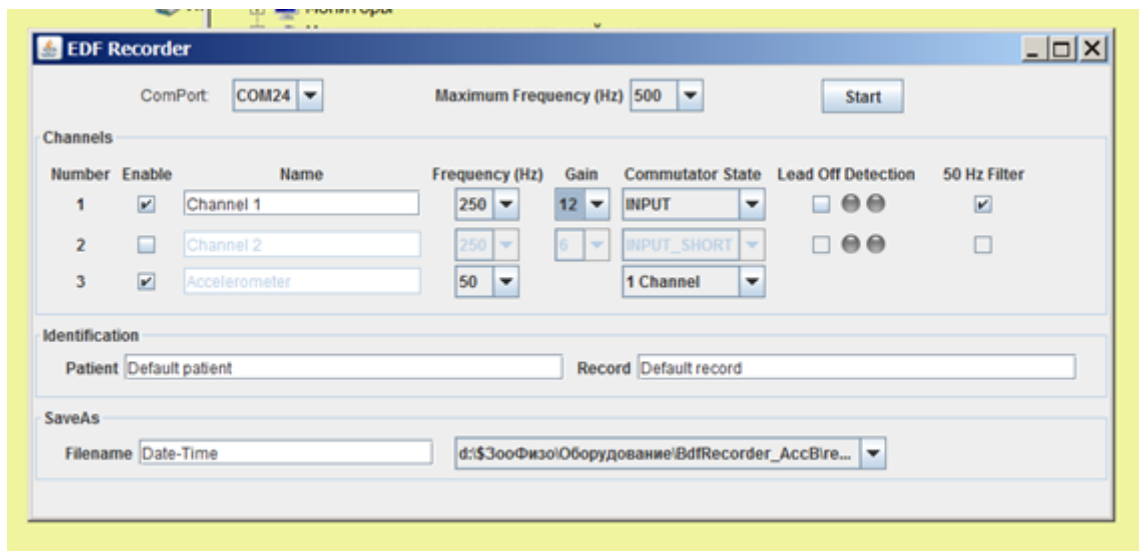


#### **2. Connecting the BdfRecorder program**

2.1. In the device Manager folder / in the Ports (COM and LPT) folder, the line “USB Serial Port (COM 50)” should appear. The COM port number may be different.



2.2. Run the BdfRecorder program (BdfRecorder\start.bat)



2.3. Check the settings and set them as shown in the picture.

2.3.1 In the ComPort field, select the value that was assigned to the USB adapter at the driver installation stage. Figure 3. In our case, this is “COM 6”.

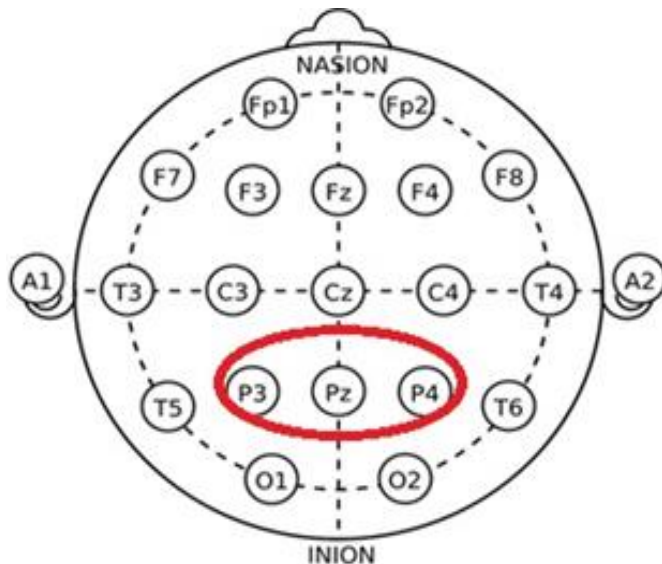
2.3.2 in the Save As field, specify the file name (you can not specify it, then the date and time of recording will be substituted) and the directory for recording data. In our case D:\tmp

2.3. Check the settings and set them as shown in the picture.

### 3. Applying electrodes for EEG registration and connecting to an amplifier

3.1. Put on a hat.

3.2. Apply electrodes (red and yellow) under the harnesses in the occipital-parietal area. Pressed against the seal. Green is fixed on the forehead.

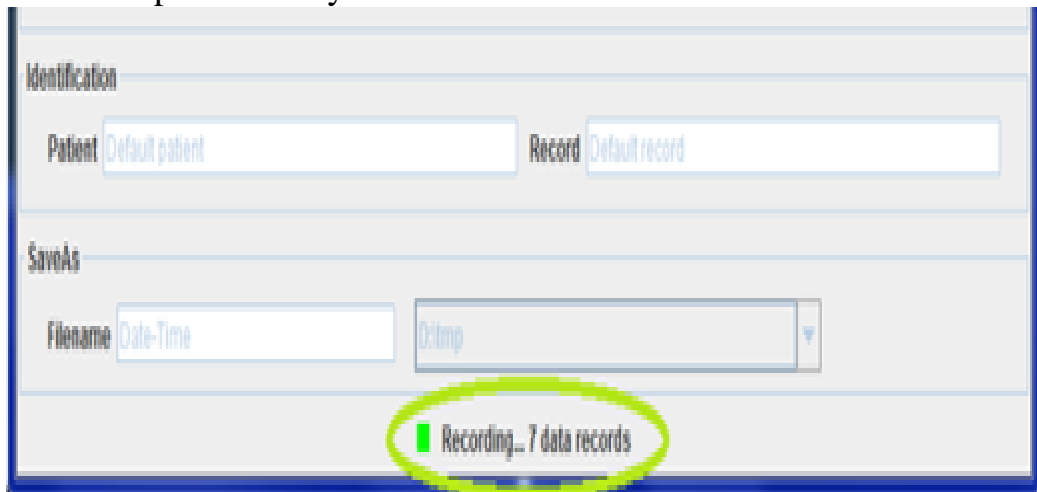


- 3.3. The green electrode is glued to the forehead.
- 3.4. Connect the cable to the amplifier.

#### 4. EEG registration (BdfRecorder and Edfbrowser)

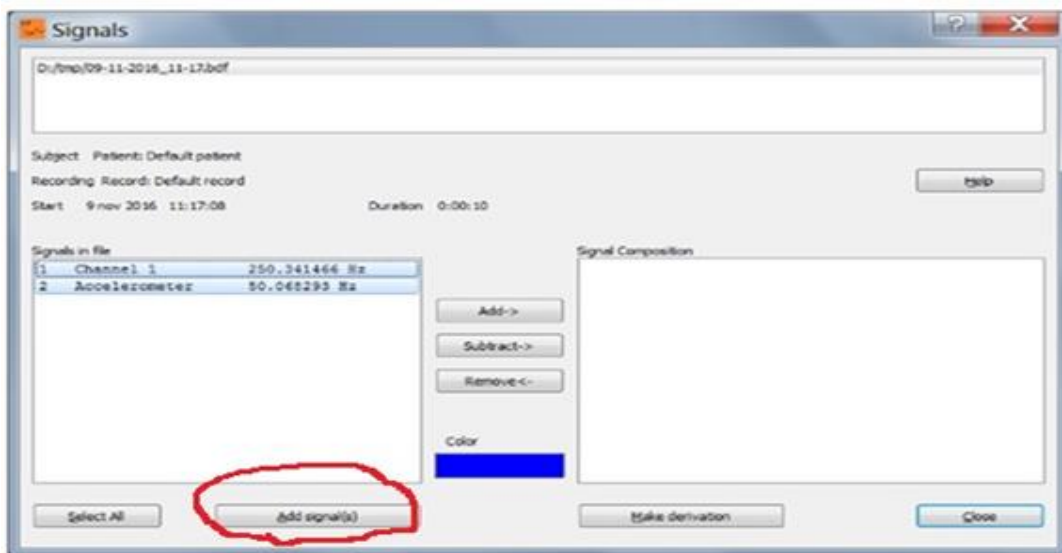
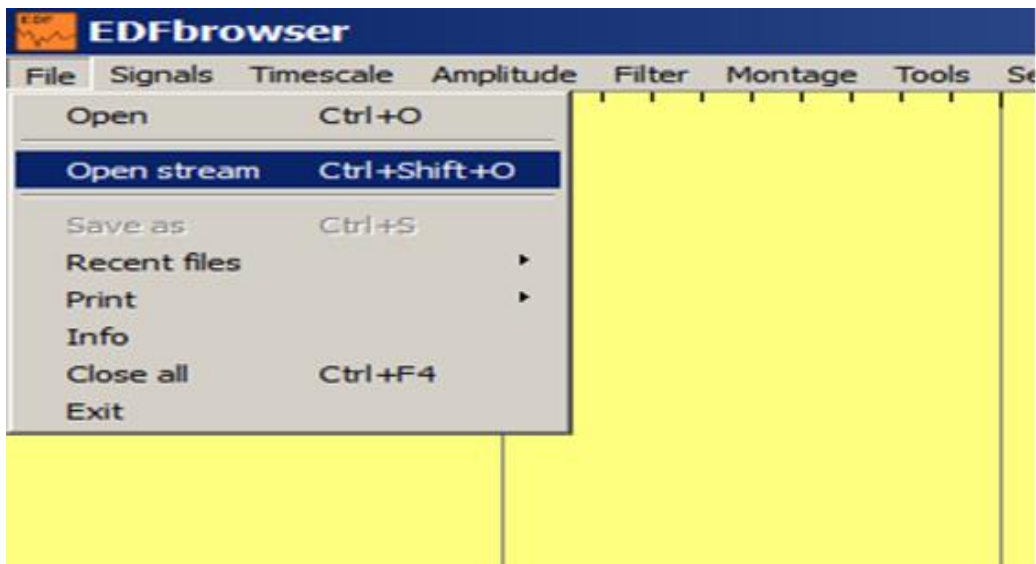
**4.1. Press the power button on the amplifier.** The blue indicator should start flashing. After a few seconds, the led on the USB adapter should light up, indicating that the connection to the amplifier is established.

In the Bdf Recorder program, click the "Start" button. The green indicator on the amplifier will stop flashing. A data file will appear in the folder you specified for recording (in our case, in the folder D:/tpm the file 09-11-2016\_11-17 appears.bdf). At the bottom of the window, information about the number of recorded blocks will be displayed, which is updated every second:



To view the recorded data, open EdfBrowser and select File/Open stream from the menu. Specify the path to the data to be recorded. In our case this is:

- 4.2 Desktop/EEG select the last file by date and time.**
- If the file does not open, we restart the computer.**

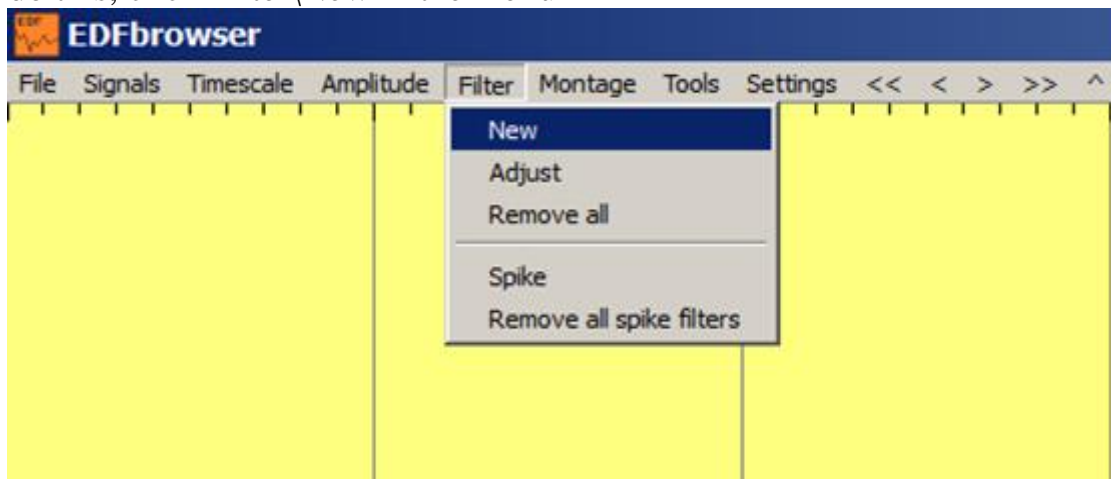


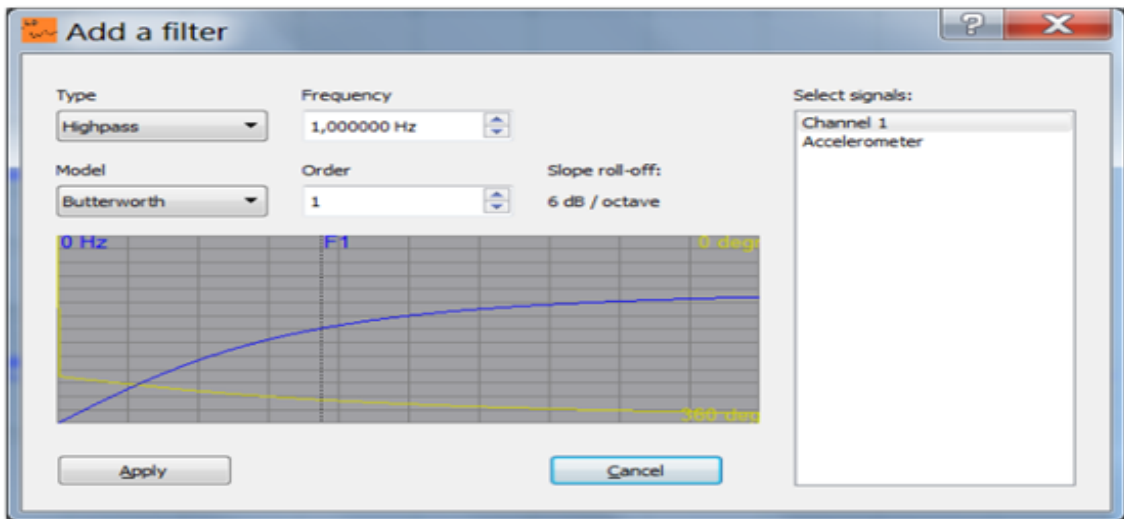
Click the "Add signals" button.

#### 4.3.1 Installation of filters.

In order to see the signal, you need to add a Hi Pass filter, which will cut off the low frequencies and the constant component.

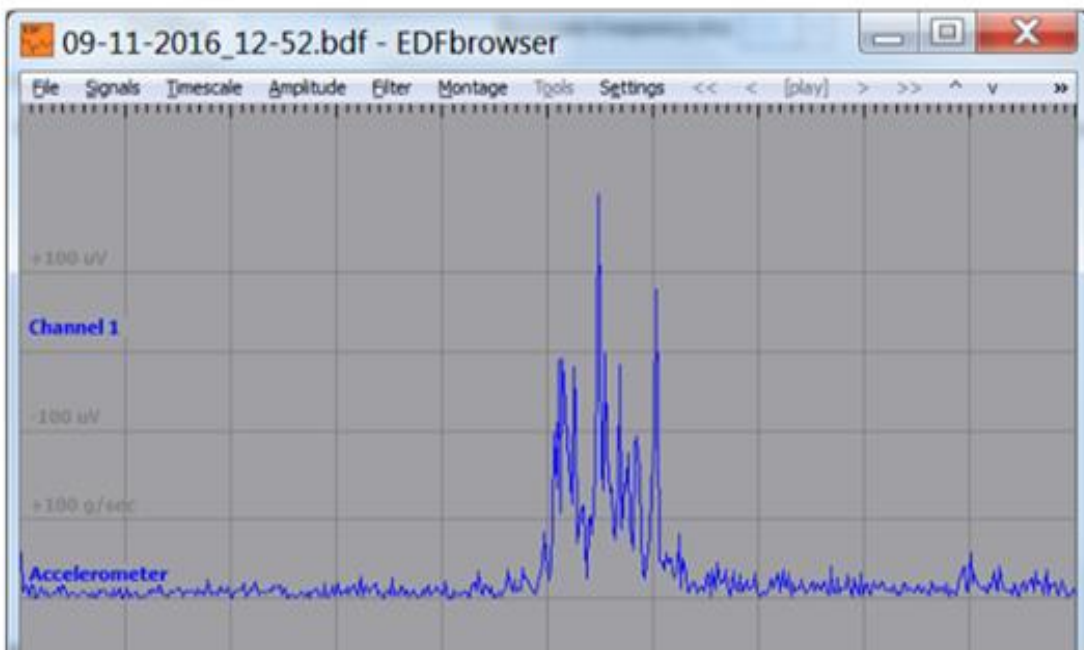
To do this, click Filter\New in the menu



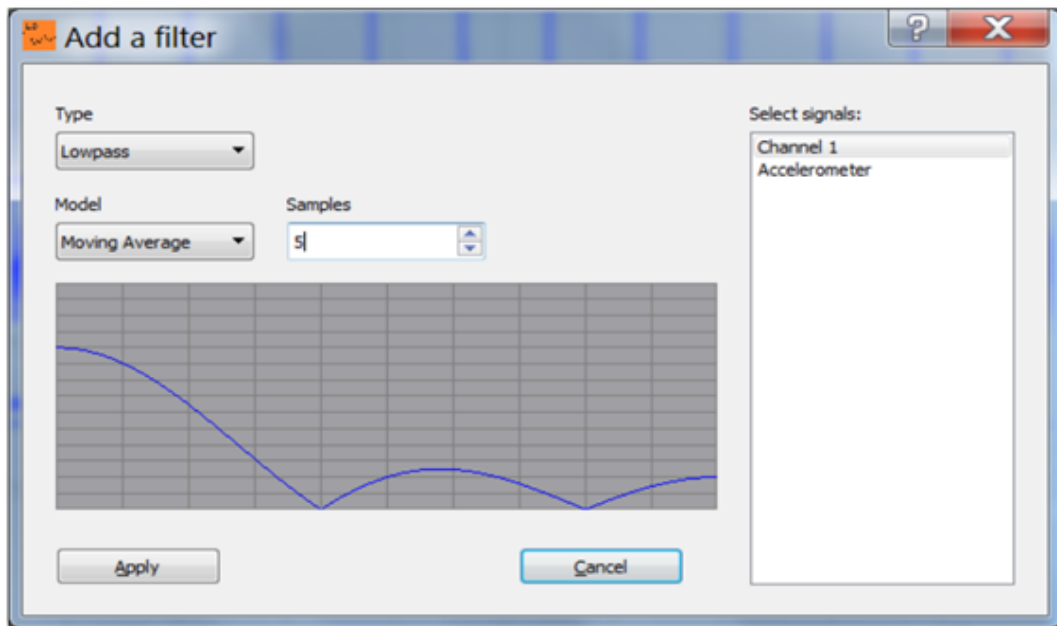


И нажмите кнопку Apply

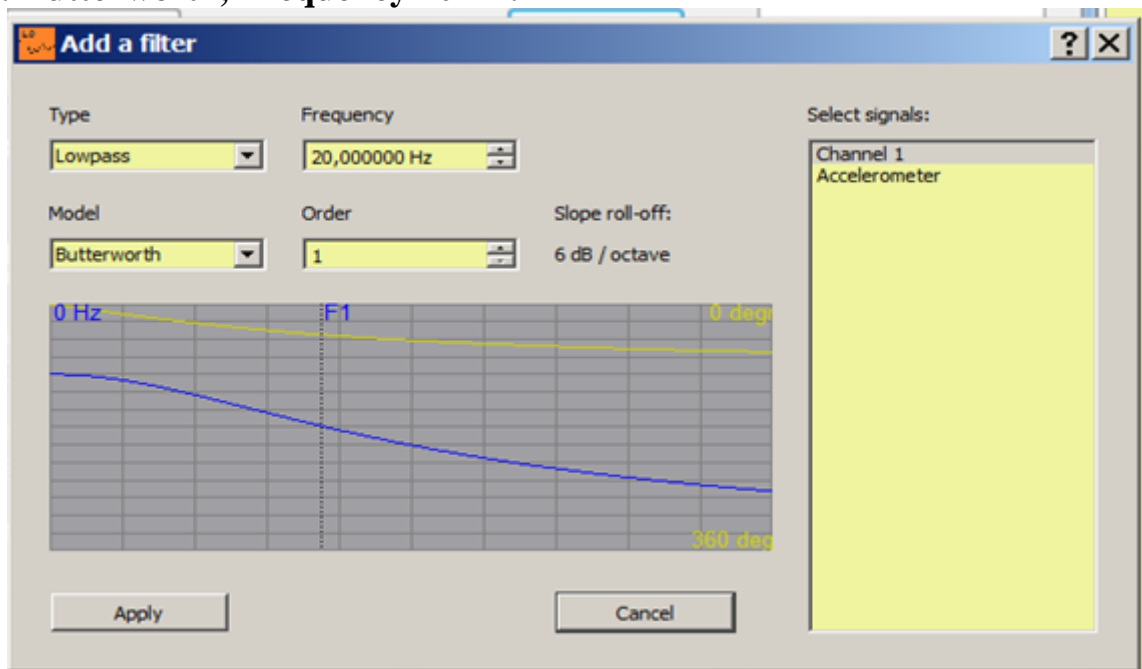
Get this picture:



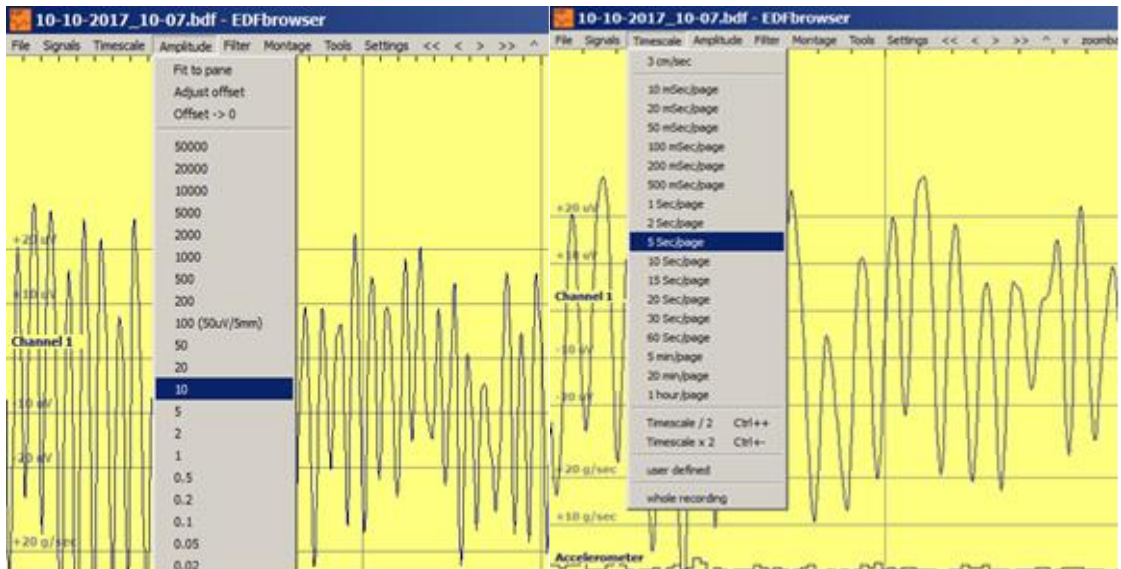
**4.3.2 To remove network interference, add the filter Filter\New, Type: Low Pass, Model: Moving Average, Samples 10.**



**4.3.3 To remove muscle artifacts, add the Filter Filter\New, Type: Low Pass, Model: Butterworth, Frequency 20 Hz.**



**5. We set the amplitude sweep of 10 microns (Amplitude)  
Set the time scan for 5 seconds (Timescale)**

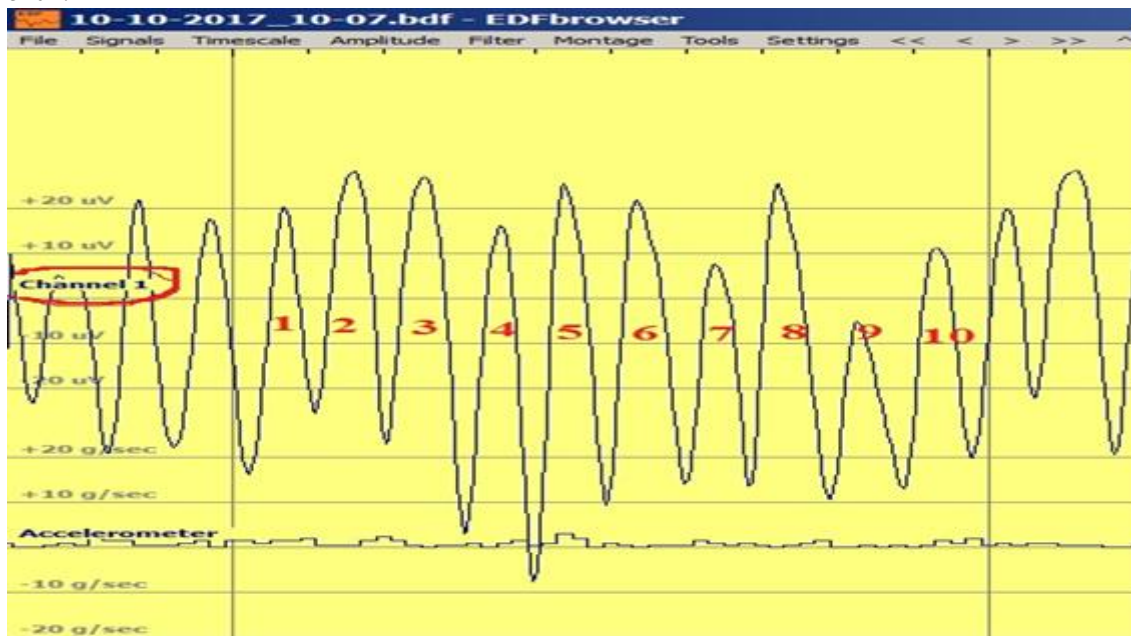


## 6. The end of the recording

In the Bdt Recorder program, click the "Stop" button. The blue indicator on the amplifier will start flashing again, indicating that you are ready for a new recording session.

## 7. Analysis of the electroencephalogram

7.1 Select the area with the functional state "Quiet wakefulness with closed eyes" and count the number of waves per 1 second (on the demo curve, it starts from 1 minute 18 seconds). The example shows that 10 waves per 1 second (1000 MS)  $1000/100 = 10$  Hertz.

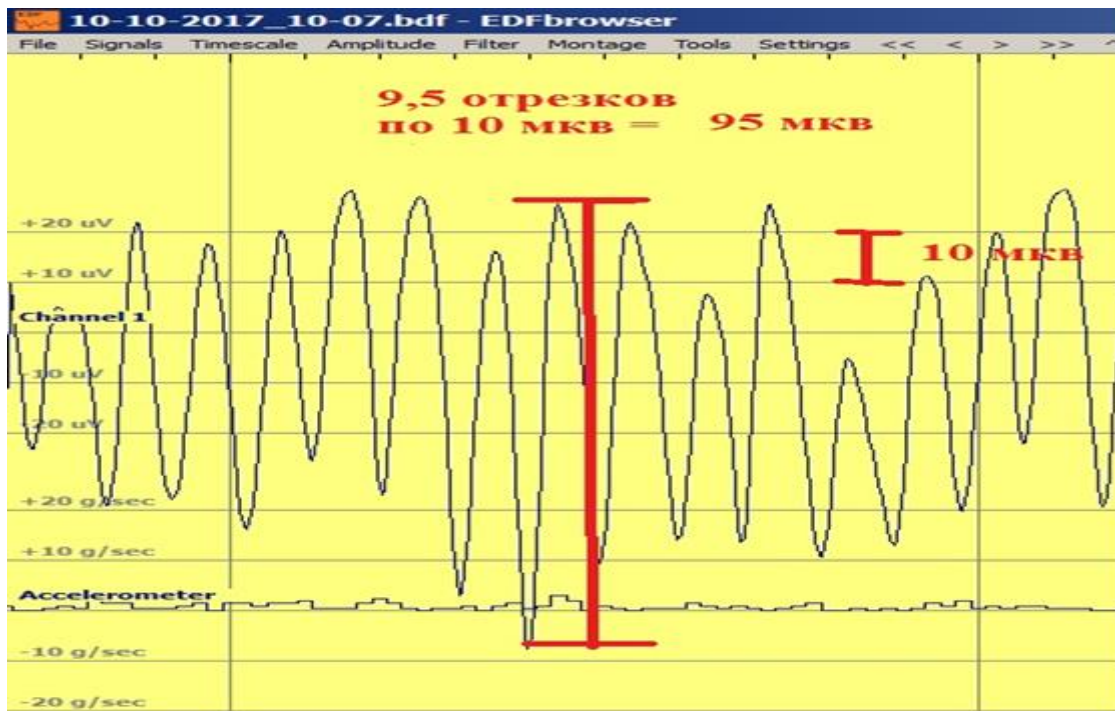


Next, measure the amplitude of the wave with the maximum span from peak to peak.

The example shows that the maximum wave span is 9.5 by a segment equal to 10 microvolt.

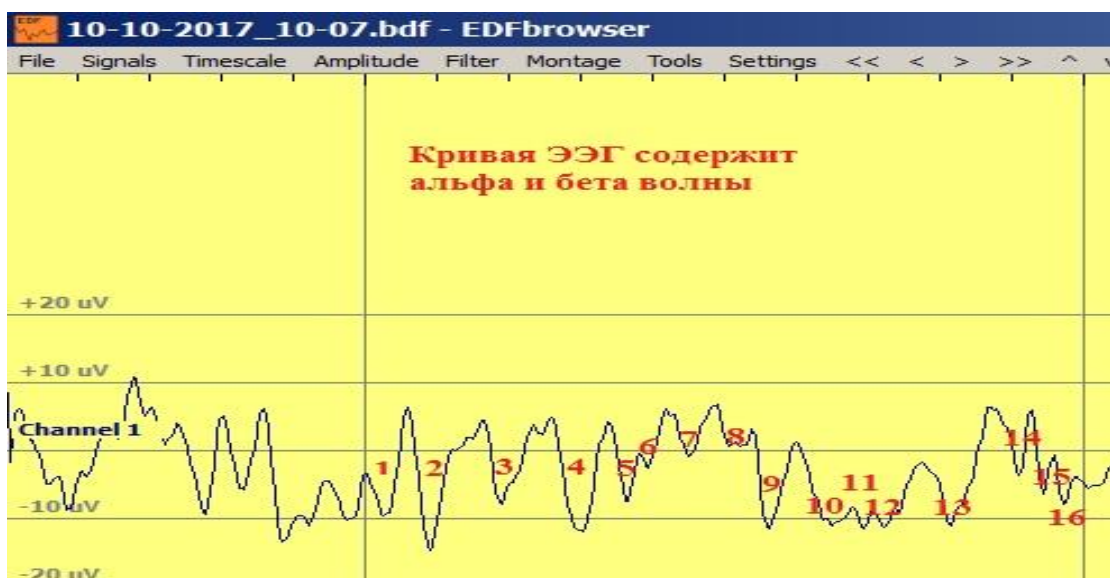
Accordingly, the maximum amplitude is 95 microvolt.

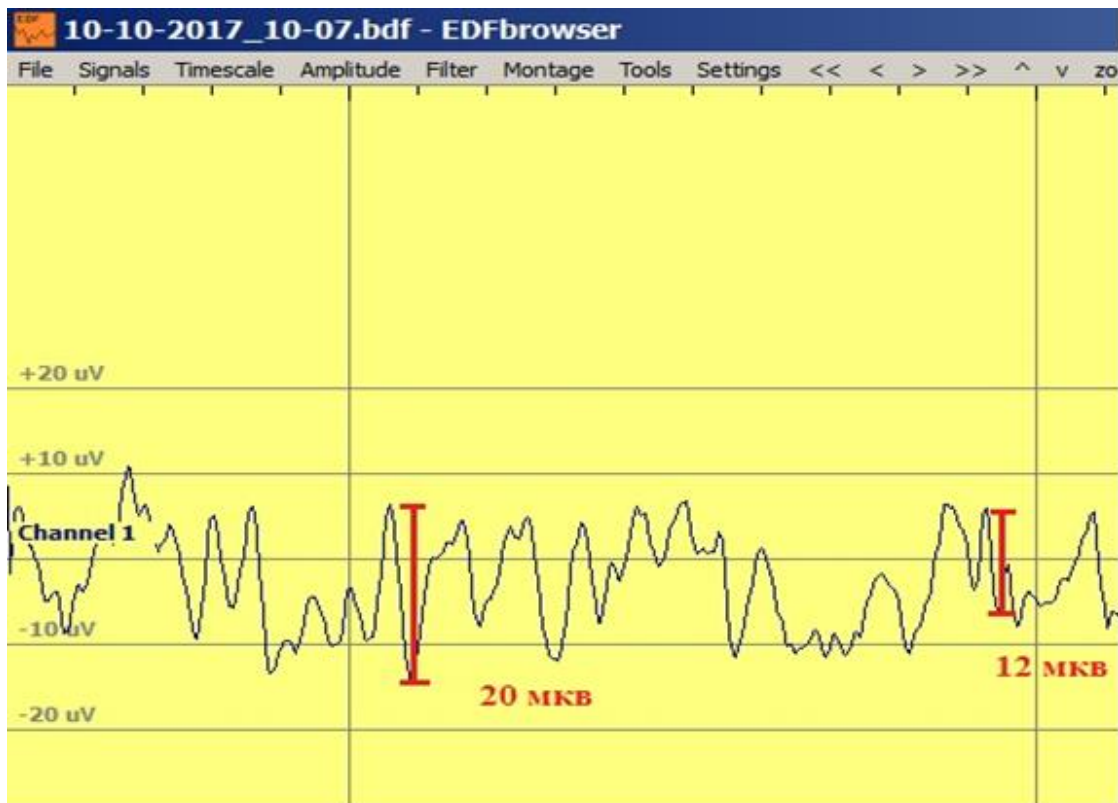




7.2 Repeat the analysis for the section with the functional state "Calm wakefulness with open eyes" (on the demo curve, it starts from 1 minute 33 seconds).

The curves show that the number of waves has increased (along with alpha waves, beta waves have appeared). The amplitude decreased.





**Draw up the results of the work.** Briefly describe the progress of the work and the results of observations.

**Practical work № 4. Study of auditory memory. Methodology**  
**"Memorization of 10 words" (by Luria A.R.).**

**The purpose of the work:** To assess the state of auditory memory for words, fatigue, activity of attention, memorization, preservation, reproduction, arbitrary attention.

The method of memorizing ten words was proposed by A. R. Luria. It allows you to explore memory processes: memorizing, saving, and playing back. The technique can be used to assess the state of memory, voluntary attention, exhaustion of patients with neuropsychiatric diseases, as well as to study the dynamics of the course of the disease and take into account the effectiveness of drug therapy.

The methodology needs to be carried out in an appropriate environment. There should be no extraneous conversations in the room. The subject is asked to remember 10 words. They must meet several conditions:

1. Monotony: all words are nouns in the singular, im. cases consisting of the same number of syllables (one-or two-syllable);
2. If possible, the words should not be related to each other (you can not offer words for memorizing: table-chair; fire - water, etc.).

A Protocol with ten short monosyllabic and two-syllabic words that have no connection between them. The following set of words are most often used: Forest, Bread, Window, Chair, Water, Horse, Mushroom, Needle, Honey, Fire.

The methodology of the study. I read the instruction (a) to the subject. After that, a number of words are read out. At the end of the reading, the words memorized by the

subject are recorded in the protocol. Then read out the instruction (b). After fixing the data in the protocol, the experiment is repeated without instructions. The material is presented several times before full memorization or 5-6 times. Before the next reading of the material, the experimenter simply says, "Again."

Thus, at each stage of the study, a protocol is filled in. A cross is placed under each reproduced word in the line that corresponds to the attempt number. If the subject calls an "extra" word, it is recorded in the corresponding column. After the end of repeating the words, the experimenter says to the subject: "In an hour, you will tell me the same words again." After an hour, the subject, at the request of the researcher, reproduces the remembered words without first reading them out, which are recorded in the protocol in circles.

### Instructions

- Instruction (a): "Now we will check your memory. I will tell you the words, you will listen to them, and then repeat them as much as you can, in any order."

- Instruction (b): "Now I will call the same words again, you will listen to them and repeat them – and those that have already been called, and those that you will remember now. You can name words in any order."

Instructions for adults.

- Instruction (a): "Now I will read a few words. Listen carefully. When I finish reading, immediately repeat as many words as you can remember. You can repeat words in any order."

- Instruction (b): "Now I will read You the same words again, and you must repeat them again, and those that You have already named, and those that you missed the first time. Word order is not important."

### Processing of results

1. Calculate the total number of correctly played words for each repetition, and write in the column of Protocol V.

2. Build a learning schedule based on this data. On the abscissa axis, the sequence numbers of repetitions are deferred, and on the ordinate axis, the values of V.

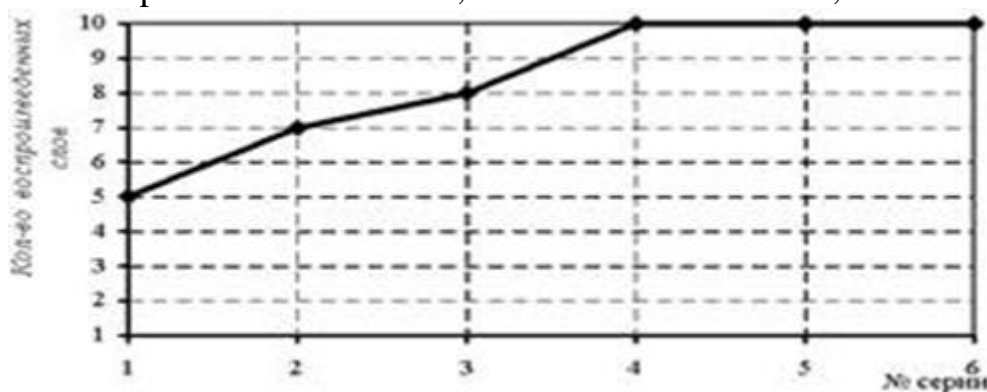


Fig. 22. Word learning schedule

3. Calculate the frequency of each word for the entire number of repetitions and calculate the memorization coefficient for them using the formula (the accuracy of calculations is 1%):

$$K_i = \frac{P_i}{n} * 100\%$$

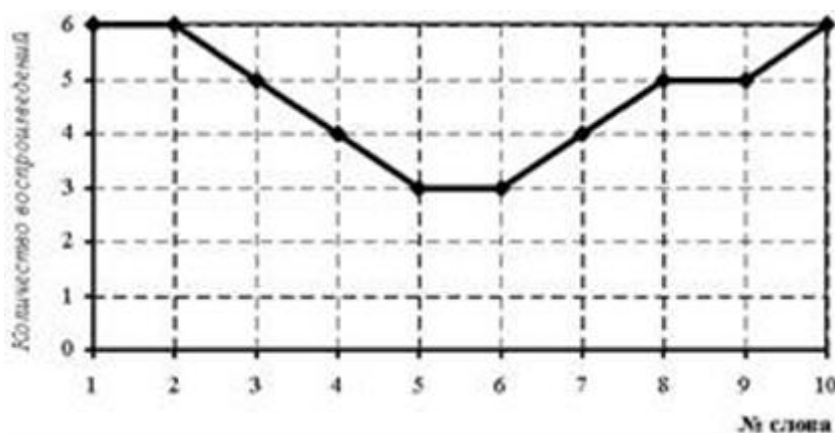
, where

K<sub>i</sub>-coefficient of memorization of the i-th word,

R<sub>i</sub> -its absolute frequency;

n - is the number of iterations.

4. Plot the frequency of memorization of each word. On the abscissa axis, the ordinal numbers of words are laid down, on the ordinate axis – the values of K.



**Fig. 30 Graph of the frequency of memorizing words**

5. Create summary tables for indicators V and K for a group of subjects; calculate the average indicators and apply these data to the individual graphs of this subject. To compare individual data with the average for the group.

6. Along with this, you can calculate the percentage of information loss an hour after memorization:

$$X = 100 - \frac{V_{\text{длительная}} \cdot 100}{V_6}$$

, where V is durham.- long-term memory capacity (after one hour)

V<sub>6</sub> — number of words played in the 6th series

### Interpretation

Analyze the forms of the received graphs, using the material of the verbal report and observations of the work progress. From the shape of the curve, you can draw conclusions about the features of memorization.

So, in healthy children, the number of correctly named words increases with each playback, weakened children reproduce less, and may show stuck on "extra" words. A large number of "extra" words indicates disinhibition or disorders of consciousness. When adults are examined for the third repetition, the subject with normal memory usually reproduces, correctly, up to 9 or 10 words.

The memory curve may indicate attenuation and / or fatigue. Increased fatigue is registered if the subject (adult or child) immediately reproduced 8-9 words, and then, each time, less and less (the curve on the graph does not increase, but decreases). In addition, if the subject reproduces fewer and fewer words, this may indicate forgetfulness and distraction. The zigzag nature of the curve indicates the instability of attention. The curve, which has the form of a "plateau", indicates the emotional lethargy of the child, his lack of interest.

In traumatic brain injury or neuroinfection, subjects remember the first and last words. In this case, the amount of material stored does not change.

In neuroses, memory is slow, the graph is zigzag, and more presentations are needed. Zigzagging also indicates the instability of attention and its fluctuations.

You should pay attention to the presence of the "edge effect".

The number of words held and played in the first series shows the amount of auditory short-term memory. The norm is a volume equal to  $7 \pm 2$  words (units of information). The number of words held and played back one hour later shows the amount of auditory long-term memory.

**Conclude.**

### **TOPIC 3. PHYSIOLOGY OF SENSORY SYSTEMS**

#### **Control questions on the topic of the lesson**

1. Visual analyzer.
2. Photochemical reactions in the receptors of the retina.
3. Auditory analyzer.
4. Vestibular analyzer.
5. Somatosensory analyzer.
6. Olfactory Analyzer.
7. Taste Analyzer.

#### **Practical work №1. The study of pupillary reflexes**

The size of the pupil changes due to the interaction of two smooth muscles of the iris: the sphincter of the pupil - the circular muscle that narrows the pupil, and the dilator-the radial muscle that expands the pupil. These muscles receive different innervation: the sphincter of the pupil-parasympathetic, the dilator-sympathetic.

The pupil of a healthy person has a regular round shape with a diameter of 3-3.5 mm. normally, the pupils are the same in diameter.

Pathological changes in the pupils include: myosis-constriction of the pupils, mydriasis - dilation of them, anisocoria (pupil inequality), deformation, disorder of the reaction of the pupils to light, convergence and accommodation.

**The purpose of the work:** to study the state of pupil reflexes and their features

## **Carrying out the work does not require the use of equipment and tools.**

### 1. Assessment of the direct reaction of pupils to light.

**Progress of work:** The subject with wide open and evenly lit eyes sits opposite the researcher. The researcher covers the subject's eyes with his hands, then quickly removes his hand from one eye — the pupil instantly narrows. The reaction of the other eye is examined in the same way. The lack of reaction of the pupils to light indicates a lesion of the parasympathetic innervation of the pupil (Yakubovich — Edinger — Westphal nucleus)

### 2. Assessment of the friendly response of pupils to light.

**Progress of work:** The researcher closes one eye of the subject with his hand, and leaves the other slightly open. With a quick withdrawal of the hand from the closed eye, the pupil narrows in the slightly open eye. The absence of a friendly reaction to light indicates a lesion of parasympathetic fibers in the longitudinal beam.

### 3. Study of the reaction of pupils to convergence.

**Progress of work:** When fixing the subject's gaze on an object that is gradually approaching the eyes, there is a narrowing of the pupils. When an object is removed, the pupils dilate. The greatest constriction of the pupils is observed when the object approaches the eyes at a distance of 10-15 cm. The absence of a reaction to convergence indicates a lesion of the longitudinal beam.

### 4. Study of pupil response to accommodation.

**Progress of work:** Check on one eye (the second is covered). Normally, there is a narrowing of the pupils when viewing an object near and expansion - when looking into the distance. The absence of a pupil response to accommodation indicates a lesion of the parasympathetic pathways in the longitudinal bundle.

**Results of the work and their design.** Briefly describe the progress of the work and the results of observations. Draw the conclusion.

## **Practical work № 2. Visual acuity research**

**The purpose of the work:** to study visual acuity using Snellen's tables.

**To work, you need:** table of, card for eyes.

**Progress of work:** The table contains 12 lines of letters, the value of which decreases from top to bottom; to the right of each line is a number indicating the distance from which the normal eye distinguishes the letters of this line at an angle of 1 (D), to the left – visual acuity (V), corresponding to the ability to see the signs of this line from a distance of 5 meters. A distance of 5 meters is considered sufficient for optimal accommodation. Visual acuity is determined by the formula:  $D \cdot d \cdot V =$ , where V (visus) - visual acuity, d - the distance of the subject from the table, D - the distance from which the normal eye should clearly see this line (table.).

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
P E Z O L C F T D	11	

**Snellen's table**

Study of visual acuity of the right and left eyes. The person is located at a distance of 5 m from the table and covers the left eye (or right) with a special shield, the eye is not closed. The experimenter shows the subject the letters and asks them to name them. Definition begins with the top line and, going down, find the lowest line, all the letters of which the subject clearly sees and correctly calls for 2-3 seconds. The value of visual acuity is determined by the formula. Repeat the measurements from distances of 1 and 3 m and calculate the visual acuity using the formula. For example, only 1 row is visible from a distance of 4 m, then the visual acuity will be  $V=4/50=0.08$ .

**Results of the work and their design.** Draw up the results in a table and make a conclusion.

Distance (m)	Clearly visible line		Acuity calculated using the formula	
	Right eye	Left eye	Right eye	Left eye
5				
2				
3				
4				

**Practical work № 3. Blind spot detection (the MARRIOTT experience)**

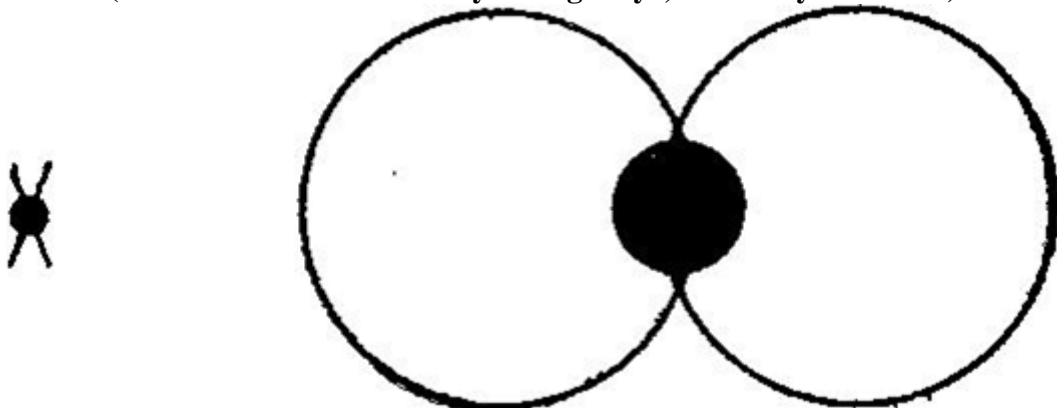
**The purpose of the work:** to make sure that there is a blind spot in the place of the exit of the optic nerve through the retina from the eyeball.

**For the work you need:** drawings and a ruler.

**Progress of work:** Place the drawings on the monitor screen in front of your eyes at arm's length, close one eye (which one is indicated for each drawing below), and slowly bring your face closer to the monitor screen. At a certain distance of the head from the screen, part of the drawing falls out of view. Measure this distance from the drawing to the eye.



**Fig. 23. Blind spot detection**  
(look at the small dot with your right eye, the left eye is closed)



**Fig. 24. Blind spot detection**  
(look at the large dot in the center of the two circles with your left eye, the right eye is closed)



**Fig. 25. Blind spot detection**  
(look at the circle with your right eye, the left eye is closed)



Next, determine the distance between the blind spot and the yellow spot using the formula  $A1B1=AB * OS1/OK$ .

To do this, mark the following points:

A1-blind spot.

B1-yellow spot.

C1 – the middle of the distance between the blind and yellow spots.

O-nodal point of the eye.

A is the center of the point where you fix the eye.

B-the center of the second figure, which disappears when the drawing approaches the eye.

C is the middle of the distance between the centers of the two figures in the drawing.

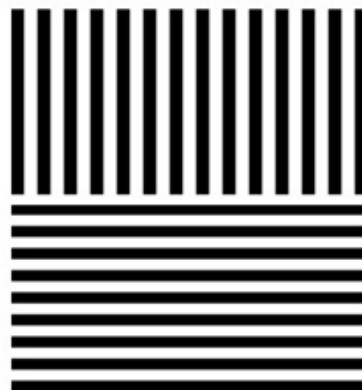
From the similarity of triangles, derive the ratio  $AB/A1B1=OK/OS1$ , where AB is measured on paper, OK is the distance from the paper to the eye, OS1 is the distance from the nodal point of the eye to the retina, which is on average 17 mm. **Results of the work and their design.** Draw the resulting triangles, calculate the resulting values from them. Conclude.

#### **Practical work № 4. Definition of astigmatism**

**The purpose of the work:** to study one of the methods for determining astigmatism.

**For the work you need:** the drawing for the detection of astigmatism, roulette.

**Progress of work:** Consider a drawing where some lines are vertical and others are horizontal, and the thickness of all lines is the same. The subject notes which lines, horizontal or vertical, are more distinct.



**Fig. 26. The image to determine astigmatism**

By bringing the drawing closer to the eye and moving it away, determine whether the rays from less clearly visible lines converged in front of the retina or behind. If, for example, the horizontal lines become more distinct as the drawing approaches, this means that the rays coming from these lines converged in front of the retina at the initial position of the drawing, and when the drawing approaches the eye, the points of convergence of the rays moved to the retina, i.e. the image was in focus. As you rotate the drawing, note that the representation of the thickness of the lines changes all the time according to the change in their position. Make conclusions Ophthalmoscopy is a method for examination of the retina, optic nerve and choroid in the rays of light reflected from the fundus. In the clinical picture, two methods of ophthalmoscopy are used-in reverse and in direct form. Ophthalmoscopy is more convenient to carry out with a wide pupil. The pupil is not expanded if glaucoma is suspected, so as not to cause an attack of increased intraocular pressure, as well as atrophy of the sphincter of the pupil, since in this case the pupil will always remain wide. **Conclude about the presence or absence of astigmatism.**

### **Practical work № 5. Ophthalmoscopy**

**The purpose of the work:** to master the technique of ophthalmoscopy.

**For the work you need:** a set of tools for reverse ophthalmoscopy, a lighting device (lamp).

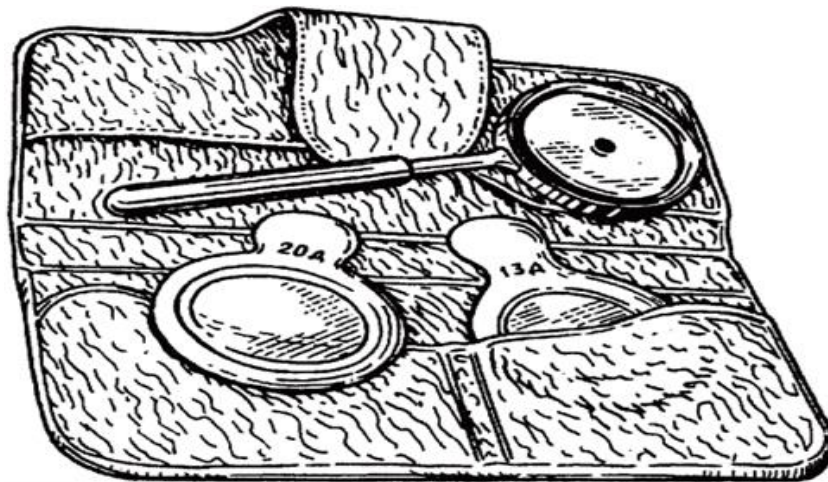
**Progress of work.** The work is carried out in pairs. Reverse ophthalmoscopy is designed for quick examination of all parts of the fundus. It is carried out in a darkened room - the observation room. The light source is installed to the left and somewhat behind the patient.



**Fig. 27. Location of the doctor and the patient when examining the fundus**

The doctor is positioned in front of the patient, holding an Ophthalmoscope in his right hand, placed against his right eye, and sends a light beam to the eye being examined. An ophthalmic lens with a force of +13.0 or +20.0 DPTR, which the doctor holds with the thumb and index finger of the left hand, is placed in front of the eye

under examination at a distance equal to the focal length of the lens-7-8 or 5 cm, respectively.



**Fig. 28. Set of tools for reverse ophthalmoscopy**

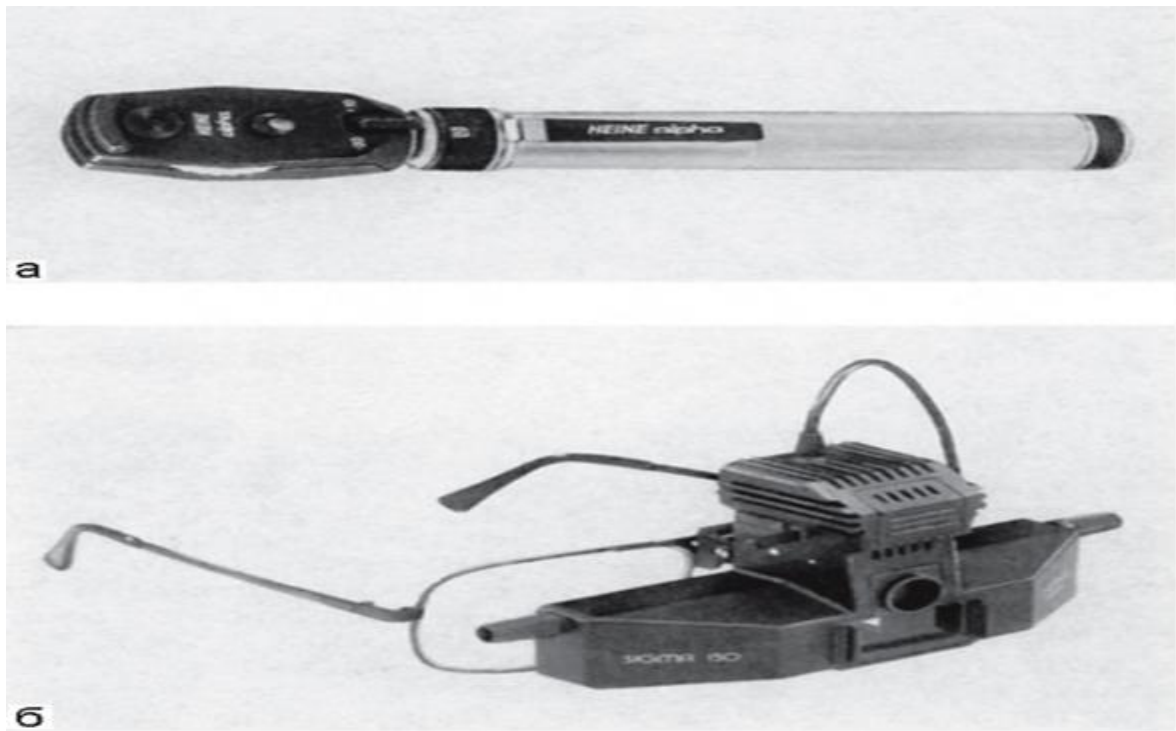
The patient's second eye remains open and looks past the doctor's right eye. The rays reflected from the patient's fundus fall on the lens, are refracted on its surface and form a real image of the studied areas of the fundus hanging in the air at the doctor's side, at its focal length (7-8 or 5 cm, respectively), but enlarged 4-6 times and inverted. Everything that appears to be lying at the top actually corresponds to the lower part of the area under study, and what is outside corresponds to the inner parts of the fundus.

In recent years, aspherical lenses have been used for ophthalmoscopy, which makes it possible to obtain an almost uniform and highly illuminated image across the entire field of view. The dimensions of the images depend on the optical power used lenses and refraction of the examined eye: the greater the power of the lens, the more magnification and less visible area of the fundus, and the increase in the case of using the same power of a lens in the study of the hyperopic eye will be greater than in the study of myopic eyes (due to different length of the eyeball).

Direct ophthalmoscopy allows you to directly view the details of the fundus that were detected during reverse ophthalmoscopy. This method can be compared to viewing objects through a magnifying glass. The study is performed using monocular binocular electric ophthalmoscopes of various models and designs (Fig.), allowing you to see the fundus in a direct view increased by 13-16 times. In this case, the doctor moves as close as possible to the patient's eye and examines the fundus through the pupil (better against the background of medical mydriasis): the right eye is the right eye of the patient, and the left - the left.

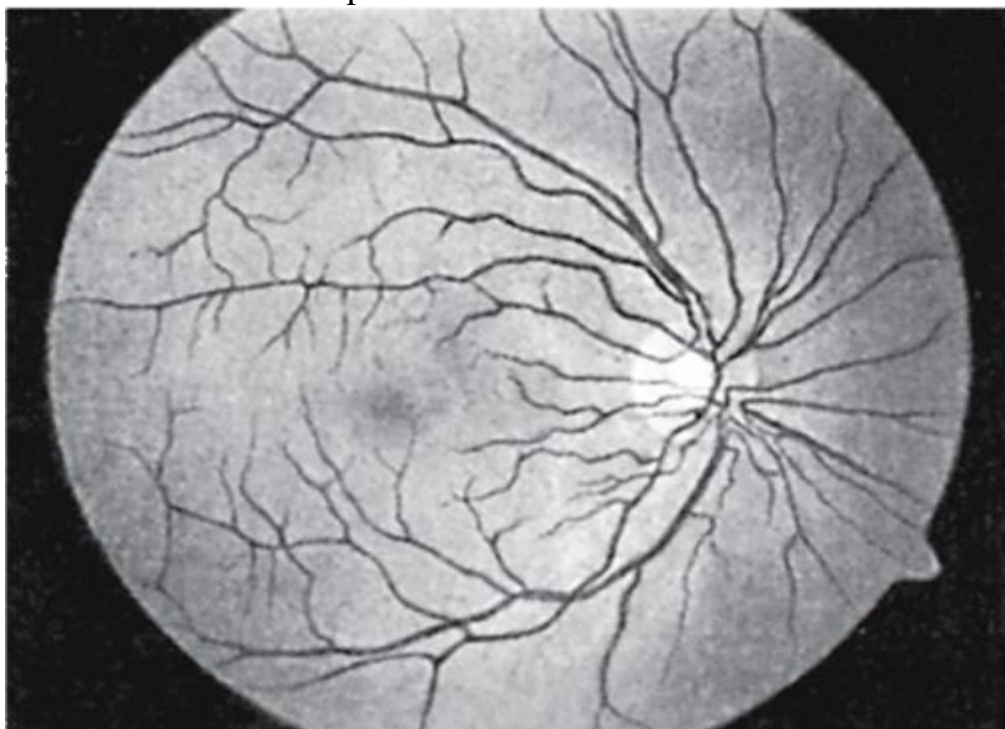
With any method of ophthalmoscopy, the fundus is examined in a certain sequence: first, the optic nerve disk is examined, then the macular area (macular area), and then the peripheral parts of the retina are examined.

When examining the optic disc in reverse, the patient should look past the doctor's right ear if the right eye is being examined, and at the researcher's left ear if the left eye is being examined.



**Fig. 29. Electric ophthalmoscopes: a-manual; b - ophthalmoscope-glasses.**

Normally, the optic disc is round or slightly oval, yellowish-pink in color with clear borders at the level of the retina (Fig .28). Due to the intense blood supply, the inner half of the optic disc has a more saturated color. In the center of the disk there is a recess (physiological excavation) - this is the place of inflection of the optic nerve fibers from the retina to the lattice plate.



**Fig. 30. Normal fundus**

Through the Central part of the disc, the Central retinal artery enters and the Central retinal vein exits. The Central retinal artery in the area of the optic disc is

divided into two branches - the upper and lower, each of which in turn is divided into the temporal and nasal. The veins completely repeat the course of the arteries. The ratio of the diameter of the arteries and veins in the corresponding trunks is 2: 3. Veins are always wider and darker than arteries. During ophthalmoscopy, a light reflex is visible around the artery.

To the outside of the optic nerve, at a distance of two disc diameters from it, there is a yellow spot, or macular area (the anatomical area of Central vision). The doctor sees it during the examination, when the patient looks directly into the Ophthalmoscope. The yellow spot has the appearance of a horizontal oval, slightly darker than the retina. In young people, this part of the retina is bordered by a light strip - the macular reflex. The Central fossa of the yellow spot, which has an even darker color, corresponds to the foveal reflex. The picture of the fundus of different people differs in color and pattern, which is determined by the saturation of the retinal epithelium with pigment and the content of melanin in the vascular membrane. In direct ophthalmoscopy, there are no light reflections from the retina, which facilitates the study. The head of the Ophthalmoscope has a set of optical lenses that allow you to focus the image clearly.

**Results of the work and their design.** A schematic sketch of the eye. Make a conclusion about the presence or absence of violations.

### **Practical work № 6. Hearing research with tuning forks**

This study is conducted for the purpose of differential diagnosis of hearing loss. It is based on a comparison of the perception of pure sounds during air and bone conduction. There are special sets of tuning forks that allow you to conduct research in a wide frequency range. However, for everyday practice, it is enough to have only two tuning forks: low (128 vibrations per second — C128) and high (2048 vibrations per second-C2048). Each tuning fork must have a "passport", that is, data about the time in seconds during which its sound is perceived by otologically healthy people.

#### **Air conduction research**

In the study of air conduction, the tuning fork is sounding the "maximum" dose impact percussion hammer (bass tuning fork can lead to the sounding blow on the lower one third of thigh) and brought brahami to the ear test, which should answer, if he hears a sound. The tuning fork is brought to the external auditory canal as close as possible, without touching the ear, so that its axis (it passes across both ears) coincides with the axis of the auditory passage. In order to avoid adaptation or fatigue of hearing, the tuning fork should be brought to the ear every 4-5 seconds. The study of bone conduction is performed using a sounding bass tuning fork, the leg of which is tightly placed to the middle of the patient's crown. The duration of perception of the sounding tuning fork during air and bone conduction is determined in seconds (quantitative study). In qualitative research of hearing with tuning forks, a number of experiments are used.

### **Research methods:**

1. Take a set of tuning forks C128, C512, C2048, start the study with low-frequency tuning forks - C128. The tuning fork C128 and higher are brought into oscillation by staccato compression of the branches with two fingers or a light blow on the tenor of the left palm, and C2048 by a click of the nail. The subject is given a clear instruction about the need to immediately inform the researcher that he has stopped hearing the tuning fork.

2. Holding the sounding tuning fork by the leg with two fingers, bring it to the external auditory canal of the subject at a distance of 0.5-1 cm with a stopwatch, measure the time during which the subject hears the sound of this tuning fork, the time begins from the moment the tuning fork is brought into vibration.

3. After the subject ceases to hear, you need to move the tuning fork away from the ear and again immediately bring it closer (without exciting it again). As a rule, after this distance of the tuning fork, the subject hears the sound for a few more seconds. The final time is marked by the patient's last response.

### **1. The study of bone conduction (Rinne's experience)**

**The purpose of the work:** using functional tests to determine the presence or absence of hearing loss.

**For the work you need:** a set of tuning forks.

**Progress of work.** Bone conduction is examined with the c128 tuning fork, since the vibration of tuning forks with a lower frequency is felt by the skin, and tuning forks with a higher frequency are listened to through the air by the other ear.

1. Put the sounding tuning fork C128 perpendicular to the foot on the platform of the mastoid process. The duration of perception is also measured with a stopwatch, keeping track of the time from the moment of excitation of the tuning fork. After the perception of sound through the tissues has stopped, the tuning fork, without exciting, is brought to the external auditory passage. In this case, the subject normally hears the vibrations of the tuning fork in the air — Rinne's experience is positive (R+)

2. If the subject, after stopping the sound of the tuning fork on the mastoid process, does not hear it and in the air near the external auditory passage, this result is called negative (R-).

In the Rinne experiment, there is a normal prevalence of air conduction of sound over bone twice (R+), with a negative one — on the contrary, bone prevails over air, which happens when the sound-conducting apparatus is affected. In diseases of the sound-receiving apparatus, there is, as in normal cases, a preponderance of air conduction over bone, while the duration of perception of the tuning fork, expressed in seconds, both air and bone conduction, is less than in normal, but Rinne's experience remains positive.

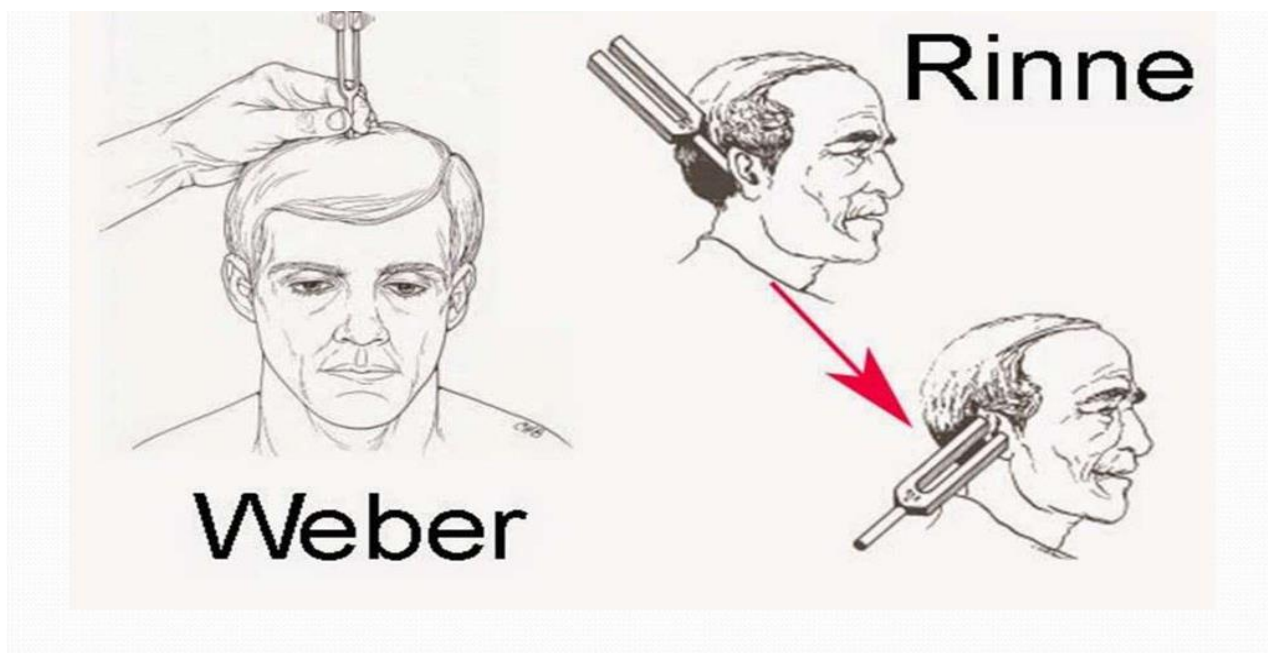
### **2. Weber's Experience (W)**

**The purpose of the work:** using functional tests to determine the presence or absence of hearing loss.

**For the work you need:** a set of tuning forks, cotton wool.

**Progress of work.** Put the sounding tuning fork C128 to the crown of the subject, so that its leg is in the middle of the head. The branches of the tuning fork should make their vibrations in the frontal plane, that is, from the right ear to the left.

Normally, the subject hears the sound of a tuning fork in the middle of the head or the same in both ears (norm W W→). In unilateral disease of the conductive apparatus lateralised sound in the affected ear (e.g., left: W→), with unilateral disease of the sound-apparatus sound lateralized in a healthy ear (e.g., to the right: ←W). In case of bilateral ear disease of different degrees or different types, the results of the experiment should be considered depending on all factors.



### 3. Schwabach Experience (Sch)

**The purpose of the work:** using functional tests to determine the presence or absence of hearing loss.

**For the work you need:** a set of tuning forks.

**Progress of work.** Sound of a tuning fork set to the top of the head under test and keep it for as long as the latter will cease to hear. Then the researcher (with normal hearing) puts the tuning fork on his head, if he continues to hear the tuning fork, then the Schwabach experience is shortened in the subject, if he also does not hear, then the Schwabach experience in the subject is normal. Shortening of the Schwabach experience is observed in diseases of the sound-receiving apparatus. In the same way, the experiment is performed on each ear: the tuning fork is placed on the platform of the mastoid process.

### 4. Jelle Experience (G)

**The purpose of the work:** using functional tests to determine the presence or absence of hearing loss.

**For the work you need:** a set of tuning forks.

**Progress of work.** Put a sounding tuning fork on the mastoid process and simultaneously thicken the air in the external auditory passage of the same ear with a funnel. At the moment of air compression, the subject with normal hearing will feel a decrease in perception (the experience is more positive), this is due to the deterioration of the mobility of the sound-conducting system due to the depression of the stirrup in the niche of the oval window. When the stirrup is stationary (otosclerosis), no change in perception will occur at the moment of air thickening in the external auditory passage (the experience is negative). If the sound-receiving device is ill, the same sound attenuation will occur as in the normal case, i.e. the experience of Zhelle will be positive.

**Filling out the auditory passport.**

The results of speech and tuning fork studies are recorded in the auditory passport for further analysis. Below is a diagram of the auditory passport of the subject with normal hearing on the right and impaired sound perception on the left.

Right ear (AD)		Left ear (AS)
+ or -	SN (subjective noise)	+ or -
In meters	WS (whisper speech)	In meters
In meters	SL (spoken language)	In meters
In seconds	C 128 aerial (N In seconds )	In seconds
In seconds	C 128 osteal (N In seconds)	In seconds
In seconds	C 2048 (N In seconds)	In seconds
+ or -	Rinne's Experience (R)	+ or -
lateralization	Weber's Experience (W)	lateralization
Lengthened, shortened, or normal	Schwabach's Experience (Sch)	Lengthened, shortened, or normal

**At the end of the experiment, make a conclusion about the presence or absence of hearing loss in the subject.**

**Practical work № 7. Esthesiometry**



Tactile sensitivity depends on the density of the location of mechanoreceptors that perceive pressure in the subcutaneous tissue. The perception of pressure and touch is characterized by a spatial threshold (how close the receptors are located between them) and a force threshold (how great the pressure on the skin is).

The spatial threshold is the smallest distance between two points of the skin that are simultaneously irritated by the sensation of two touches. The normal values of spatial thresholds are shown in the table.

**The purpose of the work:** to determine the spatial threshold of tactile sensitivity.

**For the work you need:** esthesiometer (or a compass), cotton wool, alcohol 70% to disinfect the needle of a compass.

**Progress of work:** The work is carried out in pairs. The subject is sitting on a chair with his eyes closed. The researcher touches a certain area of the skin with a compass with the legs as close as possible. The legs of the compass must touch the skin at the same time and with the same pressure! Repeat the touch, gradually pushing the legs of the compass, each time increasing the distance by 1 mm. Find the minimum distance at which there is a feeling of two separate touches and record the results in the table – this will be the spatial threshold of tactile sensitivity. Fill in the table.

**Spatial threshold of tactile sensitivity**

Study area	Norm, mm	The result of the study, mm
Lips of	2,0–2,5	
The fingertips of	2,0–2,5	
The tip of the nose	7,0	
Middle of the palm	9,0	
Back surface of the brush	30,0	
Forearm, lower leg	40,0	
Back	55,0	
Hip, shoulde	60,0	

**Results of the work and their design.** Record research results in a table and compare them with the norm. Explain the differences in tactile sensitivity of different parts of the body.

### **Practical work № 8. Olfactory analyzer adaptation study**

Adaptation in the olfactory analyzer is relatively slow (tens of seconds or minutes) and depends on the speed of the air flow over the olfactory epithelium and the concentration of the odorous substance.

**The purpose of the work:** to study the adaptation of the olfactory analyzer.

**For the work you need:** vanillin, cologne, alcohol, cotton wool, stopwatch.

**Progress of work:** The subject should bring a test tube with an odorous substance to one of the nostrils and make frequent (sniffing) breaths (exhalation is made through the mouth) until the sense of smell of the odorous substance taken disappears.

Determine the time of onset of olfactory analyzer adaptation. After the onset of adaptation, bring a test tube with the same substance every 30 seconds and determine the recovery time of the olfactory analyzer sensitivity.

**Results of the work and their design.** Describe the results obtained. Conclude.

### **Practical work № 9. Pain reception**

Nociception – pain sensitivity. The division of the peripheral pain sensory system represented by mechanical and demonolatory.

Mechanoreceptors (receptor cells that perceive strong pressure as pain) are located in the skin, tendons, and mucous membranes of the gastrointestinal tract. With strong compression or tension, the membrane of the receptor cell is deformed and it is excited, transmitting the excitation to the sensory neurons of the corresponding nerves. The signal along the ascending neural pathways reaches the Central nervous system, is processed by the brain and there is a pain sensation.

Chemoreceptors are located primarily in the internal organs, but are also present in the skin and mucous membranes. They are excited in response to the action of molecules of specific chemicals. The mechanism of transmission and processing of nerve impulses similar mechanoreceptors.

**The purpose of the work:** to find and draw a map of pain points of the studied skin areas.

**For the work you need:** sharp piercing needles, an ink pencil, a stencil with a window cm<sup>2</sup>.

**Progress of work.** The work is carried out in pairs. The researcher on different areas of the skin (the inner and back side of the hand, shoulder, back) of the subject on a stencil outlines the area of 1 cm<sup>2</sup>. Within this area, he consistently applies injections with a needle, marking the points where pain occurs on the skin with a pencil. Attention! It is necessary to make sure that the pain is specific, which differs from the pressure. The pain sensation has a negative emotional color. This is achieved with multiple impacts on the detected pain point. To compare different types of pain, you should take turns: prick yourself with a needle on the back of the hand, pull the skin hair for a long time, squeeze the skin fold between 3 and 4 fingers.

**Results of the work and their design.** Draw a map of the pain points of the areas where the study was conducted (the researcher draws in the notebook of the subject). Specify which area of the skin surface has the largest number of pain points. Explain why the area on the surface of the back is usually chosen for subcutaneous injection of drugs.

## **THE QUESTIONS OF COLLOQUIUMS**

### **Colloquium № 1**

1. The concept of irritability and excitability. Structure of the membrane of excitable cells. Functional significance of protein and lipid components of membranes.
2. Ion channel. Chemo-excitability and electro-excitability ion channels.
3. Origin of the resting potential of the excitable cell. Ionic mechanisms for the occurrence of the rest potential.
4. Action potential. Potential phases. Ionic mechanisms of potential generation.
5. Critical level of membrane depolarization. The difference between a local response and an action potential.
6. Dependence of the threshold force of irritation on its duration. The concept of accommodation.
7. Polar law of Pfluger irritation. Cat- and anelectroton. Verigo cathodic depression. Passive and active changes in the membrane potential.
8. The change in excitability during excitation. Physiological significance of the refractory phase of excitation. The concept of lability.
9. Mechanisms of excitation along muscle and nerve fibers.
10. Types of nerve fibers. Laws of excitation in nerves. The role of Ranvier intercepts.
11. Transversely striped muscles. Basic functions, structure. Physiological mechanism of muscle contraction. The role of protein components in myofibrillation contraction. The concept of the myofibril triad.
12. The energy of muscle contraction. The role of ATP. Work and strength of muscles and myelinated nerve fibers in conducting nerve impulse.
13. Isometric and isotonic contraction. Single contraction, tetanus.
14. The concept of a neuromotor unit. Classification of motor units.
15. Smooth muscle functions. Physiological features of smooth muscles. Characteristics of contractile activity of smooth muscles.
16. Neuron structure. Basic functions of neuron structural elements.
17. Electrical and chemical synapses, their structural and functional differences.
18. Transfer of excitation from nerve to skeletal muscle as an example of chemical synapse functioning.
19. Post-synaptic potential, its differences from the action potential. 20. Violation of neuromuscular transmission in fatigue.
21. Differences between central synapses and neuromuscular synapses. Necessity of summation of postsynaptic potentials to generate action potential.
22. Mediators of nerve cells: acetylcholine, noradrenaline, dopamine, serotonin, GABA, glutamate, glycine, and others.
23. Presynaptic and postsynaptic inhibition
24. Interaction of neurons in nerve centers. The summation. Facilitation, occlusion. Divergence and convergence of nerve impulses.

## **Colloquium № 2**

1. Reflex activity of the nervous system. The concept of reflex. Types of reflexes. The reflex arc. Nerve centers.
2. Mono- and polysynaptic reflexes. Receptive field of reflexes. Time of reflex.

3. Spinal cord. Its structural and functional organization.
4. Spinal cord reflexes.
5. Conductor functions of the spinal cord. Ascending systems. Downstream systems.
6. The structure and basic functions of the posterior brain.
7. The structure and basic functions of the cerebellum.
8. Thalamus and hypothalamus structure and function. 8.
9. Structure and basic functions of subcortical nuclei.
10. Structure and basic functions of ancient and old crust.
11. 11. Structure and basic functions of the new crust.
12. General plan for the structure of the autonomic nervous system.
13. Vegetative ganglia.
14. Influence of sympathetic and parasympathetic nervous system on internal organs functions.
15. Spinal and stem centers of the autonomic nervous system.
16. Role of hypothalamus, limbic system and cortex in regulation of vegetative functions.
17. The concept of endocrine system. Mechanism of action of hormones, hormone structure, their properties.
18. Structural organization of the pituitary gland. Endocrine function of the posterior and intermediate lobes of the pituitary gland. Regulation of hormone secretion.
19. Endocrine function of the anterior pituitary gland. Adjustment of secretion. 20. Hypothalamus role in endocrine regulation. Ways of hypothalamus influence on pituitary gland.
21. Hormones of thyroid and parotid glands. Regulation of secretion.
22. Structural organization and endocrine function of pancreas. Adjustment of secretion.
23. Structural organization of adrenals. Endocrine function of brain substance of adrenal glands. Regulation of secretion.
24. Hormones of the adrenal cortex. Adrenal glandular cortex hormones. Regulation of secretion.
25. Endocrine function of sex glands. Regulation of sex glands activity.
26. The concept of tissue hormones.

### **Additional questions**

1. Sleep Wake cycle. Emotions and motivation.
2. Non-associative, associative, and cognitive learning. The conditional reflex temporary connection. The types of GNI.
3. Short-term and long-term memory. Arbitrary and involuntary attention. The control of behavior.
4. The concept of a sensory system. The concept of the analyzer from the position of teaching, their role in the life of the body.
5. General properties of sensor systems. Features of the organization of the conductor and cortical departments of the sensory system.

6. Classification, mechanism of receptor excitation. Encoding information in sensor systems.
7. Morphological and functional characteristics of parts of the vision system, the role coreceptors division of this system.
8. The concept of refraction, accommodation. Refractive errors (astigmatism, myopia, farsightedness, presbyopia), their mechanisms.
9. Characteristics of the receptor section of the visual analyzer, photochemical reactions in it.
10. Structural and functional organization of the auditory sensory system. Sound reception mechanisms. Binaural hearing.
11. General morphological and functional organization of the taste sensory system departments. Receptors of the taste sensory system. Mechanism of reception and perception of taste.
12. Morpho-functional characteristics of the departments of the pain sensory system. Theories of the mechanism of pain.
13. General morphological and functional organization of the departments of the skin sensory system. Tactile, temperature analyzers.
14. The concept of pain, nociception. Components of the pain response. Classification of pain.
15. Morpho-functional characteristics of the departments of the pain sensory system. Representation of theories of the mechanism of pain.
16. The concept of antinociception and antinociceptive system (ANTS). Components and functions of ANC. ANTS levels.

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### a) Basic Literature

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2. Normal physiology [Electron resource]: a textbook / edited by B. I. Tkachenko. - 3rd ed., pp. i dop. - M. : Gotar-Media, 2014 Access mode: <http://www.studentlibrary.ru/book/ISBN9785970428610.html>.  
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### b) Additional literature:

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5. Deryugina A.V., Vedunova M.V., Shvets I.M. Some bioethical problems of medical activity. Educational and methodical manual. Registered in NNSU FER 15.11.2019. Access mode: <http://www.lib.unn.ru/students/src/bioethics.pdf>.

### c) Internet resources:

1. Digital Libraries (Znaniy.com, "EBS Student Consultant", "Lan").
2. Scientific Russian electronic library elibrary.ru
3. Science-intensive databases Scopus, Web of Science, BioMed Central
4. Periodicals online (Elsevier, Springer)
5. DOAJ-Direktory of Open Access Journals
6. PLOS-Publik Library of Science

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